

JEDEC STANDARD

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DDR5 SERIAL PRESENCE DETECT (SPD) CONTENTS

Contents

	Page
1 Introduction / Scope	1
2 History	2
3 SPD Architecture	3
4 Overlay Schema	5
4.1 Solder Down Overlay Schema	5
4.2 UDIMM Overlay Schema	5
4.3 RDIMM and LRDIMM Overlay Schema	6
4.4 MRDIMM Overlay Schema	6
4.5 DDIMM Overlay Schema	7
4.6 NVDIMM-N Overlay Schema	7
4.7 NVDIMM-P Overlay Schema	8
4.8 CAMM2 Overlay Schema	8
5 Parsing the SPD	9
6 SPD Revision Progression	11
7 Address Map	12
7.1 ASCII Decode Matrix for SPDs	14
8 Details of Each Byte	15
8.1 Blocks 0 and 1: General Configuration Section: Bytes 0~127 (0x000~0x07F).....	15
8.1.1 (DDR5): Byte 0 (0x000): Number of Bytes in SPD Device and Beta Level	19
8.1.2 (DDR5): Byte 1 (0x001): SPD Revision for Base Configuration Parameters	19
8.1.3 (DDR5): Byte 2 (0x002): Key Byte / Host Bus Command Protocol Type	21
8.1.4 (DDR5): Byte 3 (0x003): Key Byte / Module Type	22
8.1.5 (DDR5): Byte 4 (0x004): First SDRAM Density and Package	23
8.1.6 (DDR5): Byte 5 (0x005): First SDRAM Addressing	23
8.1.7 (DDR5): Byte 6 (0x006): First SDRAM I/O Width	24
8.1.8 (DDR5): Byte 7 (0x007): First SDRAM Bank Groups and Banks Per Bank Group	24
8.1.9 (DDR5): Byte 8 (0x008): Second SDRAM Density and Package	25
8.1.10 (DDR5): Byte 9 (0x009): Second SDRAM Addressing	25
8.1.11 (DDR5): Byte 10 (0x00A): Secondary SDRAM I/O Width	26
8.1.12 (DDR5): Byte 11 (0x00B): Second SDRAM Bank Groups and Banks Per Bank Group	26
8.1.13 (DDR5): Byte 12 (0x00C): SDRAM BL32 and Post Package Repair	27
8.1.14 (DDR5): Byte 13 (0x00D): SDRAM Duty Cycle Adjuster and Partial Array Self Refresh	27

DDR5 SERIAL PRESENCE DETECT (SPD) CONTENTS**Contents (cont'd)**

8.1.15 (DDR5): Byte 14 (0x00E): SDRAM Per Row Activation Counting, Fault Handling, and Temperature Sense	28
8.1.16 (DDR5): Byte 15 (0x00F): Reserved	28
8.1.17 (DDR5): Byte 16 (0x010): SDRAM Nominal Voltage, VDD	28
8.1.18 (DDR5): Byte 17 (0x011): SDRAM Nominal Voltage, VDDQ	29
8.1.19 (DDR5): Byte 18 (0x012): SDRAM Nominal Voltage, VPP	29
8.1.20 (DDR5): Byte 19 (0x013): SDRAM Timing	29
8.1.21 (DDR5): SDRAM Minimum Cycle Time (tCKAVGmin)	35
8.1.22 (DDR5): SDRAM Maximum Cycle Time (tCKAVGmax)	35
8.1.23 (DDR5): SDRAM CAS Latencies Supported	36
8.1.24 (DDR5): Byte 29 (0x01D)	37
8.1.25 (DDR5): SDRAM Read Command to First Data (tAA)	37
8.1.26 (DDR5): SDRAM Activate to Read or Write Command Delay (tRCD)	37
8.1.27 (DDR5): SDRAM Row Precharge Time (tRP)	37
8.1.28 (DDR5): SDRAM Activate to Precharge Command Period (tRAS)	38
8.1.29 (DDR5): SDRAM Activate to Activate or Refresh Command Period (tRC)	38
8.1.30 (DDR5): SDRAM Write Recovery Time (tWR)	38
8.1.31 (DDR5): SDRAM Normal Refresh Recovery Time (tRFC1, tRFC1_slr)	39
8.1.32 (DDR5): SDRAM Fine Granularity Refresh Recovery Time (tRFC2, tRFC2_slr)	39
8.1.33 (DDR5): SDRAM Same Bank Refresh Recovery Time (tRFCsb, tRFCsb_slr) ..	40
8.1.34 (DDR5): SDRAM Normal Refresh Recovery Time, 3DS Different Logical Rank (tRFC1_dlr)	40
8.1.35 (DDR5): SDRAM Fine Granularity Refresh Recovery Time, 3DS Different Logical Rank (tRFC2_dlr)	41
8.1.36 (DDR5): SDRAM Same Bank Refresh Recovery Time, 3DS Different Logical Rank (tRFCsb_dlr)	41
8.1.37 (DDR5): SDRAM Refresh Management, First SDRAM	42
8.1.38 (DDR5): SDRAM Refresh Management, Second SDRAM	43
8.1.39 (DDR5): SDRAM Adaptive Refresh Management	44
8.1.40 (DDR5): SDRAM Activate to Activate Command Delay for Same Bank Group (tRRD_L)	45
8.1.41 (DDR5): SDRAM Read to Read Command Delay for Same Bank Group (tCCD_L)	45
8.1.42 (DDR5): SDRAM Write to Write Command Delay for Same Bank Group (tCCD_L_WR)	46
8.1.43 (DDR5): SDRAM Write to Write Command Delay for Same Bank Group, Second Write not RMW (tCCD_L_WR2)	46
8.1.44 (DDR5): SDRAM Four Activate Window (tFAW)	47

DDR5 SERIAL PRESENCE DETECT (SPD) CONTENTS

Contents (cont'd)

8.1.45 (DDR5): SDRAM Write to Read Command Delay for Same Bank Group (tCCD_L_WTR)	47
8.1.46 (DDR5): SDRAM Write to Read Command Delay for Different Bank Group (tCCD_S_WTR)	48
8.1.47 (DDR5): SDRAM Read to Precharge Command Delay (tRTP, tRTP_slr)	49
8.1.48 (DDR5): SDRAM Read to Read Command Delay for Different Bank in Same Bank Group (tCCD_M)	49
8.1.49 (DDR5): SDRAM Write to Write Command Delay for Different Bank in Same Bank Group (tCCD_M_WR)	50
8.1.50 (DDR5): SDRAM Write to Read Command Delay for Different Bank in Same Bank Group (tCCD_M_WTR)	51
8.1.51 (DDR5): Reserved, Base Configuration Section	51
9 Example SPD Codes	52
9.1 Core Parameters, DDR5 Monolithic Single Die Package (SDP) SDRAMs	52
9.2 Parameters with Lower nCK Limits, DDR5 Monolithic Single Die Package SDRAMs ..	58
9.3 CAS Latency Masks, DDR5 Monolithic Single Die Package SDRAMs	60
9.4 Parameters Defined by Device Density, DDR5 Monolithic Single Die Package (SDP) SDRAMs	61
9.5 Core Parameters, DDR5 Multi-Die Packages (3DS) SDRAMs	62
9.6 Parameters with Lower nCK Limits, DDR5 Multi-Die Packages (3DS) SDRAMs	67
9.7 CAS Latency Masks, DDR5 Multi-Die Packages (3DS) SDRAMs	69
9.8 Parameters Defined by Device Density, DDR5 Multi-Die Packages (3DS) SDRAMs ..	70
10 Annex Format (Blocks 3~6, 8~9, and 10~15)	71
10.1 Blocks 3~6: Module-Specific Section: Bytes 192~447 (0x0C0~0x1BF)	71
10.2 Blocks 8~9: Module Supplier's Data: Bytes 512~639 (0x200~0x27F)	71
10.3 Blocks 10~15: End User Programmable, Bytes 640~1023 (0x280~0x3FF)	71
11 Annex A.0: Common SPD Bytes for All Module Types	72
11.1 (Common): SPD Revision for Module Information	73
11.2 (Common): Hashing Sequence	73
11.3 (Common): Module Device Information	74
11.4 (Common): Reserved	75
11.5 (Common): Additional Support Devices	75
11.6 (Common): Module Nominal Height	75
11.7 (Common): Module Maximum Thickness	76
11.8 (Common): Reference Raw Card Used	77
11.9 (Common): DIMM Attributes	78
11.10 (Common): Module Organization	78
11.11 (Common): Memory Channel Bus Width	81
11.12 (Common): Reserved	83

DDR5 SERIAL PRESENCE DETECT (SPD) CONTENTS**Contents (cont'd)**

11.13 (Common): Module Type Specific Information	83
12 Annex A.1: Module Specific Bytes for Solder Down	84
13 Annex A.2: Module Specific Bytes for Clocked or Unbuffered Memory Module Types	85
13.1 (Unbuffered): Module Specific Device Information	85
13.2 (Unbuffered): CKD-RW00 CKD Configuration	86
13.3 (Unbuffered): CKD-RW02 QCK Driver Characteristics	86
13.4 (Unbuffered): CKD-RW03 QCK Output Differential Slew Rate	87
13.5 (Unbuffered): Reserved	87
14 Annex A.3: Module Specific Bytes for Registered (RDIMM) and Load Reduced (LRDIMM) Memory Module Types	88
14.1 (RDIMM/LRDIMM): Module Specific Device Information	89
14.2 (RDIMM/LRDIMM): RCD-RW08 Clock Driver Enable	90
14.3 (RDIMM/LRDIMM): RCD-RW09 Output Address and Control Enable	91
14.4 (RDIMM/LRDIMM): RCD-RW0A QCK Driver Characteristics	91
14.5 (RDIMM/LRDIMM): RCD-RW0B	91
14.6 (RDIMM/LRDIMM): RCD-RW0C QxCA and QxCS_n Driver Characteristics	92
14.7 (RDIMM/LRDIMM): RCD-RW0D Data Buffer Interface Driver Characteristics	92
14.8 (RDIMM/LRDIMM): RCD-RW0E QCK, QCA, and QCS Output Slew Rate	93
14.9 (RDIMM/LRDIMM): RCD-RW0F BCK, BCOM, and BCS Output Slew Rate	93
14.10 (RDIMM/LRDIMM): DB-RW86 DQS RTT Park Termination	94
14.11 (RDIMM/LRDIMM): Reserved	94
15 Annex A.4: Module Specific Bytes for Multiplexed Rank (MRDIMM) Memory Module Types	95
15.1 (MRDIMM): Module Specific Device Information	97
15.2 (MRDIMM): MRCD-RW08 Clock Driver Enable	97
15.3 (MRDIMM): MRCD-RW09 Output Address and Control Enable	98
15.4 (MRDIMM): MRCD-RW0A QCK Driver Characteristics	98
15.5 (MRDIMM): MRCD-RW0B	98
15.6 (MRDIMM): MRCD-RW0C QxCA and QxCS_n Driver Characteristics	99
15.7 (MRDIMM): MRCD-RW0D Data Buffer Interface Driver Characteristics	99
15.8 (MRDIMM): MRCD-RW0E QCK, QCA, and QCS Output Slew Rate	99
15.9 (MRDIMM): MRCD-RW0F BCK, BCOM, and BCS Output Slew Rate	100
15.10 (MRDIMM): MDB-PG[C]RWE0 Duty Cycle Adjuster Configuration	100
15.11 (MRDIMM): MDB-PG[70]RWE1 DRAM Interface Receiver Type	100
15.12 (MRDIMM): Reserved	101
16 Annex A.5: Module Specific Bytes for Differential Memory Module Types	102
16.1 (Differential): Module Specific Device Information	102
16.2 (Differential): Reserved	103

DDR5 SERIAL PRESENCE DETECT (SPD) CONTENTS

Contents (cont'd)

17 Annex A.6: Non-Volatile (NVDIMM-N) Hybrid Memory Parameters	104
17.1 (NVDIMM-N): Module Specific Device Information	105
17.2 (NVDIMM-N): Reserved	105
18 Annex A.7: Non-Volatile (NVDIMM-P) Hybrid Memory Parameters	106
18.1 (NVDIMM-P): Module Specific Device Information	107
18.2 (NVDIMM-P): Module Storage Capacity	108
18.3 (NVDIMM-P): Protocol Profile	108
18.4 (NVDIMM-P): Reserved	109
18.5 Application Notes for Transactional Credit Based NVDIMMs	109
19 Annex A.8: Module Specific Bytes for Compression Attached Memory Module Types	111
19.1 (CAMM2): Module Specific Device Information	111
19.2 (CAMM2): Reserved	112
19.3 (CAMM2): Clock Driver 0 RW00 CKD Configuration	112
19.4 (CAMM2): Clock Driver 0 RW02 QCK Driver Characteristics	113
19.5 (CAMM2): Clock Driver 0 RW03 QCK Output Differential Slew Rate	113
19.6 (CAMM2): Clock Driver 1 RW00 CKD Configuration	114
19.7 (CAMM2): Clock Driver 1 RW02 QCK Driver Characteristics	114
19.8 (CAMM2): Clock Driver 1 RW03 QCK Output Differential Slew Rate	114
19.9 (CAMM2): Reserved	114
20 Blocks 8~9: Manufacturing Information: (Bytes 512~639, 0x200~0x27F)	115
20.1 Byte 512 (0x200): Module Manufacturer ID Code, First Byte, Byte 513 (0x201): Module Manufacturer ID Code, Second Byte	115
20.2 Byte 514 (0x202): Module Manufacturing Location	115
20.3 Bytes 515~516 (0x203~0x204): Module Manufacturing Date	115
20.4 Bytes 517~520 (0x205~0x208): Module Serial Number	115
20.5 Bytes 521~550 (0x209~0x226): Module Part Number	116
20.6 Byte 551 (0x227): Module Revision Code	116
20.7 Byte 552 (0x228): DRAM Manufacturer ID Code, First Byte, Byte 553 (0x229): DRAM Manufacturer ID Code, Second Byte	116
20.8 Byte 554 (0x22A): DRAM Stepping	116
20.9 Bytes 555~639 (0x22B~27F): Manufacturer's Specific Data	117
21 Blocks 10~15: End User Programmable, Bytes 640~1023 (0x280~0x3FF)	118
21.1 Bytes n~n+23: Error Logging Data	118
21.2 Bytes n~n+3: Anchor String to Indicate Valid Error Log	118
21.3 Byte n+4: Header to Indicate Error Type	119
21.4 Bytes n+5~n+12 (DRAM error): Error Location	120
21.5 Bytes n+14~n+17 (DRAM Error): Timestamp	121

DDR5 SERIAL PRESENCE DETECT (SPD) CONTENTS

Contents (cont'd)

21.6 Byte n+18 (DRAM Error): Highest DRAM Refresh Settings on the Module	122
21.7 Byte n+19~20 (DRAM error): Module Measured Temperature	123
21.8 Bytes n+21~n+23 (DRAM error): Reserved	123
Annex A — (Informative) Differences Between JESD400-5A and JESD400-5	124
Annex B — (Informative) Differences between JESD400-5A.01 and JESD400-5A	125
Annex C — (Informative) Differences between JESD400-5B and JESD400-5A.01	126
Annex D — (Informative) Differences between JESD400-5C and JESD400-5B	128

List of Figures

	Page
Figure 1 — Symmetrical Configurations (Byte 234 Bit 6 = 0)	79
Figure 2 — Asymmetrical Configurations (Byte 234 Bit 6 = 1)	80

DDR5 SERIAL PRESENCE DETECT (SPD) CONTENTS**Contents (cont'd)****List of Tables**

	Page
Table 1 — SPD Contents Alignment with Write Protection Blocks	3
Table 2 — Solder Down Overlay Schema	5
Table 3 — UDIMM Overlay Schema	5
Table 4 — RDIMM and LRDIMM Overlay Schema	6
Table 5 — MRDIMM Overlay Schema	6
Table 6 — DDIMM Overlay Schema	7
Table 7 — NVDIMM-N Overlay Schema	7
Table 8 — NVDIMM-P Overlay Schema	8
Table 9 — CAMM2 Overlay Schema	8
Table 10 — Some Relevant SPD Bytes for Parsing	9
Table 11 — Hypothetical SPD Revision Progression Showing Revision Relationships	11
Table 12 — Hypothetical Progression Showing Relationship between Feature Updates, Typo Error Corrections, Spec Revisions, and Dates	11
Table 13 — SPD Address Map for DDR5 Modules	12
Table 14 — Location of Bytes 512~639 in Blocks 8~9	14
Table 15 — Subset of Full ASCII Standard	14
Table 16 — SPD Bytes 521~550	15
Table 17 — Blocks 0 and 1 General Configuration	15
Table 18 — Number of Bytes in SPD Device	19
Table 19 — SPD Revision for Base Configuration Parameters	19
Table 20 — Key Byte / Host Bus Command Protocol Type	21
Table 21 — Key Byte / Module Type	22
Table 22 — First SDRAM Density and Package	23
Table 23 — First SDRAM Addressing	23
Table 24 — First SDRAM I/O Width	24
Table 25 — First SDRAM Bank Groups and Banks Per Bank Group	24
Table 26 — Second SDRAM Density and Package	25
Table 27 — Second SDRAM Addressing	25
Table 28 — Second SDRAM I/O Width	26
Table 29 — Second SDRAM Bank Groups and Banks Per Bank Group	26
Table 30 — SDRAM BL32 and Post Package Repair Features	27
Table 31 — SDRAM Duty Cycle Adjuster	27
Table 32 — SDRAM Per Row Activation Counting, Fault Handling, and Temperature Sense ..	28
Table 33 — SDRAM Nominal Voltage, VDD	28

DDR5 SERIAL PRESENCE DETECT (SPD) CONTENTS**Contents (cont'd)**

Table 34 — SDRAM Nominal Voltage, VDDQ	29
Table 35 — SDRAM Nominal Voltage, VPP	29
Table 36 — SDRAM Timing	29
Table 37 — Example, using Round Down Only Integer Number Math	33
Table 38 — SDRAM Minimum Cycle Time (tCKAVGmin), ps	35
Table 39 — SDRAM Maximum Cycle Time (tCKAVGmax), ps	35
Table 40 — SDRAM CAS Latencies Supported	36
Table 41 — Example 1: DDR5-4400A SDRAM	36
Table 42 — SDRAM Read Command to First Data (tAA), ps	37
Table 43 — SDRAM Activate to Read or Write Command Delay (tRCD), ps	37
Table 44 — SDRAM Row Precharge Time (tRP), ps	37
Table 45 — SDRAM Activate to Precharge Command Period (tRAS), ps	38
Table 46 — SDRAM Activate to Activate or Refresh Command Period (tRC), ps	38
Table 47 — SDRAM Write Recovery Time (tWR), ps	39
Table 48 — SDRAM Normal Refresh Recovery Time (tRFC1, tRFC1_slr), ns	39
Table 49 — SDRAM Fine Granularity Refresh Recovery Time (tRFC2, tRFC2_slr), ns	39
Table 50 — SDRAM Same Bank Refresh Recovery Time (tRFCsb, tRFCsb_slr), ns	40
Table 51 — SDRAM Normal Refresh Recovery Time, 3DS Different Logical Rank (tRFC1_dlr), ns	40
Table 52 — SDRAM Fine Granularity Refresh Recovery Time (tRFC2_dlr), ns	41
Table 53 — SDRAM Same Bank Refresh Recovery Time (tRFCsb_dlr), ns	41
Table 54 — SDRAM Refresh Management (RFM), First Byte, Byte 54 (First SDRAM)	42
Table 55 — SDRAM Refresh Management (RFM), Second Byte, Byte 55 (First SDRAM)	43
Table 56 — SDRAM Refresh Management (RFM), First Byte, Byte 56 (Second SDRAM)	43
Table 57 — SDRAM Refresh Management (RFM), Second Byte, Byte 57 (Second SDRAM) ..	44
Table 58 — SDRAM Adaptive Refresh Management (ARFM)	44
Table 59 — SDRAM Adaptive Refresh Management (ARFM), First Bytes	44
Table 60 — SDRAM Adaptive Refresh Management (ARFM), Second Bytes	44
Table 61 — SDRAM Activate to Activate Command Delay for Same Bank Group (tRRD_L) ...	45
Table 62 — SDRAM Read to Read Command Delay for Same Bank Group (tCCD_L)	45
Table 63 — SDRAM Write to Write Command Delay for Same Bank Group (tCCD_L_WR)	46
Table 64 — SDRAM Write to Write Command Delay for Same Bank Group, ,Second Write not RMW (tCCD_L_WR2)	46
Table 65 — SDRAM Four Activate Window (tFAW)	47
Table 66 — DDR5 SDRAM Write to Read Command Delay for Same Bank Group (tCCD_L_WTR)	47
Table 67 — DDR5 SDRAM Write to Read Command Delay for Different Bank Group (tCCD_S_WTR)	48

DDR5 SERIAL PRESENCE DETECT (SPD) CONTENTS

Contents (cont'd)

Table 68 — DDR5 SDRAM Read to Precharge Command Delay (tRTP, tRTP_slr)	49
Table 69 — DDR5 SDRAM Read to Read Command Delay for Different Bank in Same Bank Group (tCCD_M)	49
Table 70 — DDR5 SDRAM Write to Write Command Delay for Different Bank in Same Bank Group (tCCD_M_WR)	50
Table 71 — DDR5 SDRAM Write to Read Command Delay for Different Bank in Same Bank Group (tCCD_M_WTR)	51
Table 72 — Clock Periods Used for Standard Speed Grade Calculations	52
Table 73 — Example 1: Core Parameters, DDR5 Monolithic Single Die Package SDRAMs	52
Table 74 — Example 2: Core Parameters, DDR5 Monolithic Single Die Package SDRAMs	54
Table 75 — Example 3: Core Parameters, DDR5 Monolithic Single Die Package SDRAMs	55
Table 76 — Example 4: Core Parameters, DDR5 Monolithic Single Die Package SDRAMs	56
Table 77 — Example 5: Core Parameters, DDR5 Monolithic Single Die Package SDRAMs	57
Table 78 — Example 6: Parameters with Lower nCK Limits, DDR5 Monolithic SDP SDRAMs	58
Table 79 — Example 7: Parameters with Lower nCK Limits, DDR5 Monolithic SDP SDRAMs	59
Table 80 — CAS Latency Masks, DDR5 Monolithic Single Die Package SDRAMs	60
Table 81 — Parameters Defined by Device Density, DDR5 Monolithic Single Die Package (SDP) SDRAMs	61
Table 82 — Example 1: Core Parameters, DDR5 Multi-Die Packages (3DS) SDRAMs	62
Table 83 — Example 2: Core Parameters, DDR5 Multi-Die Packages (3DS) SDRAMs	63
Table 84 — Example 3: Core Parameters, DDR5 Multi-Die Packages (3DS) SDRAMs	64
Table 85 — Example 4: Core Parameters, DDR5 Multi-Die Packages (3DS) SDRAMs	65
Table 86 — Example 5: Core Parameters, DDR5 Multi-Die Packages (3DS) SDRAMs	66
Table 87 — Example 6: Parameters with Lower nCK Limits, DDR5 Multi-Die Packages (3DS) SDRAMs	67
Table 88 — Example 7: Parameters with Lower nCK Limits, DDR5 Multi-Die Packages (3DS) SDRAM	68
Table 89 — CAS Latency Masks, DDR5 Multi-Die Packages (3DS) SDRAMs	69
Table 90 — Parameters Defined by Device Density, DDR5 Multi-Die Packages (3DS) SDRAMs	70
Table 91 — SPD Bytes Common to All Module Types	72
Table 92 — Hashing Sequence	73
Table 93 — Module Generic Device Information	74
Table 94 — Device Types	74
Table 95 — Electrically Induced Physical Damage Protection Device Types	75
Table 96 — Module Nominal Heights	75
Table 97 — Examples of Module Nominal Heights	76
Table 98 — Module Maximum Thickness	76
Table 99 — Reference Raw Card Used	77
Table 100 — DIMM Attributes	78

DDR5 SERIAL PRESENCE DETECT (SPD) CONTENTS**Contents (cont'd)**

Table 101 — Module Organization	78
Table 102 — Rank Matrix for Symmetrical Modules (Byte 234 Bit 6 = 0)	80
Table 103 — Rank Mix for Asymmetrical Modules (Byte 242 Bit 6 = 1)	81
Table 104 — Memory Channel Bus Width	81
Table 105 — Example Memory Channel Bus Width	82
Table 106 — SPD Bytes Needed for Module DRAM Capacity Calculation	82
Table 107 — Module Specific SPD Bytes for Solder Down Memory	84
Table 108 — Module Specific SPD Bytes for Unbuffered Module Types	85
Table 109 — Unbuffered Module Specific Device Information	85
Table 110 — Unbuffered Module Specific Device Types	86
Table 111 — Unbuffered CKD-RW00: CKD Configuration	86
Table 112 — Unbuffered CKD-RW02: QCK Driver Characteristics	86
Table 113 — Unbuffered CKD-RW03: QCK Output Differential Slew Rate	87
Table 114 — Module Specific SPD Bytes for Registered and Load Reduced Module Types ...	89
Table 115 — RDIMM/LRDIMM Module Specific Device Information	89
Table 116 — RDIMM/LRDIMM Module Specific Device Types	90
Table 117 — RDIMM/LRDIMM RCD-RW08: Clock Driver Enable	90
Table 118 — RDIMM/LRDIMM RCD-RW09: Output Address and Control Enables	91
Table 119 — RDIMM/LRDIMM RCD-RW0A: QCK Driver Characteristics	91
Table 120 — RDIMM/LRDIMM RCD-RW0B	91
Table 121 — RDIMM/LRDIMM RCD-RW0C: QxCA and QxCS_n Driver Characteristics	92
Table 122 — RDIMM/LRDIMM RCD-RW0D: Data Buffer Interface Driver Characteristics	92
Table 123 — RDIMM/LRDIMM RCD-RW0E: QCK, QCA, and QCS Output Slew Rate	93
Table 124 — RDIMM/LRDIMM RCD-RW0F: BCK, BCOM, and BCS Output Slew Rate	93
Table 125 — RDIMM/LRDIMM DB-RW86: DQS RTT Park Termination	94
Table 126 — MRDIMM Terminology	95
Table 127 — Module Specific SPD Bytes for Multiplexed Rank Module Types	96
Table 128 — MRDIMM Module Specific Device Information	97
Table 129 — MRDIMM Module Specific Device Types	97
Table 130 — MRDIMM MRCD-RW08: Clock Driver Enable	97
Table 131 — MRDIMM MRCD-RW09: Output Address and Control Enables	98
Table 132 — MRDIMM MRCD-RW0A: QCK Driver Characteristics	98
Table 133 — MRDIMM MRCD-RW0B	98
Table 134 — MRDIMM MRCD-RW0C: QxCA and QxCS_n Driver Characteristics	99
Table 135 — MRDIMM MRCD-RW0D: Data Buffer Interface Driver Characteristics	99
Table 136 — MRDIMM MRCD-RW0E: QCK, QCA, and QCS Output Slew Rate	99
Table 137 — MRDIMM MRCD-RW0F: BCK, BCOM, and BCS Output Slew Rate	100
Table 138 — MRDIMM MDB-PG[C]RWE0: Duty Cycle Adjuster Configuration	100

DDR5 SERIAL PRESENCE DETECT (SPD) CONTENTS

Contents (cont'd)

Table 139 — MRDIMM MDB-PG[70]RWE1: DRAM Interface Receiver Type	100
Table 140 — Module Specific SPD Bytes for Differential Module Types	102
Table 141 — (Differential) Module Specific Device Information	102
Table 142 — (Differential) Module Specific Device Types	103
Table 143 — NVDIMM Types Currently Defined	104
Table 144 — Module Specific SPD Bytes for NVDIMM-N Module Types	104
Table 145 — NVDIMM-N Module Specific Device Information	105
Table 146 — NVDIMM-N Module Specific Device Types	105
Table 147 — NVDIMM Types Currently Defined	106
Table 148 — Module Specific SPD Bytes for NVDIMM-P Module Types	106
Table 149 — NVDIMM-P Module Specific Device Information	107
Table 150 — NVDIMM-P Module Specific Device Types	107
Table 151 — NVDIMM-P Module Storage Capacity	108
Table 152 — Example NVDIMM-P Module Storage Capacity	108
Table 153 — NVDIMM-P Protocol Profile	108
Table 154 — SPD Block 0 Programming Guidelines for Representing NVDIMM	109
Table 155 — SPD Block 3 Programming Guidelines for Representing NVDIMM	110
Table 156 — Module Specific SPD Bytes for Compression Attached Module Types	111
Table 157 — CAMM2 Module Specific Device Information	112
Table 158 — CAMM2 Module Specific Device Types	112
Table 159 — Clock Driver 0 RW00 CKD Configuration	113
Table 160 — Clock Driver 0 RW02 QCK Driver Characteristics	113
Table 161 — Clock Driver 0 RW03 QCK Output Differential Slew Rate	113
Table 162 — Clock Driver 1 RW00 CKD Configuration	114
Table 163 — Clock Driver 1 RW02 QCK Driver Characteristics	114
Table 164 — Clock Driver 1 RW03 QCK Output Differential Slew Rate 1	14
Table 165 — Encoding of Bytes 512 and 513	115
Table 166 — Example Encoding of Bytes 512 and 513	115
Table 167 — Encoding of Bytes 552 and 553	116
Table 168 — Byte 554 DRAM Stepping	116
Table 169 — Example Byte 554 DRAM Stepping	117
Table 170 — Bytes n~n+23 Error Logging Data Format	118
Table 171 — Byte n+4 Error Type Header	119
Table 172 — Bytes n+5~n+12 DRAM Error Location	120
Table 173 — Bytes n+14~n+17 DRAM Error Timestamp	121
Table 174 — Byte n+18 (DRAM error): Highest DRAM Refresh Settings on the Module	122
Table 175 — Byte n+19~20 (DRAM Error): Module Measured Temperature	123

DDR5 SERIAL PRESENCE DETECT (SPD) CONTENTS

Contents (cont'd)

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SERIAL PRESENCE DETECT (SPD) for DDR5 SDRAM MODULES

(From JEDEC Board Ballot JCB-24-30, formulated under the cognizance of JC-45, DRAM modules, item JC-45-2260.01R. This standard is broken down into various clauses with their respective revision numbers below).

DDR5 SPD Document Release 1.3
Beta release 0

Base SPD revision 1.3
Soldered down annex revision 1.1
UDIMM annex revision 1.2
RDIMM/LRDIMM annex revision 1.2
MRDIMM annex revision 1.2
DDIMM annex revision 1.1
NVDIMM-N annex revision 0.2
NVDIMM-P annex revision 1.1
CAMM2 annex revision 1.1

1 Introduction / Scope

This standard describes the serial presence detect (SPD) values for all DDR5 memory modules. In this context, "modules" applies to memory modules like traditional Dual In-line Memory Modules (DIMMs) or solder-down motherboard applications. The SPD data provides critical information about all modules on the memory channel and is intended to be used by the system's BIOS in order to properly initialize and optimize the system memory channels. The storage capacity of the SPD non-volatile memory is limited, so a number of techniques are employed to optimize the use of these bytes, including overlays and run length limited coding.

All unused entries will be coded as 0x00. All unused bits in defined bytes will be coded as 0 except where noted.

Timing parameters in the SPD represent the operation of the module including all DRAMs and support devices at the lowest supported supply voltages (see SPD bytes 16 through 18), and are valid from $t_{CKAVGmin}$ to $t_{CKAVGmax}$ (see SPD bytes 20 through 23).

To allow for maximum flexibility as devices evolve, SPD fields described in this publication may support device configuration and timing options that are not included in the JEDEC DDR5 SDRAM data sheet (JESD79-5). Please refer to DRAM supplier data sheets or JESD79-5 to determine the compatibility of components.

2 History

Computer main memory buses have traditionally been defined by the generation of memory attached to the bus, e.g., EDO, SDRAM, DDR1, etc. The bus interface protocol and characteristics have largely been defined by the memory type. Clock frequency, CAS latencies, refresh recovery times and similar parameters defined the timing of signals between memory controller and the memory, and parameters such as number of ranks installed and device widths allowed system software to determine the memory capacity and similar high level characteristics of each module.

Over time, the memory bus has been extended to include additional features for application specific requirements. Registered DIMMs, for example, increased total capacity by buffering the loading of the address bus signals, allowing more DRAM to be installed. Similarly, Load Reduced DIMMs buffered the data bus as well, allowing even more ranks of memory to be supported. As each new extension to the function of the memory bus was introduced, system software combined knowledge of those extensions with information programmed into the non-volatile memory in the SPD to determine how to use and optimize the new features. Using the RDIMM as an example, systems understood than an additional clock of latency needed to be added to the DRAM latency to accommodate propagation delay through the register.

In later generations, the DRAM to host interface is completely virtualized. A memory module may have no DRAM at all, yet may use the DRAM bus to communicate with the host by emulating the DRAM channel interface. These virtual interfaces must appear to the system as one of the base module types, i.e., UDIMM, RDIMM, LRDIMM, or DDIMM. Modules that incorporate at least one non-DRAM media type for the purpose of main memory data storage are called “hybrid”, they act like a DRAM but on the other side of the interface protocol are some other memory type(s).

3 SPD Architecture

The SPD contents architecture must support the many variations of module types while remaining efficient. A system of overlay information selected through the use of “key bytes”, or selectors for the type of information to load has been implemented. The following DDR5 module SPD address map describes where the individual lookup table entries will be held in the serial non-volatile memory.

Consistent with the definition of DDR5 generation SPD devices (SPD5118) which have 16 individual write protection blocks of 64 bytes in length each, the SPD contents are aligned with these blocks as follows:

Table 1 — SPD Contents Alignment with Write Protection Blocks

Block	Range		Description
0	0~63	0x000~0x03F	Base Configuration and DRAM Parameters
1	64~127	0x040~0x07F	Base Configuration and DRAM Parameters
2	128~191	0x080~0x0BF	Reserved for future use
3	192~239	0x0C0~0x0EF	Common Module Parameters -- See annex A.0 for details
	240~255	0x0F0~0x0FF	Standard Module Parameters -- See annexes A.x for details
4	256~319	0x100~0x13F	Standard Module Parameters -- See annexes A.x for details
5	320~383	0x140~0x17F	Standard Module Parameters -- See annexes A.x for details
6	384~447	0x180~0x1BF	Standard Module Parameters -- See annexes A.x for details
7	448~509	0x1C0~0x1FD	Reserved for future use
	510~511	0x1FE~0x1FF	CRC for SPD bytes 0~509
8	512~575	0x200~0x23F	Manufacturing information
9	576~639	0x240~0x27F	Manufacturing information
10	640~703	0x280~0x2BF	End User Programmable
11	704~767	0x2C0~0x2FF	End User Programmable
12	768~831	0x300~0x33F	End User Programmable
13	832~895	0x340~0x37F	End User Programmable
14	896~959	0x380~0x3BF	End User Programmable
15	960~1023	0x3C0~0x3FF	End User Programmable

3 SPD Architecture (cont'd)

Operating parameters for the different module types are defined in the following Annexes and will reside in the appropriate address ranges of the SPD address map depending on the module type. Please see Overlay Schema for further details.

Annex A.0: Common SPD Bytes for All Module Types

Annex A.1: Solder down memory applications

Annex A.2: UDIMMs

Annex A.3: RDIMM and LRDIMM

Annex A.4: MRDIMM

Annex A.5: DDIMM

Annex A.6: NVDIMM-N

Annex A.7: NVDIMM-P

Annex A.8: CAMM2

4 Overlay Schema

The following Schemas exemplify the manner in which the base configuration information along with the Annexes are to be overlaid onto the appropriate address spaces in order to provide a complete definition of the module.

4.1 Solder Down Overlay Schema

Key Byte 3 contains any of the following values:

- 0x0B, Solder Down

Table 2 — Solder Down Overlay Schema

Block	Range		Description
0	0~63	0x000~0x03F	Base Configuration and DRAM Parameters
1	64~127	0x040~0x07F	Base Configuration and DRAM Parameters
2	128~191	0x080~0x0BF	...
3	192~239	0x0C0~0x0EF	Insert Annex A.0: Common
	240~255	0x0F0~0x0FF	Insert Annex A.1: Solder Down
4	256~319	0x100~0x13F	Insert Annex A.1: Solder Down
5	320~383	0x140~0x17F	Insert Annex A.1: Solder Down
6	384~447	0x180~0x1BF	Insert Annex A.1: Solder Down
7~15	448~1023	0x180~0x3FF	...

4.2 UDIMM Overlay Schema

Key Byte 2 contains value 0x12 (DDR5)

Key Byte 3 contains any of the following values:

- 0x02, UDIMM
- 0x03, SODIMM
- 0x05, CUDIMM
- 0x06, CSODIMM

Table 3 — UDIMM Overlay Schema

Block	Range		Description
0	0~63	0x000~0x03F	Base Configuration and DRAM Parameters
1	64~127	0x040~0x07F	Base Configuration and DRAM Parameters
2	128~191	0x080~0x0BF	...
3	192~239	0x0C0~0x0EF	Insert Annex A.0: Common
	240~255	0x0F0~0x0FF	Insert Annex A.2: Unbuffered Memory Module Types
4	256~319	0x100~0x13F	Insert Annex A.2: Unbuffered Memory Module Types
5	320~383	0x140~0x17F	Insert Annex A.2: Unbuffered Memory Module Types
6	384~447	0x180~0x1BF	Insert Annex A.2: Unbuffered Memory Module Types
7~15	448~1023	0x180~0x3FF	...

4.3 RDIMM and LRDIMM Overlay Schema

Key Byte 2 contains value 0x12 (DDR5)

Key Byte 3 contains any of the following values:

- 0x01, RDIMM
- 0x04, LRDIMM

Table 4 — RDIMM and LRDIMM Overlay Schema

Block	Range		Description
0	0~63	0x000~0x03F	Base Configuration and DRAM Parameters
1	64~127	0x040~0x07F	Base Configuration and DRAM Parameters
2	128~191	0x080~0x0BF	...
3	192~239	0x0C0~0x0EF	Insert Annex A.0: Common
	240~255	0x0F0~0x0FF	Insert Annex A.3: Registered and Load Reduced Memory Module Types
4	256~319	0x100~0x13F	Insert Annex A.3: Registered and Load Reduced Memory Module Types
5	320~383	0x140~0x17F	Insert Annex A.3: Registered and Load Reduced Memory Module Types
6	384~447	0x180~0x1BF	Insert Annex A.3: Registered and Load Reduced Memory Module Types
7~15	448~1023	0x180~0x3FF	...

4.4 MRDIMM Overlay Schema

Key Byte 2 contains value 0x12 (DDR5)

Key Byte 3 contains any of the following values:

- 0x07, MRDIMM

Table 5 — MRDIMM Overlay Schema

Block	Range		Description
0	0~63	0x000~0x03F	Base Configuration and DRAM Parameters
1	64~127	0x040~0x07F	Base Configuration and DRAM Parameters
2	128~191	0x080~0x0BF	...
3	192~239	0x0C0~0x0EF	Insert Annex A.0: Common
	240~255	0x0F0~0x0FF	Insert Annex A.4: Multiplexed Rank Memory Module Types
4	256~319	0x100~0x13F	Insert Annex A.4: Multiplexed Rank Memory Module Types
5	320~383	0x140~0x17F	Insert Annex A.4: Multiplexed Rank Memory Module Types
6	384~447	0x180~0x1BF	Insert Annex A.4: Multiplexed Rank Memory Module Types
7~15	448~1023	0x180~0x3FF	...

4.5 DDIMM Overlay Schema

Key Byte 2 contains value 0x12 (DDR5)

Key Byte 3 contains any of the following values:

- 0x07, DDIMM

Table 6 — DDIMM Overlay Schema

Block	Range		Description
0	0~63	0x000~0x03F	Base Configuration and DRAM Parameters
1	64~127	0x040~0x07F	Base Configuration and DRAM Parameters
2	128~191	0x080~0x0BF	...
3	192~239	0x0C0~0x0EF	Insert Annex A.0: Common
	240~255	0x0F0~0x0FF	Insert Annex A.5: Differential Memory Module Types
4	256~319	0x100~0x13F	Insert Annex A.5: Differential Memory Module Types
5	320~383	0x140~0x17F	Insert Annex A.5: Differential Memory Module Types
6	384~447	0x180~0x1BF	Insert Annex A.5: Differential Memory Module Types
7~15	448~1023	0x180~0x3FF	...

4.6 NVDIMM-N Overlay Schema

Key Byte 2 contains value 0x12 (DDR5)

Key Byte 3 contains any of the following values:

- 0x9X, NVDIMM-N Hybrid
where X refers to the base memory architecture

Table 7 — NVDIMM-N Overlay Schema

Block	Range		Description
0	0~63	0x000~0x03F	Base Configuration and DRAM Parameters
1	64~127	0x040~0x07F	Base Configuration and DRAM Parameters
2	128~191	0x080~0x0BF	...
3	192~239	0x0C0~0x0EF	Insert Annex A.0: Common
	240~255	0x0F0~0x0FF	Insert Annex A.6: NVDIMM-N Memory Module Types
4	256~319	0x100~0x13F	Insert Annex A.6: NVDIMM-N Memory Module Types
5	320~383	0x140~0x17F	Insert Annex A.6: NVDIMM-N Memory Module Types
6	384~447	0x180~0x1BF	Insert Annex A.6: NVDIMM-N Memory Module Types
7~15	448~1023	0x180~0x3FF	...

4.7 NVDIMM-P Overlay Schema

Key Byte 2 contains value 0x12 (DDR5)

Key Byte 3 contains any of the following values:

- 0xA_X, NVDIMM-P Hybrid
where X refers to the base memory architecture

Table 8 — NVDIMM-P Overlay Schema

Block	Range		Description
0	0~63	0x000~0x03F	Base Configuration and DRAM Parameters
1	64~127	0x040~0x07F	Base Configuration and DRAM Parameters
2	128~191	0x080~0x0BF	...
3	192~239	0x0C0~0x0EF	Insert Annex A.0: Common
	240~255	0x0F0~0x0FF	Insert Annex A.7: NVDIMM-P Memory Module Types
4	256~319	0x100~0x13F	Insert Annex A.7: NVDIMM-P Memory Module Types
5	320~383	0x140~0x17F	Insert Annex A.7: NVDIMM-P Memory Module Types
6	384~447	0x180~0x1BF	Insert Annex A.7: NVDIMM-P Memory Module Types
7~15	448~1023	0x180~0x3FF	...

4.8 CAMM2 Overlay Schema

Key Byte 2 contains value 0x12 (DDR5)

Key Byte 3 contains any of the following values:

- 0x08, CAMM2

Table 9 — CAMM2 Overlay Schema

Block	Range		Description
0	0~63	0x000~0x03F	Base Configuration and DRAM Parameters
1	64~127	0x040~0x07F	Base Configuration and DRAM Parameters
2	128~191	0x080~0x0BF	...
3	192~239	0x0C0~0x0EF	Insert Annex A.0: Common
	240~255	0x0F0~0x0FF	Insert Annex A.8: CAMM2 Memory Module Types
4	256~319	0x100~0x13F	Insert Annex A.8: CAMM2 Memory Module Types
5	320~383	0x140~0x17F	Insert Annex A.8: CAMM2 Memory Module Types
6	384~447	0x180~0x1BF	Insert Annex A.8: CAMM2 Memory Module Types
7~15	448~1023	0x180~0x3FF	...

5 Parsing the SPD

Table 10 — Some Relevant SPD Bytes for Parsing

SPD Byte(s)	Definition
1	SPD revision for the base section of the SPD
2	DRAM interface type presented or emulated
3	Memory module interface type
0~125	Base configuration and DRAM parameters
192	SPD revision for the module specific annex
192~239	Common module parameters
240~445	Module specific parameters
510~511	CRC for bytes 0~509

The system BIOS will acquire information from the SPD in order to properly configure the system's memory controller. It is assumed the BIOS will parse the SPD data in the order listed below.

Step 1: Parse Byte 1 - Verify the SPD contents.

The first step is to verify the validity of the contents of the SPD. Calculate and verify that the 16-bit cyclic redundancy check (CRC) for bytes 0~509 matches the CRC stored in bytes 510~511.

Step 2: Parse Byte 2 - Verify the installed DRAM type is supported.

The first step in parsing the SPD is to verify that the DRAM type installed is supported by looking at DRAM device type byte 2. While it is usually not possible to physically plug in the wrong memory type, for example, a DDR3 module size or key location should prevent insertion into a DDR5 system, there are cases where byte 2 is used to prevent accidental use of an incompatible memory type.

Step 3: Parse Byte 1 - Verify SPD compatibility. See Section 6 - SPD Revision Progression

The SPD revision byte 1 "encoding" nibble may be used to force legacy systems to reject newer modules. This would typically only occur if a critical error were found in SPD encoding that would require a "fix". In this case, as in the case of an unsupported DRAM type, system initialization must be halted immediately.

The SPD revision stored in Byte 1 applies to all information for the module, including base information and module specific information. Each SPD revision exactly defines how many bytes are valid in all other SPD blocks. The number of supported bytes (or bits) may increase from one SPD revision to another within each block as indicated by the "additions" nibble of the SPD revision. For example, an SPD revision 1.3 has more bytes or bits defined than SPD revision 1.2.

This progression of SPD contents is important for the BIOS to DIMM compatibility model. An older system may have a BIOS that only understands SPD revision 1.2 encoding, so if a module is installed that contains revision 1.3 information, the system can accurately interpret all of the historical revision 1.2 information retained in the module that is the subset of the revision 1.3 specification.

5 Parsing the SPD (cont'd)

Similarly, if a module with SPD revision 1.1 information is installed, that same BIOS can interpret all information that was current at the time that SPD 1.1 was defined. Therefore, BIOSes must maintain a knowledge of the active information for each historical SPD revision in order to support older modules.

New in DDR5 SPD contents definition is a separate revision byte for sections of the contents. For example, the revision byte 1 covers only the base configuration information blocks, bytes 0 to 127. There is a separate revision byte for other sections such as the standard module parameters in bytes 192-447. The same scheme of contents and additions nibbles is used in each of these sections to allow forward and backward compatibility. Having separate revision levels in various sections of the SPD contents allows those sections to change independently.

Step 4: Parse Byte 3 - Determine module type and appropriate overlays.

Key byte 3 for module type determines the subsequent use of overlay information. Byte 3 defines the host to module interface style: unbuffered, registered, load reduced, differential, or hybrid. Standard module types are defined in Annexes A.x.

Step 5: Parse Bytes 0~127 - Make base configuration settings to memory interface based on these bytes. All module types are required to read and interpret this block of data to set up the DRAM type, maximum operating frequency, the number of row, column, bank bits, write recovery time, etc. While these bytes primarily describe the timing of the DRAMs, timing represents the capabilities of the module and it may be necessary to downgrade the timing based on other factors including layout or support components on the module, such as registers.

Step 6: Parse Byte 192 - Module-specific annex SPD revision.

This byte determines the encoding level and additions level of the module specific bytes of the SPD. Separating the base section of the SPD and module specific section prevents unnecessary churn; for example, if the UDIMM annex changes, the SPD for RDIMM/LRDIMM module need not change.

Step 7: Parse Bytes 193~447 - Configure standard module memory interface.

These bytes will be referenced and used by the system as needed based on the Standard module type that was determined after Byte 3 was parsed as indicated in Step 2. Bytes 192~239 are common byte definitions for all module types as defined in Annex A.0. Bytes 240~447 are coded differently for each standard module type as defined in Annex A.x.

6 SPD Revision Progression

SPD Contents sections have a revision code for that section of the specification. This allows each section to evolve over time independently as much as possible. For example a system may need to parse one revision level for the Base Configuration section (bytes 0~127) and a different revision level for the Standard Module Parameters section (bytes 192~447).

Table 11 — Hypothetical SPD Revision Progression Showing Revision Relationships

Section	Bytes	Revision Byte
Base Configuration and SDRAM Parameters	0~127	1
Standard Module Parameters	192~447	192

The Additions Level is never reduced even after an increment of the Encoding Level. For example, if the current SPD revision level were 1.2 and a change in Encoding Level were approved, the next revision level would be 2.2. If additions to revision 2.2 were approved, the next revision would be 2.3. Changes in the Encoding Level are extremely rare, however, since they can create incompatibilities with older systems.

The exceptions to the above rule are the SPD revision levels used during development prior to the Revision 1.0 release. Revisions 0.0 through 0.9 are used to indicate sequential pre-production SPD revision levels, however the first production release will be Revision 1.0.

A hypothetical progression is shown to illustrate the relationship between feature updates, typographical error corrections, specification revisions, and dates. In order to reduce the number of module requalifications, policy is to issue SPD releases once per year, typically in June (publication to the JEDEC public site typically takes an additional 3 months from committee approval).

Table 12 — Hypothetical Progression Showing Relationship between Feature Updates, Typo Error Corrections, Spec Revisions, and Dates

Year	Description	Document	Release Date	Base	SPD Byte 1		SPD Byte 192					
					Solder Down	UDIMM	RDIMM/LRDIMM	MRDIMM	DDIMM	NVDIMM-N	NVDIMM-P	
0	Initial SPD document release	JESD400-5	June 2021	1.0	1.0	1.0	1.0	N/A	1.0	0.1	0.1	
0	Typographical fixes	JESD400-5	September 2021	1.0	1.0	1.0	1.0	N/A	1.0	0.1	0.1	
0	Typographical fixes	JESD400-5	December 2021	1.0	1.0	1.0	1.0	N/A	1.0	0.1	0.1	
1	Additions to base, RDIMM Add MRDIMM First release NVDIMM-P Pre-production additions to NVDIMM-N	JESD400-5A	June 2022	1.1	1.0	1.0	1.1	1.0	1.0	0.2	1.0	
1	Typographical fixes	JESD400-5A	September 2022	1.1	1.0	1.0	1.1	1.0	1.0	0.2	1.0	
1	Typographical fixes	JESD400-5A	March 2023	1.1	1.0	1.0	1.1	1.0	1.0	0.2	1.0	
2	Additions to base, RDIMM, DDIMM Additions to NVDIMM-P First release NVDIMM-N	JESD400-5B	June 2023	1.2	1.0	1.0	1.2	1.0	1.1	1.0	1.1	
3	Additions to base	JESD400-5C	June 2024	1.3	1.0	1.0	1.2	1.0	1.1	1.0	1.1	
3	Typographical fixes	JESD400-5C	March 2025	1.3	1.0	1.0	1.2	1.0	1.1	1.0	1.1	
4	Additions to base, NVDIMM-N	JESD400-5D	June 2025	1.4	1.0	1.0	1.2	1.0	1.1	1.1	1.1	

7 Address Map

Table 13 shows the SPD address map for all DDR5 modules. It describes where the individual lookup table entries will be held in the serial non-volatile memory. Consistent with the definition of DDR5 generation SPD devices which have 16 individual write protection blocks of 64 bytes in length each, the SPD contents are aligned with these blocks as follows:

Table 13 — SPD Address Map for DDR5 Modules

Block	Range		Description
0	0~63	0x000~0x03F	Base Configuration and DRAM Parameters
1	64~127	0x040~0x07F	Base Configuration and DRAM Parameters
2	128~191	0x080~0x0BF	Reserved for future use
3	192~239	0x0C0~0x0EF	Common Module Parameters -- See Annex A.0 for details
	240~255	0x0F0~0x0FF	Standard Module Parameters -- See annexes A.x for details
4	256~319	0x100~0x13F	Standard Module Parameters -- See annexes A.x for details
5	320~383	0x140~0x17F	Standard Module Parameters -- See annexes A.x for details
6	384~447	0x180~0x1BF	Standard Module Parameters -- See annexes A.x for details
7	448~509	0x1C0~0x1FD	Reserved for future use
	510~511	0x1FE~0x1FF	CRC for bytes 0~509
8	512~575	0x200~0x23F	Manufacturing Information
9	576~639	0x240~0x27F	Manufacturing Information
10	640~703	0x280~0x2BF	End User Programmable
11	704~767	0x2C0~0x2FF	End User Programmable
12	768~831	0x300~0x33F	End User Programmable
13	832~895	0x340~0x37F	End User Programmable
14	896~959	0x380~0x3BF	End User Programmable
15	960~1023	0x3C0~0x3FF	End User Programmable

After programming the SPD contents, suppliers of JEDEC compliant modules must set the write protect bits for SPD device blocks 0 through 7. See the SPD5118 Device Specification for details on the block protect command protocol.

Beginning with modules supporting JESD400-5 DDR5 SPD Contents Specification Revision 1.1 or higher, write protect must also be asserted after programming on block 8 in addition to write protect on blocks 0 through 7.

Blocks 0~1: Base Configuration and DRAM Parameters

These blocks define the parameters for DDR5 SDRAMs.

Block 2: Reserved for future use

Blocks 3~6: Module Specific Parameters

Bytes 192~447 (0x0C0~0x1BF) parameters in this block are specific to the module type as selected by the contents of SPD Key Byte 3 bits 3~0. Refer to the appropriate annex for detailed byte descriptions.

7 Address Map (cont'd)

Block 7: Reserved for future use

Bytes 448~509 are reserved and must be programmed as 0.

Byte 510 (0x1FE): Cyclical Redundancy Code (CRC) for SPD Bytes 0~509, Least Significant Byte
Byte 511 (0x1FF): Cyclical Redundancy Code (CRC) for SPD Bytes 0~509, Most Significant Byte

This two-byte field contains the calculated CRC for bytes 0~509 (0x000~0x1FD) in the SPD. The following algorithm and data structures (shown in C) are to be followed in calculating and checking the code.

```
int Crc16 (char *ptr, int count)
{
    int crc, i;

    crc = 0;
    while (--count >= 0) {
        crc = crc ^ (int)*ptr++ << 8;
        for (i = 0; i < 8; ++i)
            if (crc & 0x8000)
                crc = crc << 1 ^ 0x1021;
            else
                crc = crc << 1;
    }
    return (crc & 0xFFFF);
}

char spdBytes[] = { SPD_byte_0, SPD_byte_1, ..., SPD_byte_N-1 };
int data16;

data16 = Crc16 (spdBytes, sizeof(spdBytes));
SPD_byte_510 = (char) (data16 & 0xFF);
SPD_byte_511 = (char) (data16 >> 8);
```

7 Address Map (cont'd)

Blocks 8~9: Manufacturing Information

Bytes 512~639 (0x200~0x27F). Table 14 details the location of each byte in this block.

Table 14 — Location of Bytes 512~639 in Blocks 8~9

Byte Number		Function Described	Notes
512	0x200	Module Manufacturer's ID Code, First Byte	1
513	0x201	Module Manufacturer's ID Code, Second Byte	1
514	0x202	Module Manufacturing Location	1
515~516	0x203~0x204	Module Manufacturing Date	1
517~520	0x205~0x208	Module Serial Number	1
521~550	0x209~0x226	Module Part Number	1
551	0x227	Module Revision Code	
552	0x228	DRAM Manufacturer's ID Code, First Byte	1
553	0x229	DRAM Manufacturer's ID Code, Second Byte	1
554	0x22A	DRAM Stepping	
555~637	0x22B~0x27D	Module Manufacturer's Specific Data	
NOTE 1 Required byte			

Blocks 10~15: End User Programmable

Bytes 640~1023 (0x280~0x3FF). Bytes in these blocks are reserved for use by end users. Module manufacturers should not assert write protect on blocks 10~15 unless requested to do so by customers.

7.1 ASCII Decode Matrix for SPDs

Table 15 is a subset of the full ASCII standard which is used for coding bytes in the Serial Presence Detect EEPROM that require ASCII characters:

Table 15 — Subset of Full ASCII Standard

First Hex Digit in Pair	Second Hex Digit in Pair															
	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
2	Blank Space							()				-	Dash	.	Period
3	0	1	2	3	4	5	6	7	8	9						
4		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
5	P	Q	R	S	T	U	V	W	X	Y	Z					Underscore
6		a	b	c	d	e	f	g	h	i	j	k	l	m	n	o
7	p	q	r	s	t	u	v	w	x	y	z					

Examples:

0x20 = Blank Space

0x34 = '4'

0x41 = 'A'

7.1 ASCII Decode Matrix for SPDs (cont'd)

Table 16 — SPD Bytes 521~550

Manufacturer's PN	Coded in ASCII
13M32734BCD-260Y	31334D33323733344243442D323630592020

8 Details of Each Byte

8.1 Blocks 0 and 1: General Configuration Section: Bytes 0~127 (0x000~0x07F)

This clause contains defines parameters that are common to all DDR5 module types with DDR5 SDRAM as the media type, and provides “key bytes” to allow overlay of module specific information. These bytes are defined when Key Byte 2 contains 18 (0x12), DDR5 SDRAM.

Table 17 — Blocks 0 and 1 General Configuration

Byte Number	DDR5 Function Described	Notes
0	Number of Bytes in SPD Device and Beta Level	
1	SPD Revision for Base Configuration Parameters	
2	Key Byte / Host Bus Command Protocol Type	
3	Key Byte / Module Type	
4	First SDRAM Density and Package	1
5	First SDRAM Addressing	1
6	First SDRAM I/O Width	1
7	First SDRAM Bank Groups and Banks Per Bank Group	1
8	Second SDRAM Density and Package	1
9	Second SDRAM Addressing	1
10	Second SDRAM I/O Width	1
11	Second SDRAM Bank Groups and Banks Per Bank Group	1
12	SDRAM BL32 and Post Package Repair	1
13	SDRAM Duty Cycle Adjuster and Partial Array Self Refresh	1
14	SDRAM Per Row Activation Counting, Fault Handling, and Temperature Sense	1
15	Reserved	
16	SDRAM Nominal Voltage, VDD	1
17	SDRAM Nominal Voltage, VDDQ	1
18	SDRAM Nominal Voltage, VPP	1
19	SDRAM Timing	1
20	SDRAM Minimum Cycle Time ($t_{CKAVGmin}$), Least Significant Byte	1
21	SDRAM Minimum Cycle Time ($t_{CKAVGmin}$), Most Significant Byte	1

NOTE 1 From DDR5 SDRAM datasheet.

Table 17 — Blocks 0 and 1 General Configuration (cont'd)

Byte Number	DDR5 Function Described		Notes
22	0x016	SDRAM Maximum Cycle Time ($t_{CKAVGmax}$), Least Significant Byte	1
23	0x017	SDRAM Maximum Cycle Time ($t_{CKAVGmax}$), Most Significant Byte	1
24	0x018	CAS Latencies Supported, First Byte	1
25	0x019	CAS Latencies Supported, Second Byte	1
26	0x01A	CAS Latencies Supported, Third Byte	1
27	0x01B	CAS Latencies Supported, Fourth Byte	1
28	0x01C	CAS Latencies Supported, Fifth Byte	1
29	0x01D	Reserved	1
30	0x01E	SDRAM Read Command to First Data (t_{AA}), Least Significant Byte	1
31	0x01F	SDRAM Read Command to First Data (t_{AA}), Most Significant Byte	1
32	0x020	SDRAM Activate to Read or Write Command Delay (t_{RCD}), Least Significant Byte	1
33	0x021	SDRAM Activate to Read or Write Command Delay (t_{RCD}), Most Significant Byte	1
34	0x022	SDRAM Row Precharge Time (t_{RP}), Least Significant Byte	1
35	0x023	SDRAM Row Precharge Time (t_{RP}), Most Significant Byte	1
36	0x024	SDRAM Activate to Precharge Command Period (t_{RAS}), Least Significant Byte	1
37	0x025	SDRAM Activate to Precharge Command Period (t_{RAS}), Most Significant Byte	1
38	0x026	SDRAM Activate to Activate or Refresh Command Period (t_{RC}), Least Significant Byte	1
39	0x027	SDRAM Activate to Activate or Refresh Command Period (t_{RC}), Most Significant Byte	1
40	0x028	SDRAM Write Recovery Time (t_{WR}), Least Significant Byte	1
41	0x029	SDRAM Write Recovery Time (t_{WR}), Most Significant Byte	1
42	0x02A	SDRAM Normal Refresh Recovery Time (t_{RFC1}, t_{RFC1_slr}), Least Significant Byte	1
43	0x02B	SDRAM Normal Refresh Recovery Time (t_{RFC1}, t_{RFC1_slr}), Most Significant Byte	1
44	0x02C	SDRAM Fine Granularity Refresh Recovery Time (t_{RFC2}, t_{RFC2_slr}), Least Significant Byte	1
45	0x02D	SDRAM Fine Granularity Refresh Recovery Time (t_{RFC2}, t_{RFC2_slr}), Most Significant Byte	1
46	0x02E	SDRAM Same Bank Refresh Recovery Time (t_{RFCsb}, t_{RFCsb_slr}), Least Significant Byte	1
47	0x02F	SDRAM Same Bank Refresh Recovery Time (t_{RFCsb_dlr}), Most Significant Byte	1
48	0x030	SDRAM Normal Refresh Recovery Time, 3DS Different Logical Rank (t_{RFC1_dlr}), Least Significant Byte	1
49	0x031	SDRAM Normal Refresh Recovery Time, 3DS Different Logical Rank (t_{RFC1_dlr}), Most Significant Byte	1
50	0x032	SDRAM Fine Granularity Refresh Recovery Time, 3DS Different Logical Rank (t_{RFC2_dlr}), Least Significant Byte	1

NOTE 1 From DDR5 SDRAM datasheet.

Table 17 — Blocks 0 and 1 General Configuration (cont'd)

Byte Number		DDR5 Function Described	Notes
51	0x033	SDRAM Fine Granularity Refresh Recovery Time, 3DS Different Logical Rank (t_{RFC2_dlr}), Most Significant Byte	1
52	0x034	SDRAM Same Bank Refresh Recovery Time, 3DS Different Logical Rank (t_{RFCsb_dlr}), Least Significant Byte	1
53	0x035	SDRAM Same Bank Refresh Recovery Time, 3DS Different Logical Rank (t_{RFCsb_dlr}), Most Significant Byte	1
54	0x036	SDRAM Refresh Management, First Byte, First SDRAM	1
55	0x037	SDRAM Refresh Management, Second Byte, First SDRAM	1
56	0x038	SDRAM Refresh Management, First Byte, Second SDRAM	1
57	0x039	SDRAM Refresh Management, Second Byte, Second SDRAM	1
58	0x03A	SDRAM Adaptive Refresh Management Level A, First Byte, First SDRAM	1
59	0x03B	SDRAM Adaptive Refresh Management Level A, Second Byte, First SDRAM	1
60	0x03C	SDRAM Adaptive Refresh Management Level A, First Byte, Second SDRAM	1
61	0x03D	SDRAM Adaptive Refresh Management Level A, Second Byte, Second SDRAM	1
62	0x03E	SDRAM Adaptive Refresh Management Level B, First Byte, First SDRAM	1
63	0x03F	SDRAM Adaptive Refresh Management Level B, Second Byte, First SDRAM	1
64	0x040	SDRAM Adaptive Refresh Management Level B, First Byte, Second SDRAM	1
65	0x041	SDRAM Adaptive Refresh Management Level B, Second Byte, Second SDRAM	1
66	0x042	SDRAM Adaptive Refresh Management Level C, First Byte, First SDRAM	1
67	0x043	SDRAM Adaptive Refresh Management Level C, Second Byte, First SDRAM	1
68	0x044	SDRAM Adaptive Refresh Management Level C, First Byte, Second SDRAM	1
69	0x045	SDRAM Adaptive Refresh Management Level C, Second Byte, Second SDRAM	1
70	0x046	SDRAM Activate to Activate Command Delay for Same Bank Group (t_{RRD_L}), Least Significant Byte	1
71	0x047	SDRAM Activate to Activate Command Delay for Same Bank Group (t_{RRD_L}), Most Significant Byte	1
72	0x048	SDRAM Activate to Activate Command Delay for Same Bank Group (t_{RRD_L}), Lower Clock Limit	1
73	0x049	SDRAM Read to Read Command Delay for Same Bank Group (t_{CCD_L}), Least Significant Byte	1
74	0x04A	SDRAM Read to Read Command Delay for Same Bank Group (t_{CCD_L}), Most Significant Byte	1
75	0x04B	SDRAM Read to Read Command Delay for Same Bank Group (t_{CCD_L}), Lower Clock Limit	1
76	0x04C	SDRAM Write to Write Command Delay for Same Bank Group ($t_{CCD_L_WR}$), Least Significant Byte	1
77	0x04D	SDRAM Write to Write Command Delay for Same Bank Group ($t_{CCD_L_WR}$), Most Significant Byte	1
78	0x04E	SDRAM Write to Write Command Delay for Same Bank Group ($t_{CCD_L_WR}$), Lower Clock Limit	1
79	0x04F	SDRAM Write to Write Command Delay for Same Bank Group, Second Write not RMW ($t_{CCD_L_WR2}$), Least Significant Byte	1

NOTE 1 From DDR5 SDRAM datasheet.

Table 17 — Blocks 0 and 1 General Configuration (cont'd)

Byte Number		DDR5 Function Described	Notes
80	0x050	SDRAM Write to Write Command Delay for Same Bank Group, Second Write not RMW ($t_{CCD_L_WR2}$), Most Significant Byte	1
81	0x051	SDRAM Write to Write Command Delay for Same Bank Group, Second Write not RMW ($t_{CCD_L_WR2}$), Lower Clock Limit	1
82	0x052	SDRAM Four Activate Window (t_{FAW}), Least Significant Byte	1
83	0x053	SDRAM Four Activate Window (t_{FAW}), Most Significant Byte	1
84	0x054	SDRAM Four Activate Window (t_{FAW}), Lower Clock Limit	1
85	0x055	SDRAM Write to Read Command Delay for Same Bank Group ($t_{CCD_L_WTR}$), Least Significant Byte	1
86	0x056	SDRAM Write to Read Command Delay for Same Bank Group ($t_{CCD_L_WTR}$), ($t_{CCD_L_WTR}$), Most Significant Byte	1
87	0x057	SDRAM Write to Read Command Delay for Same Bank Group ($t_{CCD_L_WTR}$), Lower Clock Limit	1
88	0x058	SDRAM Write to Read Command Delay for Different Bank Group ($t_{CCD_S_WTR}$), Least Significant Byte	1
89	0x059	SDRAM Write to Read Command Delay for Different Bank Group ($t_{CCD_S_WTR}$), Most Significant Byte	1
90	0x05A	SDRAM Write to Read Command Delay for Different Bank Group, ($t_{CCD_S_WTR}$), Lower Clock Limit	1
91	0x05B	SDRAM Read to Precharge Command Delay (t_{RTP} , t_{RTP_slr}), Least Significant Byte	1
92	0x05C	SDRAM Read to Precharge Command Delay (t_{RTP} , t_{RTP_slr}), Most Significant Byte	1
93	0x05D	SDRAM Read to Precharge Command Delay (t_{RTP} , t_{RTP_slr}), Lower Clock Limit	1
94	0x05E	SDRAM Read to Read Command Delay for Different Bank in Same Bank Group (t_{CCD_M}), Least Significant Byte	1
95	0x05F	SDRAM Read to Read Command Delay for Different Bank in Same Bank Group (t_{CCD_M}), Most Significant Byte	1
96	0x060	SDRAM Read to Read Command Delay for Different Bank in Same Bank Group (t_{CCD_M}), Lower Clock Limit	1
97	0x061	SDRAM Write to Write Command Delay for Different Bank in Same Bank Group ($t_{CCD_M_WR}$), Least Significant Byte	1
98	0x062	SDRAM Write to Write Command Delay for Different Bank in Same Bank Group ($t_{CCD_M_WR}$), Most Significant Byte	1
99	0x063	SDRAM Write to Write Command Delay for Different Bank in Same Bank Group ($t_{CCD_M_WR}$), Lower Clock Limit	1
100	0x064	SDRAM Write to Read Command Delay for Same Bank Group ($t_{CCD_M_WTR}$), Least Significant Byte	1
101	0x065	SDRAM Write to Read Command Delay for Same Bank Group ($t_{CCD_M_WTR}$), Most Significant Byte	1
102	0x066	SDRAM Write to Read Command Delay for Same Bank Group ($t_{CCD_M_WTR}$), Lower Clock Limit	1
103~127	0x067~0x07F	Reserved -- must be coded as 0x00	

NOTE 1 From DDR5 SDRAM datasheet.

8.1.1 (DDR5): Byte 0 (0x000): Number of Bytes in SPD Device and Beta Level

The least significant nibble of this byte describes the total number of bytes used by the module manufacturer for the SPD data and any (optional) specific supplier information. The byte count includes the fields for all required and optional data. Bits 6~4 describe the total size of the serial memory used to hold the Serial Presence Detect data. Bits 7,3~0 define the Beta Level of the SPD encoding.

Table 18 — Number of Bytes in SPD Device

Bit 7	Bits 6~4	Bits 3~0
Beta Level 4	SPD Bytes Total	Beta Level 3~0
See bits 3~0	000: Undefined 001: 256 010: 512 011: 1024 (e.g., SPD5118) 100: 2048 (e.g., ESPD5216) All others reserved	Bits 7,3~0: Beta Level Values 0 to 31
NOTE The 5-bit Beta Level field (bit 7 and bits 3~0) is the incremental documentation release level to track changes between major external publications of the SPD Contents specification, typically done once per year. This value shall be reset to 00000 upon each external release and will be visible only to JEDEC members between releases. The Beta Level applies to all sections of the document, including DRAM and module annex sections.		

8.1.2 (DDR5): Byte 1 (0x001): SPD Revision for Base Configuration Parameters

Base SPD revision 1.2, code as 0x12

This byte describes the compatibility level of the encoding of the bytes contained in the SPD EEPROM, and the current collection of valid defined bytes. Software should examine the upper nibble (Encoding Level) to determine if it can correctly interpret the contents of the module SPD. The lower nibble (Additions Level) can optionally be used to determine which additional bytes or attribute bits have been defined; however, since any undefined additional byte must be encoded as 0x00 or undefined attribute bit must be defined as 0, software can safely detect additional bytes and use safe defaults if a zero encoding is read for these bytes.

Table 19 — SPD Revision for Base Configuration Parameters

Production Status	SPD Revision	Encoding Level				Additions Level				Hex
		Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	
Pre-production	Revision 0.0	0	0	0	0	0	0	0	0	00
	Revision 0.1	0	0	0	0	0	0	0	1	01

	Revision 0.9	0	0	0	0	1	0	0	1	09
Production	Revision 1.0	0	0	0	1	0	0	0	0	10
	Revision 1.1	0	0	0	1	0	0	0	1	11

Undefined	Undefined	1	1	1	1	1	1	1	1	FF

8.1.2 (DDR5): Byte 1 (0x001): SPD Revision for Base Configuration Parameters (cont'd)

The Additions Level is never reduced even after an increment of the Encoding Level. For example, if the current SPD revision level were 1.2 and a change in Encoding Level were approved, the next revision level would be 2.2. If additions to revision 2.2 were approved, the next revision would be 2.3. Changes in the Encoding Level are extremely rare, however, since they can create incompatibilities with older systems.

The exceptions to the above rule are the SPD revision levels used during development prior to the Revision 1.0 release. Revisions 0.0 through 0.9 are used to indicate sequential pre-production SPD revision levels, however the first production release will be Revision 1.0.

Revisions for each module specific overlay are coded in the same format so that each module type can evolve over time independent of the base configuration parameters section.

The Beta Level (SPD byte 0, bits 7,3~0) may also be used to decode changes made since the last external publication of the SPD Contents.

8.1.3 (DDR5): Byte 2 (0x002): Key Byte / Host Bus Command Protocol Type

This byte is the key byte used by the system BIOS to determine how to interpret all other bytes in the SPD EEPROM. The BIOS must check this byte first to ensure that the EEPROM data is interpreted correctly. This command protocol is often based on the interface parameters for a specific memory device such as a DDR5 SDRAM, however may also be a general media interface protocol such as DDR5 NVDIMM-P. Protocol extensions such as the use of registers or data buffers must be documented in Byte 3, the Module Type byte, and such differences comprehended and accounted for by the system and memory controller. Some non-DRAM solutions called "Hybrid" use an extension of a DRAM bus protocol, such as NVDIMM-N, and use the code for the emulated DRAM protocol in this byte, such as DDR4 SDRAM.

Table 20 — Key Byte / Host Bus Command Protocol Type

Line #	Hex	SDRAM / Module Type Corresponding to Key Byte
0	00	Reserved
1	01	Fast Page Mode
2	02	EDO
3	03	Pipelined Nibble
4	04	SDRAM
5	05	ROM
6	06	DDR SGRAM
7	07	DDR SDRAM
8	08	DDR2 SDRAM
9	09	DDR2 SDRAM FB-DIMM
10	0A	DDR2 SDRAM FB-DIMM PROBE
11	0B	DDR3 SDRAM
12	0C	DDR4 SDRAM
13	0D	Reserved
14	0E	DDR4E SDRAM
15	0F	LPDDR3 SDRAM
16	10	LPDDR4 SDRAM
17	11	LPDDR4X SDRAM
18	12	DDR5 SDRAM
19	13	LPDDR5 SDRAM
20	14	DDR5 NVDIMM-P
21	15	LPDDR5X SDRAM
-	-	-
253	FD	Reserved
254	FE	Reserved
255	FF	Reserved

8.1.4 (DDR5): Byte 3 (0x003): Key Byte / Module Type

This byte is a Key Byte used to index the module specific section of the SPD from bytes 512~639. Byte 3 bits 3~0 identifies the SDRAM memory module type, and bits 7~4 describe hybrid memory extensions.

Some modules may have no base memory, but will have only a secondary memory type. For example, a Flash-only memory module. These are classified as “hybrid” for the purposes of interpreting the SPD. Where base memory parameters apply to this class of hybrid module, these will be documented with those bytes in the base section.

Table 21 — Key Byte / Module Type

Bit 7	Bits 6~4	Bits 3~0
Hybrid	Hybrid Media	Base Module Type
0: Not hybrid (Module is DRAM only) 1: Hybrid module (See bits 6~4 for hybrid type)	000: Not hybrid 001: NVDIMM-N Hybrid 010: NVDIMM-P Hybrid All other codes reserved	0000: Reserved 0001: RDIMM 0010: UDIMM 0011: SODIMM 0100: LRDIMM 0101: CUDIMM 0110: CSODIMM 0111: MRDIMM 1000: CAMM2 1001: Reserved 1010: DDIMM 1011: Solder down 1100: Reserved 1101: Reserved 1110: Reserved 1111: Reserved

Base Module Type Definitions:
Solder down: Direct attachment to memory controller
RDIMM: Registered Dual In-Line Memory Module
UDIMM: Unbuffered Dual In-Line Memory Module
SODIMM: Unbuffered Small Outline Dual In-Line Memory Module
CUDIMM: Clocked Unbuffered Dual In-Line Memory Module
CSODIMM: Clocked Small Outline Dual In-Line Memory Module
LRDIMM: Load Reduced Dual In-Line Memory Module
MRDIMM: Multiplexed Rank Dual In-Line Memory Module
CAMM2: Compression Attached Memory Module
DDIMM: Differential Dual In-Line Memory Module

Hybrid Memory Type Definitions:
NVDIMM-N: Non-Volatile Dual In-Line Memory Module, Hybrid module with a DDR5 SDRAM interface with one or more non-DRAM components for data storage
NVDIMM-P: Non-Volatile Dual In-Line Memory Module, Hybrid module with a DDR5 NVDIMM-P interface with one or more non-DRAM components for data storage

Examples:

- 0x01: RDIMM, no hybrid memory present
- 0x91: RDIMM, NVDIMM-N hybrid memory present
- 0x94: LRDIMM, NVDIMM-N hybrid memory present
- 0x0B = soldered down memory, no hybrid memory present

8.1.5 (DDR5): Byte 4 (0x004): First SDRAM Density and Package

This byte describes the SDRAM package type, loading as seen by the system, and device density in Gbits. These values come from the DDR5 SDRAM data sheet, JESD79-5. This byte applies to the even rank SDRAMs for asymmetrical memory configurations, or for all SDRAMs for symmetrical configurations.

Table 22 — First SDRAM Density and Package

Bits 7~5	Bits 4~0
Die Per Package	SDRAM Density Per Die
000: 1 die; Monolithic SDRAM	00000: No memory; not defined
001: 2 die; Dual-die package (DDP)	00001: 4 Gb
010: 2 die; 2H 3DS	00010: 8 Gb
011: 4 die; 4H 3DS	00011: 12 Gb
100: 8 die; 8H 3DS	00100: 16 Gb
101: 16 die; 16H 3DS	00101: 24 Gb
All others reserved	00110: 32 Gb
	00111: 48 Gb
	01000: 64 Gb
	All others reserved

8.1.6 (DDR5): Byte 5 (0x005): First SDRAM Addressing

This byte describes the number SDRAM column and row address bits. These values come from the DDR5 SDRAM data sheet, JESD79-5. This byte applies to the even rank SDRAMs for asymmetrical memory configurations, or for all SDRAMs for symmetrical configurations.

Table 23 — First SDRAM Addressing

Bits 7~5	Bits 4~0
First SDRAM Column Address Bits	First SDRAM Row Address Bits
000: 10 columns	00000: 16 rows
001: 11 columns	00001: 17 rows
All others reserved	00010: 18 rows
	All others reserved

8.1.7 (DDR5): Byte 6 (0x006): First SDRAM I/O Width

This byte describes the number SDRAM I/O bits (DQ) and the number of bank groups. These values come from the DDR5 SDRAM data sheet, JESD79-5. This byte applies to the even rank SDRAMs for asymmetrical memory configurations, or for all SDRAMs for symmetrical configurations.

Table 24 — First SDRAM I/O Width

Bits 7~5	Bits 4~0
SDRAM I/O Width	Reserved
000: x4 001: x8 010: x16 011: x32 All others reserved	Reserved; must be coded as 00000

8.1.8 (DDR5): Byte 7 (0x007): First SDRAM Bank Groups and Banks Per Bank Group

This byte describes the number SDRAM banks per bank group. These values come from the DDR5 SDRAM data sheet, JESD79-5. This byte applies to the even rank SDRAMs for asymmetrical memory configurations, or for all SDRAMs for symmetrical configurations.

Table 25 — First SDRAM Bank Groups and Banks Per Bank Group

Bits 7~5	Bits 4~3	Bits 2~0
First SDRAM Bank Groups	Reserved	First SDRAM Banks Per Bank Group
000: 1 bank group 001: 2 bank groups 010: 4 bank groups 011: 8 bank groups All others reserved	Reserved; must be coded as 00	000: 1 bank per bank group 001: 2 banks per bank group 010: 4 banks per bank group All others reserved

8.1.9 (DDR5): Byte 8 (0x008): Second SDRAM Density and Package

This byte describes the SDRAM package type, loading as seen by the system, and device density in Gbits. These values come from the DDR5 SDRAM data sheet, JESD79-5. This byte applies to the odd rank SDRAMs for asymmetrical memory configurations only.

Table 26 — Second SDRAM Density and Package

Bits 7~5	Bits 4~0
Die Per Package	SDRAM Density Per Die
000: 1 die; Monolithic SDRAM	00000: No memory; not defined
001: 2 die; Dual-die package (DDP)	00001: 4 Gb
010: 2 die; 2H 3DS	00010: 8 Gb
011: 4 die; 4H 3DS	00011: 12 Gb
100: 8 die; 8H 3DS	00100: 16 Gb
101: 16 die; 16H 3DS	00101: 24 Gb
All others reserved	00110: 32 Gb
	00111: 48 Gb
	01000: 64 Gb
	All others reserved
NOTE This byte is defined only for asymmetrical memory systems; for symmetrical systems this byte must be coded as 0x00.	

8.1.10 (DDR5): Byte 9 (0x009): Second SDRAM Addressing

This byte describes the number SDRAM column and row address bits. These values come from the DDR5 SDRAM data sheet, JESD79-5. This byte describes the number SDRAM bank groups. These values come from the DDR5 SDRAM data sheet, JESD79-5. This byte applies to the odd rank SDRAMs for asymmetrical memory configurations only.

Table 27 — Second SDRAM Addressing

Bits 7~5	Bits 4~0
Second SDRAM Column Address Bits	Second SDRAM Row Address Bits
000: 10 columns	00000: 16 rows
001: 11 columns	00001: 17 rows
All others reserved	00010: 18 rows
	All others reserved
NOTE This byte is defined only for asymmetrical memory systems; for symmetrical systems this byte must be coded as 0x00.	

8.1.11 (DDR5): Byte 10 (0x00A): Secondary SDRAM I/O Width

This byte describes the number SDRAM I/O bits (DQ) and the number of bank groups. These values come from the DDR5 SDRAM data sheet, JESD79-5. This byte applies to the odd rank SDRAMs for asymmetrical memory configurations only.

Table 28 — Second SDRAM I/O Width

Bits 7~5	Bits 4~0
SDRAM I/O Width	Reserved
000: x4 001: x8 010: x16 011: x32	Reserved; must be coded as 00000
All others reserved	
NOTE This byte is defined only for asymmetrical memory systems; for symmetrical systems this byte must be coded as 0x00.	

8.1.12 (DDR5): Byte 11 (0x00B): Second SDRAM Bank Groups and Banks Per Bank Group

This byte describes the number SDRAM banks per bank group. These values come from the DDR5 SDRAM data sheet, JESD79-5. This byte applies to the odd rank SDRAMs for asymmetrical memory configurations only.

Table 29 — Second SDRAM Bank Groups and Banks Per Bank Group

Bits 7~5	Bits 4~3	Bits 2~0
Second SDRAM Bank Groups	Reserved	Second SDRAM Banks Per Bank Group
000: 1 bank group 001: 2 bank groups 010: 4 bank groups 011: 8 bank groups	Reserved; must be coded as 00	000: 1 bank per bank group 001: 2 banks per bank group 010: 4 banks per bank group
All others reserved		All others reserved
NOTE This byte is defined only for asymmetrical memory systems; for symmetrical systems this byte must be coded as 0x00.		

8.1.13 (DDR5): Byte 12 (0x00C): SDRAM BL32 and Post Package Repair

This byte defines support for SDRAM features for burst length 32 (BL32) support and post package repair (PPR). These values come from the DDR5 SDRAM data sheet, JESD79-5.

Table 30 — SDRAM BL32 and Post Package Repair Features

Bit 7	Bit 6	Bit 5	Bit 4
sPPR Granularity	Reserved	sPPR Undo/Lock	BL32
0 = One repair element per bank group 1 = One repair element per bank	Reserved; must be coded as 0	0: sPPR Undo/Lock not supported 1: sPPR Undo/Lock supported	0: Burst length 32 not supported 1: Burst length 32 supported
Bits 3~2		Bit 1	Bit 0
Reserved		MBIST/mPPR	Reserved
Reserved; must be coded as 00		0: MBIST/mPPR not supported 1: MBIST/mPPR supported	Reserved; must be coded as 0
NOTES: MBIST = Memory Built-In Self Test PPR = Post Package Repair hPPR = Hard PPR sPPR = Soft PPR mPPR = MBIST PPR			

8.1.14 (DDR5): Byte 13 (0x00D): SDRAM Duty Cycle Adjuster and Partial Array Self Refresh

This byte describes the options for the DDR5 SDRAM duty cycle adjuster (DCA).

Table 31 — SDRAM Duty Cycle Adjuster

Bits 7~5	Bit 4	Bits 3~2	Bits 1~0
Reserved	PASR	Reserved	DCA Types Supported
Reserved; must be coded as 000	0: PASR not supported 1: PASR supported	Reserved; must be coded as 00	00 = Device does not support DCA 01 = Device supports DCA for single/ 2-phase internal clock(s) 10 = Device supports DCA for 4-phase internal clock(s) 11 = Reserved
NOTES: PASR = Partial Array Self Refresh DCA = Duty Cycle Adjuster			

8.1.15 (DDR5): Byte 14 (0x00E): SDRAM Per Row Activation Counting, Fault Handling, and Temperature Sense

This byte defines support for a variety of SDRAM features: Per Row Activation Counting (PRAC), Alert Back-Off (ABO), ALERT_n Verification, wide on-die temperature sensing range, writeback suppression, and bounded fault. These values comes from the DDR5 SDRAM data sheet, JESD79-5 which also documents the mode registers (MRs).

Table 32 — SDRAM Per Row Activation Counting, Fault Handling, and Temperature Sense

SDRAM Per Row Activation Counting, Fault Handling, and Temperature Sense			
Bits 7~5		Bit 4	
Reserved		PRAC and ABO	
Reserved; must be coded as 000			0: PRAC and ABO not supported 1: PRAC and ABO supported
Bit 3	Bit 2	Bit 1	Bit 0
Wide Temperature Sense	x4 RMW/ECS Writeback Suppression	x4 RMW/ECS Writeback Suppression MR Selector	Bounded Fault
0: Wide temperature sense and reporting not supported 1: Wide temperature sense and reporting supported	0: Writeback suppression not supported 1: Writeback suppression supported	0: Writeback suppression control in MR9 1: Writeback suppression control in MR15	0: Bounded Fault not supported 1: Bounded Fault supported
NOTES: ECS = Error Check Scrub RMW = Read-Modify-Write MR = Mode Register PRAC, ABO: See MR70 Wide temperature range: See MR4 Writeback suppression: See MR9, MR14, MR15 Bounded fault: See MR14			

8.1.16 (DDR5): Byte 15 (0x00F): Reserved

Reserved; must be coded as 0x00.

8.1.17 (DDR5): Byte 16 (0x010): SDRAM Nominal Voltage, VDD

This byte describes the voltage levels for the SDRAM VDD supply only.

'Operable' is defined as the VDD voltage at which module operation is allowed using the performance values programmed in the SPD.

'Endurant' is defined as the VDD voltage at which the module may be powered without adversely affecting the life expectancy or reliability. Operation is not supported at this voltage.

Table 33 — SDRAM Nominal Voltage, VDD

Nominal	Operable	Endurant
Bits 7~4	Bits 3~2	Bits 1~0
0000: 1.1 V All others reserved	00: 1.1 V All others reserved	00: 1.1 V All others reserved

8.1.18 (DDR5): Byte 17 (0x011): SDRAM Nominal Voltage, VDDQ

This byte describes the voltage levels for the SDRAM VDDQ supply only.

'Operable', 'Endurant': See byte 16.

Table 34 — SDRAM Nominal Voltage, VDDQ

Nominal	Operable	Endurant
Bits 7~4	Bits 3~2	Bits 1~0
0000: 1.1 V All others reserved	00: 1.1 V All others reserved	00: 1.1 V All others reserved

8.1.19 (DDR5): Byte 18 (0x012): SDRAM Nominal Voltage, VPP

This byte describes the voltage levels for the SDRAM VPP supply only.

'Operable', 'Endurant': See byte 16.

Table 35 — SDRAM Nominal Voltage, VPP

Nominal	Operable	Endurant
Bits 7~4	Bits 3~2	Bits 1~0
0000: 1.8 V All others reserved	00: 1.8 V All others reserved	00: 1.8 V All others reserved

8.1.20 (DDR5): Byte 19 (0x013): SDRAM Timing

This byte describes whether the SDRAM uses only standard core timings per JESD79-5, or non-standard timings for markets such as overclocking systems. Core timings refer to tCKmin, tAAmin, tRCDmin, and tRPmin. This information assists in determining the most robust algorithm for calculating valid CAS latency settings.

Table 36 — SDRAM Timing

Reserved	Non-Standard Core Timing
Bits 7~1	Bit 0
Reserved; must be coded as 0000000	0 = SDRAM uses standard core timings per JESD79-5 1 = SDRAM supports non-standard core timings

Timebases

Timebases in the DDR5 SPD are simplified compared to previous generations. Timing for parameters is expressed in either picosecond (ps) or nanosecond (ns) units. When programming memory controllers, it is often necessary to convert these timings to integer numbers of clocks (nCK) units. The algorithm for this conversion is described next.

Algorithms for Converting Time-based Parameters to Clock Counts

DDR5 SDRAM timing parameters are typically expressed in time units such as ns or ps, however digital logic design requires that these parameters be converted to a fixed number of clock periods “nCK” at the application frequency. The primary algorithm for this conversion is called the Rounding Algorithm, and it accounts for factors including errors caused by rounding and by digital integer expression or math calculation accuracy. The Rounding Algorithm is used for most parameters such as tRCDmin, tRCmin, tRFCmin, etc. A separate conversion called the CL Algorithm is defined specifically for determination of valid CAS Latency settings and accounts for factors including even latency requirements and unsupported CL settings.

The DDR5 SDRAM data sheet, JESD79-5, defines a baseline setting for timing that is common across vendors. However, specific devices in the industry may exceed the baseline timings for target markets such as point-to-point or overclocker systems. For these devices, the CL Algorithm may not apply, so specific rules are defined for determining valid CL settings. For non-standard SDRAMs, the memory supplier is expected to test for the additional boundary conditions created.

The guidelines for calculating CAS Latency are as follows:

- If Non-standard Core Timing (SPD byte 19 bit 0) = 0 (i.e., the DRAM supports all JEDEC standard core timings), the preferred method for calculating valid CAS Latency settings is to use the CL Algorithm as it accounts for operation across a broad range of data rates including full speed or downbinning.
- Systems may prefer to use other methods to calculate CAS Latency settings, including applying the Rounding Algorithm on tAAmin (SPD bytes 30~31) to determine the desired CL setting, rounding up if necessary to ensure that only even nCK values are used, and applying the CAS Latency Mask (SPD bytes 24~28) to find a supported CL setting. If Non-standard Core Timing (SPD byte 19 bit 0) = 1, the DRAM may support one or more exceptions or extensions of JEDEC standard core timings in which case other methods such as the Rounding Algorithm method described here are preferred to the CL Algorithm. Contact the memory supplier for details on supported CAS Latency conditions and recommended practices.

Rounding Algorithm

Software algorithms for calculation of timing parameters are subject to rounding errors from many sources. For example, a system may use a memory clock with a nominal frequency of 2200 MHz (4400 MT/s) for the DDR5-4400 speed bin, which mathematically yields a nominal clock period tCK(AVG) of 0.454545... ns. In most cases, it is impossible to express all digits after the decimal point exactly, and rounding must be used. The DDR5 SDRAM specification establishes a minimum granularity for timing parameters of 1 ps.

Rounding Algorithm (cont'd)

Rules for rounding must be defined to allow optimization of device performance without violating device parameters. All timing parameters specified in the time domain (ns, ps, etc.) which must then be converted to the clock domain (nCK units) shall be defined to align with these rules. The key point is, minimum and maximum timing parameter values shall generally use the same rounding rules used to define tCK(AVG)min and tCK(AVG)max. The resulting rounding algorithms rely on results that are within correction factors of device testing and specification to avoid losing performance due to rounding errors. These rules are:

- **DEFINING TIMING PARAMETER VALUES**: Minimum and maximum timing parameter values, including tCK(AVG)min and tCK(AVG)max, are to be rounded down and defined to 1 ps of accuracy in the DDR5 SDRAM specification based on the non-rounded nominal tCK(AVG) for a given speed bin. If the nominal timing parameter values require more than 1 ps of accuracy, they can be rounded down (faster) to the next 1 ps according to the rounding algorithms, and the DDR5 SDRAM is responsible for absorbing this the resulting small parameter extensions. In other words, the DDR5 SDRAM specification only lists the nominal parameter values rounded down to the next 1 ps. For example, this extends the DDR5-4400 tCK(AVG)min definition to be exactly 0.454 ns which is slightly smaller (faster) than the nominal memory clock period of 0.454545... ns by less than 1 ps.
- **CALCULATING THE REAL MINIMUM TIMING PARAMETER VALUES**: For minimum timing parameters, other than tCK(AVG)min, to avoid losing performance due to additional erroneous nCKs and to calculate the true real minimum values, their nominal values listed in the DDR5 SDRAM specification must be reduced (faster) by the maximum %error (correction factor) used to define tCK(AVG)min. The DDR5 SDRAM is responsible for absorbing the resulting small parameter extensions. For example, tWRmin has a nominal value of 30.000 ns, however, applying the 0.30% correction factor allows a more aggressive timing (for example, 29.910 ns) to be supported, which allows the intended smaller (faster) nCK value to be maintained when rounding tCK(AVG)min down to the next 1 ps. Note, parameter values defined to be 0 ps do not need to be reduced by a correction factor, and therefore do not require these rounding algorithms.
- **CALCULATING THE REAL MAXIMUM TIMING PARAMETER VALUES**: For maximum timing parameters, including tCK(AVG)max, to avoid losing performance due to excluding erroneous nCKs and to calculate the true real maximum values, their nominal values listed in the DDR5 SDRAM specification must be increased (slower) by the maximum %error caused by rounding tCK(AVG) down to the next 1 ps. The DDR5 SDRAM is responsible for absorbing the resulting small parameter extensions. For example, tREFI_{max} has a nominal value of 3.9 μ s. And the DDR5-8400 speed bin mathematically yields a nominal clock period tCK(AVG) of 0.238095... ns, resulting in a theoretical maximum %error of 0.42% (0.239 ns/0.238 ns-100%). So the true real tREFI_{max} value is 3.916386... μ s (3.9 μ s * 0.239 ns/0.238 ns) for the DDR5-8400 speed bin.
- **ROUNDING ALGORITHM FOR MINIMUM TIMING PARAMETER VALUES**: Round down only integer number math is commonly used in the industry to calculate nCK values. This rounding algorithm for minimum timing parameters uses scaling by 1000 to allow use of integer math. Nominal minimum timing parameters like tWRmin, tRCDmin, etc., which are programmed in systems in numbers of clocks (nCK) but expressed in units of time-(ps), are rounded down to the next 1 ps, multiplied by the scaled inverse correction factor (1000 - 3 = 997) prior to division by the application memory clock period rounded down to the next 1 ps, and adding 1 scaled by 1000 to that result effectively adds 1 nCK. Division by 1000 undoes the scaling effects, resulting in a number of clocks as the final answer which has been effectively rounded up to the next 1 nCK by adding 1 nCK in the previous step and then rounding down to the next 1 nCK. The caveat is, effectively adding 1 prior to rounding down is mostly equivalent to rounding up except when the result is equal to an integer in which case the result will not be rounded down as intended, and therefore performance would be lost.

Rounding Algorithm (cont'd)

To address this, the maximum 0.28% correction factor needed for 3600 MHz (0.277 ns/0.277777...ns-100%) operation has been increased slightly to 0.30% in this rounding algorithm. This accounts for all integer boundary conditions, except for the specific case when the nominal minimum timing parameter value is defined to be 0 ps. No rounding is required for parameter values equal to 0 ps. This rounding algorithm is not optimized for parameter values that are less than or equal to 0 ps, and may result in unintended lost performance if used for parameter values that are less than or equal to 0 ps.

$$nCK[\min_parameter] = \text{truncate} \left\{ \frac{\left(\frac{\text{truncate}[\text{nominal_min_parameter_in_ps}] \times 997}{\text{truncate}[tCK(\text{AVG})\text{real_in_ps}]} \right) + 1000}{1000} \right\}$$

- **ROUNDING ALGORITHM FOR MAXIMUM TIMING PARAMETER VALUES:** Round down only integer number math is commonly used in the industry to calculate nCK values. This rounding algorithm is used for maximum timing parameters. Nominal maximum timing parameters like tREFI_{max}, etc., which programmed in systems in numbers of clocks (nCK) but expressed in units of time (ps), are rounded down to the next 1 ps prior to division by the application memory clock period rounded down to the next 1 ps, resulting in a number of clocks as the final answer which is rounded down to the next 1 nCK. No rounding is required for parameter values equal to 0 ps, but this rounding algorithm can still be used for parameter values equal to 0 ps and no performance will be lost. This rounding algorithm is not optimized for parameter values that are less than 0 ps (negative parameter values), and may result in violating the parameter specification if used for parameter values that are less than 0 ps.

$$nCK[\max_parameter] = \text{truncate} \left(\frac{\text{truncate}[\text{nominal_max_parameter_in_ps}]}{\text{truncate}[tCK(\text{AVG})\text{real_in_ps}]} \right)$$

- **CL ALGORITHM FOR STANDARD SPEED BINS:** The rounding algorithms shall be used for all timing parameters when converting from the time domain (ns, ps, etc.) to the clock domain (nCK units), except for when converting tAA to CL. If these rounding algorithms are used to convert tAA to CL, they'll return invalid CL's for some cases when down clocking (and the DIMM SPD CL Mask doesn't protect against all of these cases). The proper setting of CL shall be determined by the memory controller, either by using the speed bin tables, or by using the CL algorithm, or by some other means. Refer to the Speed Bins and Operations section for more information. Note, the CL algorithm replaces the need to use the DIMM SPD CL Mask.
- **CL ALGORITHM FOR CUSTOM SPEED BINS:** If the DDR5 SDRAM supports non-standard tCK, tAA, tRCD, and tRP speed bin timings, the CL algorithm will still only return valid CL's as defined in the speed bin tables, which may not be the intended CL's for non-standard speed bins. In these cases, the rounding algorithms may need to be used to convert tAA to CL, instead of the CL algorithm. The CL returned by the rounding algorithms shall be incremented up to the next supported CL according to the DIMM SPD CL Mask. Consult the memory vendor for more information.

Rounding Algorithm (cont'd)

Example, using round down only integer number math to convert $t_{WR(min)}$ from ps to nCK:

```
// This algorithm reduces the nominal minimum timing parameter value by a 0.30% correction factor,
// rounds tCK(AVG) down, calculates nCK, adds 1 nCK, and rounds nCK down to the next integer value

int TwrMin, Correction, ClockPeriod, TempTwr, TempNck, TwrInNck;

TwrMin      = 30000;                      // tWRmin in ps
Correction   = 3;                         // 0.30% per the rounding algorithm
ClockPeriod = ApplicationTck;             // Clock period in ps is application specific
TempTwr     = TwrMin * (1000 - Correction); // Apply correction factor, scaled by 1000
TempNck     = TempTwr / ClockPeriod;        // Initial nCK calculation, scaled by 1000
TempNck     = TempNck + 1000;               // Add 1, scaled by 1000, to effectively round up
TwrInNck    = (int)(TempNck / 1000);        // Round down to next integer
```

Table 37 — Example, using Round Down Only Integer Number Math

DDR5 Device Operating at Standard Application Frequencies Timing Parameter: $t_{WR(min)} = 30.000 \text{ ns} = 30000 \text{ ps}$					
Application Speed Grade	Device t_{WR}	Application t_{CK}	Device t_{WR} / Application t_{CK}	Device $t_{WR} * (1000 - Correction) / Application t_{CK} + 1000$	Truncate Corrected nCK / 1000
MT/s	ps	ps	nCK (real)	scaled nCK (corrected)	nCK (integer)
3200	30000	625	48.00	48856	48
3600	30000	555	54.05	54891	54
4000	30000	500	60.00	60820	60
4400	30000	454	66.08	66881	66
4800	30000	416	72.12	72899	72

CL Algorithm

The CL Algorithm specifically determines the valid CAS latency settings for SDRAMs with standard core timing values. This includes “downbinning”, i.e., operating the SDRAMs at data rates below the maximum data rate supported by a specific device bin. This algorithm selects up to four valid CAS Latency values based on the combination of the t_{AAmin} value for the installed SDRAM, the actual clock period t_{CKreal} for the application data rate, and the valid CAS Latencies for standard JEDEC speeds. Some returned values may be RESERVED in which case a higher CAS Latency returned must be used – typically, the next higher CL value returned, though other values may be used to coordinate timing among various modules or memory channels. If no valid CL values are returned, i.e., all values are RESERVED, the algorithm has failed and other means must be used to determine a CAS Latency setting; contact your memory supplier for guidance. Similarly, if the four values returned are not sufficient for coordinating inter-module timings, other methods such as the CL Mask (SPD bytes 24~28) must be used to determine a common CL setting.

CL Algorithm (cont'd)

In pseudocode, the CL Algorithm is:

```

// Variables defined in the DDR5 SDRAM specification, JESD79-5
CorrFact = 0.30                                     // (%) Rounding Algorithm correction factor
ScaledCorrFact = 997                                // Scaled correction factor (1000*(1-0.30%))
tCKreal = 1011-952, 682-238                         // (ps) Real application tCK(AVG) (1980-2100MT/s, 2933-9200MT/s)
tAAmin MONO=14000-17500, 3DS=16000-20000          // (ps) From Speed Bin Tables and DIMM SPD bytes 30-31
tRCDtRPmin MONO=14000-17500, 3DS=14000-17500       // (ps) From Speed Bin Tables and DIMM SPD bytes 32-33 (tRCD=tRP)
tAAcorr = TRUNC(tAAmin*ScaledCorrFactor/1000)        // (ps) Corrected tAA(min) per the Rounding Algorithm rules
tRCDtRPcorr = TRUNC(tRCDtRPmin*ScaledCorrFactor/1000) // (ps) Corrected tRCD(min), tRP(min) per the Rounding Algorithm
FUNC RA(targ) = TRUNC((targ*ScaledCorrFact/tCKstd+1000)/1000) // (nCK) Use Rounding Algorithm to convert bin target timing to nCK

// Round tCKreal down to the next faster standard frequency (tCK in ps)
IF (TRUNC(2000000/(2000*99%))>=TRUNC(tCKreal)>=TRUNC(2000000/(2000*105%)))           // Check for 1980-2100 nominal data rates
    tCKstd=TRUNC(2000000/2000)                                         // Assign standard 2000 tCK (ps)
ELSE IF (TRUNC(2000000/(2000+7*(133+(1/3))))>=TRUNC(tCKreal)>=TRUNC(2000000/3200))      // Check for 2933-3200 nominal data rates
    tCKstd=TRUNC(2000000/3200)                                         // Assign standard 3200 tCK (ps)
ELSE
    FOR (DataRateNom=3200; DataRateNom<=8400; DataRateNom=DataRateNom+400)           // Check for >3200-9200 nominal data rates
        IF (TRUNC(2000000/DataRateNom)>TRUNC(tCKreal)>=TRUNC(2000000/(DataRateNom+400)))
            tCKstd=TRUNC(2000000/(DataRateNom+400))                                // Assign standard 3600-9600 tCK (ps)
        ELSE
            tCKstd=RESERVED                                                 // No valid data rate found

// Timing targets (ps) that have been used to define the Speed Bin Tables
// MONO targets          // 3DS targets
BinAN_tAAtarg = 14000      BinAN_tAAtarg = 16000      // tAA target for AN bins
BinB_tAAtarg = 16000       BinB_tAAtarg = 18500     // tAA target for AN, B bins
BinBN_tAAtarg = 16000      BinBN_tAAtarg = 18500     // tAA target for AN, B, BN bins
BinC_tAAtarg = 17500       BinC_tAAtarg = 20000     // tAA target for AN, B, BN, C bins
BinAN_tRCDtRPtarg = 14000   BinAN_tRCDtRPtarg = 14000   // tRCD, tRP target for AN bins
BinBN_tRCDtRPtarg = 16000   BinBN_tRCDtRPtarg = 16000   // tRCD, tRP target for AN, B, BN bins
BinC_tRCDtRPtarg = 17500   BinC_tRCDtRPtarg = 17500   // tRCD, tRP target for AN, B, BN, C bins
IF (TRUNC(2000000/3600)>tCKstd)                         // tRCD, tRP target for B bins is frequency dependent
    BinB_tRCDtRPtarg = 16000 BinB_tRCDtRPtarg = 16000   // tRCD, tRP target for AN, B bins data rates faster than 3600
ELSE
    // 16250=(2000000/3200)*EVEN(TRUNC((BinB_tRCDtRPtarg*ScaledCorrFact/(2000000/3200)+1000)/1000))
    BinB_tRCDtRPtarg = 16250 BinB_tRCDtRPtarg = 16250   // tRCD, tRP target for AN, B bins for data rates 3600 and slower

// CL Algorithm using variables defined above
// Up to four valid CL's can be returned for a specific freq: CL(AN), CL(B), CL(BN), CL(C), depending on tAAmin, tRCDmin, tRPmin
// The B and BN bins return the same CL
// Only even CL's (not odd CL's) are valid per the DDR5 SDRAM specification
// nRCD, nRP are only even at standard native frequencies for the AN, BN bins (can be even or odd at intermediate frequencies)
// nRCD, nRP may be even or odd at standard native frequencies for the B, C bins (can be even or odd at intermediate frequencies)
IF (TRUNC(2000000/2000)=tCKstd)                         // CL22 is the only valid CL for 1980-2100 data rates
    CL(AN)=22                                         // Valid even CL for AN bins
    CL(B)=22                                         // Valid even CL for AN, B, bins
    CL(BN)=22                                         // Valid even CL for AN, B, BN bins
    CL(C)=22                                         // Valid even CL for AN, B, BN, C bins
ELSE IF (TRUNC(2000000/3200)>=tCKstd>=TRUNC(2000000/8800)) // Valid CL for 2933-9200 data rates
    IF ((EVEN(RA(BinAN_tAAtarg))*tCKstd>=tAAcorr)AND(EVEN(RA(BinAN_tRCDtRPtarg))*tCKstd>=tRCDtRPcorr)) // nRCD, nRP even only
        CL(AN)=EVEN(RA(BinAN_tAAtarg))                // Valid even CL for AN bins
        CL(B)=EVEN(RA(BinB_tAAtarg))                  // Valid even CL for AN, B bins
        CL(BN)=EVEN(RA(BinBN_tAAtarg))                // Valid even CL for AN, B, BN bins
        CL(C)=EVEN(RA(BinC_tAAtarg))                  // Valid even CL for AN, B, BN, C bins
    ELSE IF ((EVEN(RA(BinB_tAAtarg))*tCKstd>=tAAcorr)AND( (RA(BinB_tRCDtRPtarg))*tCKstd>=tRCDtRPcorr)) // nRCD, nRP even, odd
        CL(AN)=RESERVED                               // Valid even CL for AN bins
        CL(B)=EVEN(RA(BinB_tAAtarg))                  // Valid even CL for AN, B bins
        CL(BN)=EVEN(RA(BinBN_tAAtarg))                // Valid even CL for AN, B, BN bins
        CL(C)=EVEN(RA(BinC_tAAtarg))                  // Valid even CL for AN, B, BN, C bins
    ELSE IF ((EVEN(RA(BinBN_tAAtarg))*tCKstd>=tAAcorr)AND(EVEN(RA(BinBN_tRCDtRPtarg))*tCKstd>=tRCDtRPcorr)) // nRCD, nRP even only
        CL(AN)=RESERVED                               // Valid even CL for AN bins
        CL(B)=RESERVED                               // Valid even CL for AN, B bins
        CL(BN)=EVEN(RA(BinBN_tAAtarg))                // Valid even CL for AN, B, BN bins
        CL(C)=EVEN(RA(BinC_tAAtarg))                  // Valid even CL for AN, B, BN, C bins
    ELSE IF ((EVEN(RA(BinC_tAAtarg))*tCKstd>=tAAcorr)AND( (RA(BinC_tRCDtRPtarg))*tCKstd>=tRCDtRPcorr)) // nRCD, nRP even, odd
        CL(AN)=RESERVED                               // Valid even CL for AN bins
        CL(B)=RESERVED                               // Valid even CL for AN, B bins
        CL(BN)=RESERVED                               // Valid even CL for AN, B, BN bins
        CL(C)=RESERVED                               // Valid even CL for AN, B, BN, C bins

```

CL Algorithm (cont'd)

```

CL(C)=EVEN(RA(BinC__tAtarg))
    // Valid even CL for AN, B, BN, C bins
ELSE
    CL(AN)=RESERVED
    CL(B)=RESERVED
    CL(BN)=RESERVED
    CL(C)=RESERVED
    // No valid CL found (tAAmin, tRCDmin, tRPmin are too slow)
    // Valid even CL for AN bins
    // Valid even CL for AN, B bins
    // Valid even CL for AN, B, BN bins
    // Valid even CL for AN, B, BN, C bins
ELSE
    CL(AN)=RESERVED
    CL(B)=RESERVED
    CL(BN)=RESERVED
    // No valid data rate found
    // Valid even CL for AN bins
    // Valid even CL for AN, B bins
    // Valid even CL for AN, B, BN bins
    // Valid even CL for AN, B, BN, C bins
    CL(C)=RESERVED
        // Valid even CL for AN, B, BN, C bins

```

8.1.21 (DDR5): SDRAM Minimum Cycle Time ($t_{CKAVGmin}$)

Byte 20 (0x014): Least Significant Byte

Byte 21 (0x015): Most Significant Byte

This 16-bit word defines the minimum cycle time for the SDRAM module, in picoseconds (ps). This number applies to all applicable components on the module. This byte applies to SDRAM and support components as well as the overall capability of the DIMM. These values come from the DDR5 SDRAM data sheet, JESD79-5, and support component data sheets.

Table 38 — SDRAM Minimum Cycle Time ($t_{CKAVGmin}$), ps

Byte 21	Byte 20
Bits 15~8	Bits 7~0
Values defined from 1 to 65535 ps 0x0000: Reserved	

8.1.22 (DDR5): SDRAM Maximum Cycle Time ($t_{CKAVGmax}$)

Byte 22 (0x016): Least Significant Byte

Byte 23 (0x017): Most Significant Byte

This 16-bit word defines the maximum cycle time for the SDRAM module, in picoseconds (ps). This number applies to all applicable components on the module. This byte applies to SDRAM and support components as well as the overall capability of the DIMM. These values come from the DDR5 SDRAM data sheet, JESD79-5, and support component data sheets.

Table 39 — SDRAM Maximum Cycle Time ($t_{CKAVGmax}$), ps

Byte 23	Byte 22
Bits 15~8	Bits 7~0
Values defined from 1 to 65535 ps 0x0000: Reserved	

8.1.23 (DDR5): SDRAM CAS Latencies Supported

Byte 24 (0x018): First Byte

Byte 25 (0x019): Second Byte

Byte 26 (0x01A): Third Byte

Byte 27 (0x01B): Fourth Byte

Byte 28 (0x01C): Fifth Byte

These bytes define which CAS Latency (CL) values are supported with one bit per possible CAS Latency. A 1 in a bit position means that CL is supported, a 0 in that bit position means it is not supported. These values come from the DDR5 SDRAM, JESD79-5. CAS Latency Mask covers both DBI and non-DBI modes of operation.

Table 40 — SDRAM CAS Latencies Supported

Byte 24	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
CL =	34	32	30	28	26	24	22	20
Byte 25	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
CL =	50	48	46	44	42	40	38	36
Byte 26	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
CL =	66	64	62	60	58	56	54	52
Byte 27	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
CL =	82	80	78	76	74	72	70	68
Byte 28	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
CL =	98	96	94	92	90	88	86	84

NOTE For each bit position, 0 means this CAS Latency is not supported, 1 means this CAS Latency is supported.

Example 1: DDR5-4400A SDRAM

CAS latencies supported: 22, 26, 28, 30, 32, 36, 40

Table 41 — Example 1: DDR5-4400A SDRAM

SPD Byte	Bit	7	6	5	4	3	2	1	0	Hex Code
Byte 24	CAS Latencies	34	32	30	28	26	24	22	20	
	CL Mask	0	1	1	1	1	0	1	0	0x7A
Byte 25	CAS Latencies	50	48	46	44	42	40	38	36	
	CL Mask	0	0	0	0	0	1	0	1	0x05
Byte 26	CAS Latencies	66	64	62	60	58	56	54	52	
	CL Mask	0	0	0	0	0	0	0	0	0x00
Byte 27	CAS Latencies	82	80	78	76	74	72	70	68	
	CL Mask	0	0	0	0	0	0	0	0	0x00
Byte 28	CAS Latencies	98	96	94	92	90	88	86	84	
	CL Mask	0	0	0	0	0	0	0	0	0x00

8.1.24 (DDR5): Byte 29 (0x01D)

Reserved; must be coded as 0x00.

8.1.25 (DDR5): SDRAM Read Command to First Data (t_{AA})

Byte 30 (0x01E): Least Significant Byte

Byte 31 (0x01F): Most Significant Byte

This 16-bit word defines the minimum SDRAM Read command to first data (CAS Latency) in picoseconds (ps). These values come from the DDR5 SDRAM data sheet, JESD79-5.

Table 42 — SDRAM Read Command to First Data (t_{AA}), ps

Byte 31	Byte 30
Bits 15~8	Bits 7~0
Values defined from 1 to 65535 ps 0x0000: Reserved	

8.1.26 (DDR5): SDRAM Activate to Read or Write Command Delay (t_{RCD})

Byte 32 (0x020): Least Significant Byte

Byte 33 (0x021): Most Significant Byte

This 16-bit word defines the minimum SDRAM Activate to Read or Write command delay in picoseconds (ps). This value comes from the DDR5 SDRAM data sheet, JESD79-5.

Table 43 — SDRAM Activate to Read or Write Command Delay (t_{RCD}), ps

Byte 33	Byte 32
Bits 15~8	Bits 7~0
Values defined from 1 to 65535 ps 0x0000: Reserved	

8.1.27 (DDR5): SDRAM Row Precharge Time (t_{RP})

Byte 34 (0x022): Least Significant Byte

Byte 35 (0x023): Most Significant Byte

This 16-bit word defines the minimum SDRAM Row Precharge Time in picoseconds (ps). This value comes from the DDR5 SDRAM data sheet, JESD79-5.

Table 44 — SDRAM Row Precharge Time (t_{RP}), ps

Byte 35	Byte 34
Bits 15~8	Bits 7~0
Values defined from 1 to 65535 ps 0x0000: Reserved	

8.1.28 (DDR5): SDRAM Activate to Precharge Command Period (t_{RAS})

Byte 36 (0x024): Least Significant Byte

Byte 37 (0x025): Most Significant Byte

This 16-bit word defines the minimum SDRAM Activate to Precharge command period in picoseconds (ps). This value comes from the DDR5 SDRAM data sheet, JESD79-5.

Table 45 — SDRAM Activate to Precharge Command Period (t_{RAS}), ps

Byte 37	Byte 36
Bits 15~8	Bits 7~0
Values defined from 1 to 65535 ps 0x0000: Reserved	

8.1.29 (DDR5): SDRAM Activate to Activate or Refresh Command Period (t_{RC})

Byte 38 (0x026): Least Significant Byte

Byte 39 (0x027): Most Significant Byte

This 16-bit word defines the minimum SDRAM Activate to Activate/Refresh command period in picoseconds (ps). This value comes from the DDR5 SDRAM data sheet, JESD79-5.

Table 46 — SDRAM Activate to Activate or Refresh Command Period (t_{RC}), ps

Byte 39	Byte 38
Bits 15~8	Bits 7~0
Values defined from 1 to 65535 ps 0x0000: Reserved	

By DDR5 device design, t_{RCmin} must always be greater than or equal to $t_{RASmin} + t_{RPmin}$. When converting time in ns to nCK units using the appropriate rounding algorithms for these three parameters, systems must account for the overall design requirement and choose the larger of t_{RCmin} or $(t_{RASmin} + t_{RPmin})$ as a minimum setting.

8.1.30 (DDR5): SDRAM Write Recovery Time (t_{WR})

Byte 40 (0x028): Least Significant Byte

Byte 41 (0x029): Most Significant Byte

This 16-bit word defines the minimum SDRAM Write Recovery time in picoseconds (ps). This value comes from the DDR5 SDRAM data sheet, JESD79-5.

8.1.30 (DDR5): SDRAM Write Recovery Time (t_{WR}) (cont'd)

Table 47 — SDRAM Write Recovery Time (t_{WR}), ps

Byte 41	Byte 40
Bits 15~8	Bits 7~0
Values defined from 1 to 65535 ps 0x0000: Reserved	

8.1.31 (DDR5): SDRAM Normal Refresh Recovery Time (t_{RFC1} , t_{RFC1_slr})

Byte 42 (0x02A): Least Significant Byte

Byte 43 (0x02B): Most Significant Byte

This 16-bit word defines the SDRAM Normal Refresh recovery time in nanoseconds (ns). t_{RFC1} relates to monolithic SDRAMs, t_{RFC1_slr} to 3DS SDRAMs. These values come from the DDR5 SDRAM data sheet, JESD79-5.

Table 48 — SDRAM Normal Refresh Recovery Time (t_{RFC1} , t_{RFC1_slr}), ns

Byte 43	Byte 42
Bits 15~8	Bits 7~0
Values defined from 1 to 65535 ns 0x0000 = Reserved	
NOTE t_{RFC1} relates to monolithic SDRAMs, t_{RFC1_slr} relates to 3DS SDRAMs.	

8.1.32 (DDR5): SDRAM Fine Granularity Refresh Recovery Time (t_{RFC2} , t_{RFC2_slr})

Byte 44 (0x02C): Least Significant Byte

Byte 45 (0x02D): Most Significant Byte

This 16-bit word defines the SDRAM Fine Granularity Refresh recovery time in nanoseconds (ns). t_{RFC2} relates to monolithic SDRAMs, t_{RFC2_slr} to 3DS SDRAMs. These values come from the DDR5 SDRAM data sheet, JESD79-5.

Table 49 — SDRAM Fine Granularity Refresh Recovery Time (t_{RFC2} , t_{RFC2_slr}), ns

Byte 45	Byte 44
Bits 15~8	Bits 7~0
Values defined from 1 to 65535 ns 0x0000 = Reserved	
NOTE t_{RFC2} relates to monolithic SDRAMs, t_{RFC2_slr} relates to 3DS SDRAMs.	

8.1.33 (DDR5): SDRAM Same Bank Refresh Recovery Time (t_{RFCsb} , t_{RFCsb_slr})

Byte 46 (0x02E): Least Significant Byte

Byte 47 (0x02F): Most Significant Byte

This 16-bit word defines the SDRAM Same Bank Refresh recovery time in nanoseconds (ns). t_{RFCsb} relates to monolithic SDRAMs, t_{RFCsb_slr} to 3DS SDRAMs. These values come from the DDR5 SDRAM data sheet, JESD79-5.

Table 50 — SDRAM Same Bank Refresh Recovery Time (t_{RFCsb} , t_{RFCsb_slr}), ns

Byte 47	Byte 46
Bits 15~8	Bits 7~0
Values defined from 1 to 65535 ns 0x0000: Reserved	
NOTE t_{RFCsb} relates to monolithic SDRAMs, t_{RFCsb_slr} relates to 3DS SDRAMs.	

8.1.34 (DDR5): SDRAM Normal Refresh Recovery Time, 3DS Different Logical Rank (t_{RFC1_dlr})

Byte 48 (0x030): Least Significant Byte

Byte 49 (0x031): Most Significant Byte

This 16-bit word defines the SDRAM Normal Refresh recovery time in nanoseconds (ns). t_{RFC1_dlr} relates to 3DS SDRAMs only. For monolithic SDRAMs, these bytes must be encoded as 0x0000. These values come from the DDR5 SDRAM data sheet, JESD79-5.

Table 51 — SDRAM Normal Refresh Recovery Time, 3DS Different Logical Rank (t_{RFC1_dlr}), ns

Byte 49	Byte 48
Bits 15~8	Bits 7~0
Values defined from 1 to 65535 ns 0x0000 = Reserved	
NOTE These bytes are defined for 3DS only; for monolithic SDRAMs, code as 0x0000	

8.1.35 (DDR5): SDRAM Fine Granularity Refresh Recovery Time, 3DS Different Logical Rank (t_{RFC2_dlr})

Byte 50 (0x032): Least Significant Byte

Byte 51 (0x033): Most Significant Byte

This 16-bit word defines the SDRAM Fine Granularity Refresh recovery time in nanoseconds (ns). t_{RFC2_dlr} relates to 3DS SDRAMs only. For monolithic SDRAMs, these bytes must be encoded as 0x0000. These values come from the DDR5 SDRAM data sheet, JESD79-5.

Table 52 — SDRAM Fine Granularity Refresh Recovery Time (t_{RFC2_dlr}), ns

Byte 51	Byte 50
Bits 15~8	Bits 7~0
Values defined from 1 to 65535 ns 0x0000 = Reserved	
NOTE These bytes are defined for 3DS only; for monolithic SDRAMs, code as 0x0000	

8.1.36 (DDR5): SDRAM Same Bank Refresh Recovery Time, 3DS Different Logical Rank (t_{RFCsb_dlr})

Byte 52 (0x034): Least Significant Byte

Byte 53 (0x035): Most Significant Byte

This 16-bit word defines the SDRAM Same Bank Refresh recovery time for different logical ranks in nanoseconds (ns). t_{RFCsb_dlr} relates to 3DS SDRAMs only. For monolithic SDRAMs, these bytes must be encoded as 0x0000. These values come from the DDR5 SDRAM data sheet, JESD79-5.

Table 53 — SDRAM Same Bank Refresh Recovery Time (t_{RFCsb_dlr}), ns

Byte 53	Byte 52
Bits 15~8	Bits 7~0
Values defined from 1 to 65535 ns 0x0000 = Reserved	
NOTE These bytes are defined for 3DS only; for monolithic SDRAMs, code as 0x0000	

8.1.37 (DDR5): SDRAM Refresh Management, First SDRAM
Byte 54 (0x036): SDRAM Refresh Management, First Byte, First SDRAM
Byte 55 (0x037): SDRAM Refresh Management, Second Byte, First SDRAM

These bytes represent the refresh management (RFM) settings for the SDRAMs used on this module. These are identical to the contents of the DDR5 SDRAM mode registers MR58 and MR59. These values come from the DDR5 SDRAM data sheet, JESD79-5. If all devices in a group (i.e., First or Second) are not matched, the value coded must represent the worst case for any device in the group.

Table 54 — SDRAM Refresh Management (RFM), First Byte
Byte 54 (First SDRAM)

Bits 7~5 (MR58:OP[7:5])		Bits 4~1 (MR58:OP[4:1])		Bit 0 (MR58:OP[0])
RAAMMT		RAAIMT		RFM Required
Normal	FGR	Normal	FGR	
000~010: Reserved 011: 3X 100: 4X 101: 5X 110: 6X 111: Reserved	000~010: Reserved 011: 6X 100: 8X 101: 10X 110: 12X 111: Reserved	0000-0011: Reserved 0100: 32 0101: 40 ... 1001: 72 1010: 80 All other codings reserved	0000-0011: Reserved 0100: 16 0101: 20 ... 1001: 36 1010: 40 All other codings reserved	0: Refresh management not required 1: Refresh management required
NOTES: RFM = Refresh Management RAAMMT = Rolling Accumulated ACT Maximum Management Threshold RAAIMT = Rolling Accumulated ACT Initial Management Threshold Normal = Normal refresh mode FGR = Fine granularity refresh mode First SDRAM applies to all package ranks of SDRAMs in symmetrical configurations or even ranks in asymmetrical configurations Second SDRAM applies to odd ranks in asymmetrical configurations only				

8.1.37 (DDR5): SDRAM Refresh Management, First SDRAM (cont'd)

**Table 55 — SDRAM Refresh Management (RFM), Second Byte
Byte 55 (First SDRAM)**

Bits 7~6 (MR59:OP[7:6])	Bits 5~4 (MR59:OP[5:4])	Bit 3 (MR59:OP[3])	Bits 2~1 (MR59:OP[2:1])	Bit 0 (MR59:OP[0])
RFM RAA Counter Decrement per REF command	ARFM Level	BRC Support Level	Recommended Bounded Refresh Configuration	DRFM Supported
00: RAAIMT 01: RAAIMT ÷ 2 Other codes reserved	Reserved; must be coded in the SPD as 00; modified by the host controller via MRW to select ARFM Level	0: BRC2, 3, 4 (default) 1: BRC2 only	00: BRC2 = always +/- 1, ratio +/- 2 01: BRC3 = always +/- 1, +/- 2, ratio +/- 3 10: BRC4 = always +/- 1, +/- 2, +/- 3, ratio +/- 4 11: Reserved	0 = DRFM not supported 1 = DRFM supported

NOTES:

ARFM = Adaptive Refresh Management.
BRC = Bounded Refresh Configuration. The SPD field bits 2~1 define the module supplier's recommended value, however the host may program other values into the SDRAM mode register based on system policy. BRC values define how many rows are refreshed.
DRFM = Directed Refresh Management. SPD bit 0 defines whether the SDRAM supports the DRFM feature, the host must still program 1 into the SDRAM mode register bit to enable the feature.
BRC Support Level = indicates how many BRC options the DRAM can support which is set by the DRAM vendor in the read only MR59:OP[3]. The module supplier is required to program the value in DDR5 SDRAM MR59:OP[3] into SPD bit 3.
MRW = mode register write SDRAM command.
RAA = Rolling Accumulated ACT.
RAAIMT = Rolling Accumulated ACT Initial Management Threshold.
First SDRAM applies to all package ranks of SDRAMs in symmetrical configurations or even ranks in asymmetrical configurations.
Second SDRAM applies to odd ranks in asymmetrical configurations only.
Selection of ARFM level is managed by writing to SDRAM mode register bits MR59:OP[5:4].

8.1.38 (DDR5): SDRAM Refresh Management, Second SDRAM

Byte 56 (0x038): SDRAM Refresh Management, First Byte, Second SDRAM

Byte 57 (0x039): SDRAM Refresh Management, Second Byte, Second SDRAM

These bytes represent the refresh management (RFM) settings for the Second SDRAMs used on this module for odd ranks in asymmetrical assemblies.

**Table 56 — SDRAM Refresh Management (RFM), First Byte
Byte 56 (Second SDRAM)**

Bits 7~5 (MR58:OP[7:5])	Bits 4~1 (MR58:OP[4:1])	Bit 0 (MR58:OP[0])
RAAMMT	RAAIMT	RFM Required

See byte 54 for details. For symmetrical assemblies (all ranks use identical SDRAMs), must be coded as 0x00.

8.1.38 (DDR5): SDRAM Refresh Management, Second SDRAM (cont'd)

**Table 57 — SDRAM Refresh Management (RFM), Second Byte
Byte 57 (Second SDRAM)**

Bits 7~6 (MR59:OP[7:6])	Bits 5~4 (MR59:OP[5:4])	Bit 3 (MR59:OP[3])	Bits 2~1 (MR59:OP[2:1])	Bit 0 (MR59:OP[0])
RFM RAA Counter Decrement per REF command	ARFM Level	BRC Support Level	Recommended Bounded Refresh Configuration	DRFM Supported
See byte 55 for details. For symmetrical assemblies (all ranks use identical SDRAMs), must be coded as 0x00.				

8.1.39 (DDR5): SDRAM Adaptive Refresh Management

Bytes 58~69 (0x03A~0x045)

These bytes represent the adaptive refresh management (ARFM) settings for the SDRAMs used on this module. These values are vendor specific and come from the vendor's DDR5 SDRAM data sheet.

Table 58 — SDRAM Adaptive Refresh Management (ARFM)

ARFM Level	First SDRAM		Second SDRAM	
	First Byte	Second Byte	First Byte	Second Byte
A	SPD Byte 58 (0x03A)	SPD Byte 59 (0x03B)	SPD Byte 60 (0x03C)	SPD Byte 61 (0x03D)
B	SPD Byte 62 (0x03E)	SPD Byte 63 (0x03F)	SPD Byte 64 (0x040)	SPD Byte 65 (0x041)
C	SPD Byte 66 (0x042)	SPD Byte 67 (0x043)	SPD Byte 68 (0x044)	SPD Byte 69 (0x045)

NOTES:

ARFM = Adaptive Refresh Management
These bytes use similar encoding to the RFM bytes 54~55, with the difference that bit 0 of all First Bytes is to be decoded as "ARFM Level Supported"

Table 59 — SDRAM Adaptive Refresh Management (ARFM), First Bytes

Bits 7~5 (MR58:OP[7:5])	Bits 4~1 (MR58:OP[4:1])	Bit 0 (MR58:OP[0])
RAAMMT	RAAIMT	ARFM Level
See byte 54 for details.		0: ARFM Level not supported 1: ARFM Level supported

Table 60 — SDRAM Adaptive Refresh Management (ARFM), Second Bytes

Bits 7~6 (MR59:OP[7:6])	Bits 5~4 (MR59:OP[5:4])	Bit 3 (MR59:OP[3])	Bits 2~1 (MR59:OP[2:1])	Bit 0 (MR59:OP[0])
RFM RAA Counter Decrement per REF command	ARFM Level	BRC Support Level	Recommended Bounded Refresh Configuration	DRFM Supported
See byte 55 for details.				

8.1.40 (DDR5): SDRAM Activate to Activate Command Delay for Same Bank Group (t_{RRD_L})

Byte 70 (0x046): Least Significant Byte

Byte 71 (0x047): Most Significant Byte

Byte 72 (0x048): Lower Clock Limit

The 16-bit word in the lower two bytes defines the minimum SDRAM Activate to Activate command delay in picoseconds (ps) when accessing the same bank group. The third byte defines the minimum number of clocks (nCK) required. For monolithic SDRAMs, this parameter is t_{RRD_L}(1K) min or t_{RRD_L}(2K) min; for 3DS devices, this parameter is t_{RRD_L_slr} (1K) min. These values come from the DDR5 SDRAM data sheet, JESD79-5. The general algorithm is:

- Calculate the target t_{RRD_L} clock count by applying the standard rounding algorithm to the 16-bit ps value and the application clock period in ps.
- Set the application t_{RRD_L} in nCK units to the greater of the target t_{RRD_L} or the Lower Clock Limit.

Table 61 — SDRAM Activate to Activate Command Delay for Same Bank Group (t_{RRD_L})

nCK	ps	
Byte 72	Byte 71	Byte 70
Bits 7~0	Bits 15~8	Bits 7~0
Values defined from 1 to 255 clocks (nCK) 0x00: Reserved	Values defined from 1 to 65535 ps 0x0000: Reserved	

8.1.41 (DDR5): SDRAM Read to Read Command Delay for Same Bank Group (t_{CCD_L})

Byte 73 (0x049): Least Significant Byte

Byte 74 (0x04A): Most Significant Byte

Byte 75 (0x04B): Lower Clock Limit

The 16-bit word in the lower two bytes defines the minimum SDRAM Read to Read command delay in picoseconds (ps) when accessing the same bank group. The third byte defines the minimum number of clocks (nCK) required. For monolithic SDRAMs, this parameter is t_{CCD_L}; for 3DS devices, this parameter is t_{CCD_L_slr}. These values come from the DDR5 SDRAM data sheet, JESD79-5. The general algorithm is:

- Calculate the target t_{CCD_L} clock count by applying the standard rounding algorithm to the 16-bit ps value and the application clock period in ps.
- Set the application t_{CCD_L} in nCK units to the greater of the target t_{CCD_L} or the lower clock limit.

Table 62 — SDRAM Read to Read Command Delay for Same Bank Group (t_{CCD_L})

nCK	ps	
Byte 75	Byte 74	Byte 73
Bits 7~0	Bits 15~8	Bits 7~0
Values defined from 1 to 255 clocks (nCK) 0x00: Reserved	Values defined from 1 to 65535 ps 0x0000: Reserved	

8.1.42 (DDR5): SDRAM Write to Write Command Delay for Same Bank Group (t_{CCD_L_WR})

Byte 76 (0x04C): Least Significant Byte

Byte 77 (0x04D): Most Significant Byte

Byte 78 (0x04E): Lower Clock Limit

The 16-bit word in the lower two bytes defines the minimum SDRAM Write to Write command delay in picoseconds (ps) when accessing the same bank group. The third byte defines the minimum number of clocks (nCK) required. For monolithic SDRAMs, this parameter is t_{CCD_L_WR}; for 3DS devices, this parameter is t_{CCD_L_WR_slr}. These values come from the DDR5 SDRAM data sheet, JESD79-5. The general algorithm is:

- Calculate the target t_{CCD_L_WR} clock count by applying the standard rounding algorithm to the 16-bit ps value and the application clock period in ps.
- Set the application t_{CCD_L_WR} in nCK units to the greater of the target t_{CCD_L_WR} or the lower clock limit.

Table 63 — SDRAM Write to Write Command Delay for Same Bank Group (t_{CCD_L_WR})

nCK	ps	
Byte 78	Byte 77	Byte 76
Bits 7~0	Bits 15~8	Bits 7~0
Values defined from 1 to 255 clocks (nCK) 0x00: Reserved	Values defined from 1 to 65535 ps 0x0000: Reserved	

8.1.43 (DDR5): SDRAM Write to Write Command Delay for Same Bank Group, Second Write not RMW (t_{CCD_L_WR2})

Byte 79 (0x04F): Least Significant Byte

Byte 80 (0x050): Most Significant Byte

Byte 81 (0x051): Lower Clock Limit

The 16-bit word in the lower two bytes defines the minimum SDRAM Write to Write command delay in picoseconds (ps) when accessing the same bank group and the second write is not a read-modify-write. The third byte defines the minimum number of clocks (nCK) required. For monolithic SDRAMs, this parameter is t_{CCD_L_WR2}; for 3DS devices, this parameter is t_{CCD_L_WR2_slr}. These values come from the DDR5 SDRAM data sheet, JESD79-5. The general algorithm is:

- Calculate the target t_{CCD_L_WR2} clock count by applying the standard rounding algorithm to the 16-bit ps value and the application clock period in ps.
- Set the application t_{CCD_L_WR2} in nCK units to the greater of the target t_{CCD_L_WR2} or the lower clock limit.

Table 64 — SDRAM Write to Write Command Delay for Same Bank Group, Second Write not RMW (t_{CCD_L_WR2})

nCK	ps	
Byte 81	Byte 80	Byte 79
Bits 7~0	Bits 15~8	Bits 7~0
Values defined from 1 to 255 clocks (nCK) 0x00: Reserved	Values defined from 1 to 65535 ps 0x0000: Reserved	

8.1.44 (DDR5): SDRAM Four Activate Window (t_{FAW})

Byte 82 (0x052): Least Significant Byte

Byte 83 (0x053): Most Significant Byte

Byte 84 (0x054): Lower Clock Limit

The 16-bit word in the lower two bytes defines the minimum SDRAM Four Activate Window in picoseconds (ps). The third byte defines the minimum number of clocks (nCK) required. For monolithic SDRAMs, this parameter is $t_{FAW}(1K)$ or $t_{FAW}(2K)$; for 3DS devices, this parameter is $t_{FAW_slr}(1K)$. These values come from the DDR5 SDRAM data sheet, JESD79-5. The general algorithm is:

- Calculate the target t_{FAW} clock count by applying the standard rounding algorithm to the 16-bit ps value and the application clock period in ps.
- Set the application t_{FAW} in nCK units to the greater of the target t_{FAW} or the lower clock limit.

Table 65 — SDRAM Four Activate Window (t_{FAW})

nCK	ps	
Byte 84	Byte 83	Byte 82
Bits 7~0	Bits 15~8	Bits 7~0
Values defined from 1 to 255 clocks (nCK) 0x00: Reserved	Values defined from 1 to 65535 ps 0x0000: Reserved	

8.1.45 (DDR5): SDRAM Write to Read Command Delay for Same Bank Group ($t_{CCD_L_WTR}$)

Byte 85 (0x055): Least Significant Byte

Byte 86 (0x056): Most Significant Byte

Byte 87 (0x057): Lower Clock Limit

The 16-bit word in the lower two bytes defines the analog portion (WTR(L)) of the minimum Write to Read command delay in picoseconds (ps) when accessing the same bank group. The third byte defines the minimum number of clocks (nCK) required. For monolithic SDRAMs, this parameter is $t_{CCD_L_WTR}$; for 3DS devices, this parameter is $t_{CCD_L_WTR_slr}$. These values come from the DDR5 SDRAM data sheet, JESD79-5. The general algorithm is:

- Calculate the command time in clocks for CAS Write Latency (CWL) plus Write Burst Length divided by 2.
- Calculate the target WTR(L) clock count by applying the standard rounding algorithm to the 16-bit ps value and the application clock period in ps.
- Set the application WTR(L) in nCK units to the greater of the target WTR(L) or the lower clock limit.
- Set the application $t_{CCD_L_WTR}$ to the sum of command time and WTR(L):

$$t_{CCD_L_WTR} = CWL + WBL/2 + WTR(L)$$

Table 66 — DDR5 SDRAM Write to Read Command Delay for Same Bank Group ($t_{CCD_L_WTR}$)

nCK	ps	
Byte 87	Byte 86	Byte 85
Bits 7~0	Bits 15~8	Bits 7~0
Values defined from 1 to 255 clocks (nCK) 0x00: Reserved	Values defined from 1 to 65535 ps 0x0000: Reserved	

8.1.46 (DDR5): SDRAM Write to Read Command Delay for Different Bank Group (t_{CCD_S_WTR})

Byte 88 (0x058): Least Significant Byte

Byte 89 (0x059): Most Significant Byte

Byte 90 (0x05A): Lower Clock Limit

The 16-bit word in the lower two bytes defines the analog portion (WTR(S)) of the minimum Write to Read command delay in picoseconds (ps) when accessing different bank groups. The third byte defines the minimum number of clocks (nCK) required. For monolithic SDRAMs, this parameter is tWTR_S; for 3DS devices, this parameter is tWTR_S_slr. These values come from the DDR5 SDRAM data sheet, JESD79-5. The general algorithm is:

- Calculate the command time in clocks for CAS Write Latency (CWL) plus Write Burst Length divided by 2.
- Calculate the target WTR(S) clock count by applying the standard rounding algorithm to the 16-bit ps value and the application clock period in ps.
- Set the application WTR(S) in nCK units to the greater of the target WTR(S) or the lower clock limit.
- Set the application tCCD_L_WTR to the sum of command time and WTR(S):
 $t_{CCD_S_WTR} = CWL + WBL/2 + WTR(S)$

Table 67 — DDR5 SDRAM Write to Read Command Delay for Different Bank Group (t_{CCD_S_WTR})

nCK	ps	
Byte 90	Byte 89	Byte 88
Bits 7~0	Bits 15~8	Bits 7~0
Values defined from 1 to 255 clocks (nCK) 0x00: Reserved	Values defined from 1 to 65535 ps 0x0000: Reserved	

8.1.47 (DDR5): SDRAM Read to Precharge Command Delay (t_{RTP} , t_{RTP_slr})

Byte 91 (0x05B): Least Significant Byte

Byte 92 (0x05C): Most Significant Byte

Byte 93 (0x05D): Lower Clock Limit

The 16-bit word in the lower two bytes defines the minimum Read to Precharge command delay in picoseconds (ps). The third byte defines the minimum number of clocks (nCK) required. For monolithic SDRAMs, this parameter is t_{RTP} ; for 3DS devices, this parameter is t_{RTP_slr} . These values come from the DDR5 SDRAM data sheet, JESD79-5. The general algorithm is:

- Calculate the target t_{RTP} clock count by applying the standard rounding algorithm to the 16-bit ps value and the application clock period in ps.
- Set the application t_{RTP} in nCK units to the greater of the target t_{RTP} or the lower clock limit.

Parameter t_{CCD_WTRA} (write to read with autoprecharge command delay) is calculated as $t_{CCD_WTRA} = t_{WR} - t_{RTP}$. This calculation must be maintained when using the rounding algorithm on each parameter individually, or rounding on the result of the subtraction, and the higher number of resulting clocks must be used.

Table 68 — DDR5 SDRAM Read to Precharge Command Delay (t_{RTP} , t_{RTP_slr})

nCK	ps	
Byte 93	Byte 92	Byte 91
Bits 7~0	Bits 15~8	Bits 7~0
Values defined from 1 to 255 clocks (nCK) 0x00: Reserved	Values defined from 1 to 65535 ps 0x0000: Reserved	

8.1.48 (DDR5): SDRAM Read to Read Command Delay for Different Bank in Same Bank Group (t_{CCD_M})

Byte 94 (0x05E): Least Significant Byte

Byte 95 (0x05F): Most Significant Byte

Byte 96 (0x060): Lower Clock Limit

The 16-bit word in the lower two bytes defines the minimum SDRAM Read to Read command delay in picoseconds (ps) when accessing a different bank in the same bank group. The third byte defines the minimum number of clocks (nCK) required. For monolithic SDRAMs, this parameter is t_{CCD_M} ; for 3DS devices, this parameter is $t_{CCD_M_slr}$. These values come from the DDR5 SDRAM data sheet, JESD79-5. The general algorithm is:

- Calculate the target t_{CCD_M} clock count by applying the standard rounding algorithm to the 16-bit ps value and the application clock period in ps.
- Set the application t_{CCD_M} in nCK units to the greater of the target t_{CCD_M} or the lower clock limit.

Table 69 — DDR5 SDRAM Read to Read Command Delay for Different Bank in Same Bank Group (t_{CCD_M})

nCK	ps	
Byte 96	Byte 95	Byte 94
Bits 7~0	Bits 15~8	Bits 7~0
Values defined from 1 to 255 clocks (nCK) 0x00: Reserved	Values defined from 1 to 65535 ps 0x0000: Reserved	

8.1.49 (DDR5): SDRAM Write to Write Command Delay for Different Bank in Same Bank Group (t_{CCD_M_WR})

Byte 97 (0x061): Least Significant Byte

Byte 98 (0x062): Most Significant Byte

Byte 99 (0x063): Lower Clock Limit

The 16-bit word in the lower two bytes defines the minimum SDRAM Write to Write command delay in picoseconds (ps) when accessing a different bank in the same bank group. The third byte defines the minimum number of clocks (nCK) required. For monolithic SDRAMs, this parameter is t_{CCD_M_WR}; for 3DS devices, this parameter is t_{CCD_M_WR_slr}. These values come from the DDR5 SDRAM data sheet, JESD79-5. The general algorithm is:

- Calculate the target t_{CCD_M_WR} clock count by applying the standard rounding algorithm to the 16-bit ps value and the application clock period in ps.
- Set the application t_{CCD_M_WR} in nCK units to the greater of the target t_{CCD_M_WR} or the lower clock limit.

Table 70 — DDR5 SDRAM Write to Write Command Delay for Different Bank in Same Bank Group (t_{CCD_M_WR})

nCK	ps	
Byte 99	Byte 98	Byte 97
Bits 7~0	Bits 15~8	Bits 7~0
Values defined from 1 to 255 clocks (nCK) 0x00: Reserved	Values defined from 1 to 65535 ps 0x0000: Reserved	

8.1.50 (DDR5): SDRAM Write to Read Command Delay for Different Bank in Same Bank Group (t_{CCD_M_WTR})

Byte 100 (0x064): Least Significant Byte

Byte 101 (0x065): Most Significant Byte

Byte 102 (0x066): Lower Clock Limit

The 16-bit word in the lower two bytes defines the analog portion (WTR(M)) of the minimum Write to Read command delay in picoseconds (ps) when accessing a different bank in the same bank group. The third byte defines the minimum number of clocks (nCK) required. For monolithic SDRAMs, this parameter is t_{CCD_M_WTR}; for 3DS devices, this parameter is t_{CCD_M_WTR_slr}. These values come from the DDR5 SDRAM data sheet, JESD79-5. The general algorithm is:

- Calculate the command time in clocks for CAS Write Latency (CWL) plus Write Burst Length divided by 2.
- Calculate the target WTR(M) clock count by applying the standard rounding algorithm to the 16-bit ps value and the application clock period in ps.
- Set the application WTR(M) in nCK units to the greater of the target WTR(L) or the lower clock limit.
- Set the application t_{CCD_M_WTR} to the sum of command time and WTR(M):
 $t_{CCD_M_WTR} = CWL + WBL/2 + WTR(M)$

Table 71 — DDR5 SDRAM Write to Read Command Delay for Different Bank in Same Bank Group (t_{CCD_M_WTR})

nCK	ps	
Byte 102	Byte 101	Byte 100
Bits 7~0	Bits 15~8	Bits 7~0
Values defined from 1 to 255 clocks (nCK) 0x00: Reserved	Values defined from 1 to 65535 ps 0x0000: Reserved	

8.1.51 (DDR5): Reserved, Base Configuration Section

Bytes 103~127 (0x067~0x07F)

Must be coded as 0x00

9 Example SPD Codes

The following tables show example codes for the SPD contents. These calculations account for the 0.3% correction factor allowed for digital math inaccuracies.

The clock periods for each standard speed grade used for these calculations are:

Table 72 — Clock Periods Used for Standard Speed Grade Calculations

tCK		
Grade	tCKmin	tCKmax
3200	0.625	1.010
3600	0.555	1.010
4000	0.500	1.010
4400	0.454	1.010
4800	0.416	1.010
5200	0.384	1.010
5600	0.357	1.010
6000	0.333	1.010
6400	0.312	1.010
6800	0.294	1.010
7200	0.277	1.010
7600	0.263	1.010
8000	0.250	1.010
8400	0.238	1.010
8800	0.227	1.010
9200	0.217	1.010

9.1 Core Parameters, DDR5 Monolithic Single Die Package (SDP) SDRAMs

Table 73 — Example 1: Core Parameters, DDR5 Monolithic Single Die Package SDRAMs

	3200AN Mono	3200B Mono	3200BN Mono	3200C Mono	3600AN Mono	3600B Mono	3600BN Mono	3600C Mono	4000AN Mono	4000B Mono	4000BN Mono	4000C Mono	
tCKmin	0.625	0.625	0.625	0.625	0.555	0.555	0.555	0.555	0.500	0.500	0.500	0.500	
tCKmax	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	
tAA	15.000	16.250	16.250	17.500	14.444	16.250	16.666	17.500	14.000	16.000	16.000	17.500	
tRCD	15.000	16.250	16.250	17.500	14.444	16.250	16.666	17.500	14.000	16.000	16.000	17.500	
tRP	15.000	16.250	16.250	17.500	14.444	16.250	16.666	17.500	14.000	16.000	16.000	17.500	
tRAS	32.000	32.000	32.000	32.000	32.000	32.000	32.000	32.000	32.000	32.000	32.000	32.000	
tRC	47.000	48.250	48.250	49.500	46.444	48.250	48.666	49.500	46.000	48.000	48.000	49.500	
tWR	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	
SPD #	tCKmin (ps)	625	625	625	625	555	555	555	555	500	500	500	500
20	tCKmin low	0x71	0x71	0x71	0x71	0x2B	0x2B	0x2B	0x2B	0xF4	0xF4	0xF4	0xF4
21	tCKmin high	0x02	0x02	0x02	0x02	0x02	0x02	0x02	0x02	0x01	0x01	0x01	0x01

Table 73 — Example 1: Core Parameters, DDR5 Monolithic Single Die Package SDRAMs (cont'd)

SPD #	tCKmax (ps)	1010	1010	1010	1010	1010	1010	1010	1010	1010	1010
22	tCKmax low	0xF2									
23	tCKmax high	0x03									
SPD #	tAA (ps)	15000	16250	16250	17500	14444	16250	16666	17500	14000	16000
30	tAA low	0x98	0x7A	0x7A	0x5C	0x6C	0x7A	0x1A	0x5C	0xB0	0x80
31	tAA high	0x3A	0x3F	0x3F	0x44	0x38	0x3F	0x41	0x44	0x3E	0x44
SPD #	tRCD (ps)	15000	16250	16250	17500	14444	16250	16666	17500	14000	16000
32	tRCD low	0x98	0x7A	0x7A	0x5C	0x6C	0x7A	0x1A	0x5C	0xB0	0x80
33	tRCD high	0x3A	0x3F	0x3F	0x44	0x38	0x3F	0x41	0x44	0x3E	0x44
SPD #	tRP (ps)	15000	16250	16250	17500	14444	16250	16666	17500	14000	16000
34	tRP low	0x98	0x7A	0x7A	0x5C	0x6C	0x7A	0x1A	0x5C	0xB0	0x80
35	tRP high	0x3A	0x3F	0x3F	0x44	0x38	0x3F	0x41	0x44	0x3E	0x44
SPD #	tRAS (ps)	32000	32000	32000	32000	32000	32000	32000	32000	32000	32000
36	tRAS low	0x00									
37	tRAS high	0x7D									
SPD #	tRC (ps)	47000	48250	48250	49500	46444	48250	48666	49500	46000	48000
38	tRC low	0x98	0x7A	0x7A	0x5C	0x6C	0x7A	0x1A	0x5C	0xB0	0x80
39	tRC high	0xB7	0xBC	0xBC	0xC1	0xB5	0xBC	0xBE	0xC1	0xB3	0xBB
SPD #	tWR (ps)	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000
40	tWR low	0x30									
41	tWR high	0x75									

9.1 Core Parameters, DDR5 Monolithic Single Die Package (SDP) SDRAMs (cont'd)

Table 74 — Example 2: Core Parameters, DDR5 Monolithic Single Die Package SDRAMs

	4400AN Mono	4400B Mono	4400BN Mono	4400C Mono	4800AN Mono	4800B Mono	4800BN Mono	4800C Mono	5200AN Mono	5200B Mono	5200BN Mono	5200C Mono	
tCKmin	0.454	0.454	0.454	0.454	0.416	0.416	0.416	0.416	0.384	0.384	0.384	0.384	
tCKmax	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	
tAA	14.545	16.000	16.363	17.500	14.166	16.000	16.666	17.500	14.615	16.000	16.153	17.500	
tRCD	14.545	16.000	16.363	17.500	14.166	16.000	16.666	17.500	14.615	16.000	16.153	17.500	
tRP	14.545	16.000	16.363	17.500	14.166	16.000	16.666	17.500	14.615	16.000	16.153	17.500	
tRAS	32.000	32.000	32.000	32.000	32.000	32.000	32.000	32.000	32.000	32.000	32.000	32.000	
tRC	46.545	48.000	48.363	49.500	46.166	48.000	48.666	49.500	46.615	48.000	48.153	49.500	
tWR	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	
SPD #	tCKmin (ps)	454	454	454	454	416	416	416	416	384	384	384	384
20	tCKmin low	0xC6	0xC6	0xC6	0xC6	0xA0	0xA0	0xA0	0xA0	0x80	0x80	0x80	0x80
21	tCKmin high	0x01	0x01	0x01	0x01								
SPD #	tCKmax (ps)	1010	1010	1010	1010	1010	1010	1010	1010	1010	1010	1010	1010
22	tCKmax low	0xF2	0xF2	0xF2	0xF2								
23	tCKmax high	0x03	0x03	0x03	0x03								
SPD #	tAA (ps)	14545	16000	16363	17500	14166	16000	16666	17500	14615	16000	16153	17500
30	tAA low	0xD1	0x80	0xEB	0x5C	0x56	0x80	0x1A	0x5C	0x17	0x80	0x18	0x5C
31	tAA high	0x38	0x3E	0x3F	0x44	0x37	0x3E	0x41	0x44	0x39	0x3E	0x3F	0x44
SPD #	tRCD (ps)	14545	16000	16363	17500	14166	16000	16666	17500	14615	16000	16153	17500
32	tRCD low	0xD1	0x80	0xEB	0x5C	0x56	0x80	0x1A	0x5C	0x17	0x80	0x18	0x5C
33	tRCD high	0x38	0x3E	0x3F	0x44	0x37	0x3E	0x41	0x44	0x39	0x3E	0x3F	0x44
SPD #	tRP (ps)	14545	16000	16363	17500	14166	16000	16666	17500	14615	16000	16153	17500
34	tRP low	0xD1	0x80	0xEB	0x5C	0x56	0x80	0x1A	0x5C	0x17	0x80	0x18	0x5C
35	tRP high	0x38	0x3E	0x3F	0x44	0x37	0x3E	0x41	0x44	0x39	0x3E	0x3F	0x44
SPD #	tRAS (ps)	32000	32000	32000	32000	32000	32000	32000	32000	32000	32000	32000	32000
36	tRAS low	0x00	0x00	0x00	0x00								
37	tRAS high	0x7D	0x7D	0x7D	0x7D								
SPD #	tRC (ps)	46545	48000	48363	49500	46166	48000	48666	49500	46615	48000	48153	49500
38	tRC low	0xD1	0x80	0xEB	0x5C	0x56	0x80	0x1A	0x5C	0x17	0x80	0x19	0x5C
39	tRC high	0xB5	0xBB	0xBC	0xC1	0xB4	0xBB	0xBE	0xC1	0xB6	0xBB	0xBC	0xC1
SPD #	tWR (ps)	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000
40	tWR low	0x30	0x30	0x30	0x30								
41	tWR high	0x75	0x75	0x75	0x75								

9.1 Core Parameters, DDR5 Monolithic Single Die Package (SDP) SDRAMs (cont'd)

Table 75 — Example 3: Core Parameters, DDR5 Monolithic Single Die Package SDRAMs

	5600AN Mono	5600B Mono	5600BN Mono	5600C Mono	6000AN Mono	6000B Mono	6000BN Mono	6000C Mono	6400AN Mono	6400B Mono	6400BN Mono	6400C Mono	
tCKmin	0.357	0.357	0.357	0.357	0.333	0.333	0.333	0.333	0.312	0.312	0.312	0.312	
tCKmax	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	
tAA	14.285	16.000	16.428	17.500	14.000	16.000	16.000	17.500	14.375	16.000	16.250	17.500	
tRCD	14.285	16.000	16.428	17.500	14.000	16.000	16.000	17.500	14.375	16.000	16.250	17.500	
tRP	14.285	16.000	16.428	17.500	14.000	16.000	16.000	17.500	14.375	16.000	16.250	17.500	
tRAS	32.000	32.000	32.000	32.000	32.000	32.000	32.000	32.000	32.000	32.000	32.000	32.000	
tRC	46.285	48.000	48.428	49.500	46.000	48.000	48.000	49.500	46.375	48.000	48.250	49.500	
tWR	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	
SPD #	tCKmin (ps)	357	357	357	357	333	333	333	333	312	312	312	312
20	tCKmin low	0x65	0x65	0x65	0x65	0x4D	0x4D	0x4D	0x4D	0x38	0x38	0x38	0x38
21	tCKmin high	0x01	0x01	0x01	0x01								
SPD #	tCKmax (ps)	1010	1010	1010	1010	1010	1010	1010	1010	1010	1010	1010	1010
22	tCKmax low	0xF2	0xF2	0xF2	0xF2								
23	tCKmax high	0x03	0x03	0x03	0x03								
SPD #	tAA (ps)	14285	16000	16428	17500	14000	16000	16000	17500	14375	16000	16250	17500
30	tAA low	0xCD	0x80	0x2C	0x5C	0xB0	0x80	0x80	0x5C	0x27	0x80	0x7A	0x5C
31	tAA high	0x37	0x3E	0x40	0x44	0x36	0x3E	0x3E	0x44	0x38	0x3E	0x3F	0x44
SPD #	tRCD (ps)	14285	16000	16428	17500	14000	16000	16000	17500	14375	16000	16250	17500
32	tRCD low	0xCD	0x80	0x2C	0x5C	0xB0	0x80	0x80	0x5C	0x27	0x80	0x7A	0x5C
33	tRCD high	0x37	0x3E	0x40	0x44	0x36	0x3E	0x3E	0x44	0x38	0x3E	0x3F	0x44
SPD #	tRP (ps)	14285	16000	16428	17500	14000	16000	16000	17500	14375	16000	16250	17500
34	tRP low	0xCD	0x80	0x2C	0x5C	0xB0	0x80	0x80	0x5C	0x27	0x80	0x7A	0x5C
35	tRP high	0x37	0x3E	0x40	0x44	0x36	0x3E	0x3E	0x44	0x38	0x3E	0x3F	0x44
SPD #	tRAS (ps)	32000	32000	32000	32000	32000	32000	32000	32000	32000	32000	32000	32000
36	tRAS low	0x00	0x00	0x00	0x00								
37	tRAS high	0x7D	0x7D	0x7D	0x7D								
SPD #	tRC (ps)	46285	48000	48428	49500	46000	48000	48000	49500	46375	48000	48250	49500
38	tRC low	0xCD	0x80	0x2C	0x5C	0xB0	0x80	0x80	0x5C	0x27	0x80	0x7A	0x5C
39	tRC high	0xB4	0xBB	0xBD	0xC1	0xB3	0xBB	0xBB	0xC1	0xB5	0xBB	0xBC	0xC1
SPD #	tWR (ps)	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000
40	tWR low	0x30	0x30	0x30	0x30								
41	tWR high	0x75	0x75	0x75	0x75								

9.1 Core Parameters, DDR5 Monolithic Single Die Package (SDP) SDRAMs (cont'd)

Table 76 — Example 4: Core Parameters, DDR5 Monolithic Single Die Package SDRAMs

	6800AN Mono	6800B Mono	6800BN Mono	6800C Mono	7200AN Mono	7200B Mono	7200BN Mono	7200C Mono	7600AN Mono	7600B Mono	7600BN Mono	7600C Mono	
tCKmin	0.294	0.294	0.294	0.294	0.277	0.277	0.277	0.277	0.263	0.263	0.263	0.263	
tCKmax	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	
tAA	14.117	16.000	16.470	17.500	14.444	16.000	16.111	17.500	14.210	16.000	16.315	17.500	
tRCD	14.117	16.000	16.470	17.500	14.444	16.000	16.111	17.500	14.210	16.000	16.315	17.500	
tRP	14.117	16.000	16.470	17.500	14.444	16.000	16.111	17.500	14.210	16.000	16.315	17.500	
tRAS	32.000	32.000	32.000	32.000	32.000	32.000	32.000	32.000	32.000	32.000	32.000	32.000	
tRC	46.117	48.000	48.000	49.500	46.444	48.000	48.111	49.500	46.210	48.000	48.315	49.500	
tWR	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	
SPD #	tCKmin (ps)	294	294	294	294	277	277	277	277	263	263	263	263
20	tCKmin low	0x26	0x26	0x26	0x26	0x15	0x15	0x15	0x15	0x07	0x07	0x07	0x07
21	tCKmin high	0x01	0x01	0x01	0x01								
SPD #	tCKmax (ps)	1010	1010	1010	1010	1010	1010	1010	1010	1010	1010	1010	1010
22	tCKmax low	0xF2	0xF2	0xF2	0xF2								
23	tCKmax high	0x03	0x03	0x03	0x03								
SPD #	tAA (ps)	14117	16000	16470	17500	14444	16000	16111	17500	14210	16000	16315	17500
30	tAA low	0x25	0x80	0x56	0x5C	0x6C	0x80	0xEF	0x5C	0x82	0x80	0xBB	0x5C
31	tAA high	0x37	0x3E	0x40	0x44	0x38	0x3E	0x3E	0x44	0x37	0x3E	0x3F	0x44
SPD #	tRCD (ps)	14117	16000	16470	17500	14444	16000	16111	17500	14210	16000	16315	17500
32	tRCD low	0x25	0x80	0x56	0x5C	0x6C	0x80	0xEF	0x5C	0x82	0x80	0xBB	0x5C
33	tRCD high	0x37	0x3E	0x40	0x44	0x38	0x3E	0x3E	0x44	0x37	0x3E	0x3F	0x44
SPD #	tRP (ps)	14117	16000	16470	17500	14444	16000	16111	17500	14210	16000	16315	17500
34	tRP low	0x25	0x80	0x56	0x5C	0x6C	0x80	0xEF	0x5C	0x82	0x80	0xBB	0x5C
35	tRP high	0x37	0x3E	0x40	0x44	0x38	0x3E	0x3E	0x44	0x37	0x3E	0x3F	0x44
SPD #	tRAS (ps)	32000	32000	32000	32000	32000	32000	32000	32000	32000	32000	32000	32000
36	tRAS low	0x00	0x00	0x00	0x00								
37	tRAS high	0x7D	0x7D	0x7D	0x7D								
SPD #	tRC (ps)	46117	48000	48000	49500	46444	48000	48111	49500	46210	48000	48315	49500
38	tRC low	0x25	0x80	0x80	0x5C	0x6C	0x80	0xEF	0x5C	0x82	0x80	0xBB	0x5C
39	tRC high	0xB4	0xBB	0xBB	0xC1	0xB5	0xBB	0xBB	0xC1	0xB4	0xBB	0xBC	0xC1
SPD #	tWR (ps)	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000
40	tWR low	0x30	0x30	0x30	0x30								
41	tWR high	0x75	0x75	0x75	0x75								

9.1 Core Parameters, DDR5 Monolithic Single Die Package (SDP) SDRAMs (cont'd)

Table 77 — Example 5: Core Parameters, DDR5 Monolithic Single Die Package SDRAMs

	8000AN Mono	8000B Mono	8000BN Mono	8000C Mono	8400AN Mono	8400B Mono	8400BN Mono	8400C Mono	8800AN Mono	8800B Mono	8800BN Mono	8800C Mono	9200AN Mono	9200B Mono	9200BN Mono	9200C Mono	
tCKmin	0.250	0.250	0.250	0.250	0.238	0.238	0.238	0.238	0.227	0.227	0.227	0.227	0.217	0.217	0.217	0.217	
tCKmax	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	
tAA	14.000	16.000	16.000	17.500	14.285	16.000	16.190	17.500	14.090	16.000	16.363	17.500	14.347	16.000	16.086	17.500	
tRCD	14.000	16.000	16.000	17.500	14.285	16.000	16.190	17.500	14.090	16.000	16.363	17.500	14.347	16.000	16.086	17.500	
tRP	14.000	16.000	16.000	17.500	14.285	16.000	16.190	17.500	14.090	16.000	16.363	17.500	14.347	16.000	16.086	17.500	
tRAS	32.000	32.000	32.000	32.000	32.000	32.000	32.000	32.000	32.000	32.000	32.000	32.000	32.000	32.000	32.000	32.000	
tRC	46.000	48.000	48.000	49.500	46.285	48.000	48.190	49.500	46.090	48.000	48.363	49.500	46.347	48.000	48.087	49.500	
tWR	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	
SPD #	tCKmin (ps)	250	250	250	250	238	238	238	238	227	227	227	227	217	217	217	217
20	tCKmin low	0xFA	0xFA	0xFA	0xFA	0xEE	0xEE	0xEE	0xEE	0xE3	0xE3	0xE3	0xE3	0xD9	0xD9	0xD9	0xD9
21	tCKmin high	0x00	0x00	0x00	0x00												
SPD #	tCKmax (ps)	1010	1010	1010	1010	1010	1010	1010	1010	1010	1010	1010	1010	1010	1010	1010	1010
22	tCKmax low	0xF2	0xF2	0xF2	0xF2												
23	tCKmax high	0x03	0x03	0x03	0x03												
SPD #	tAA (ps)	14000	16000	16000	17500	14285	16000	16190	17500	14090	16000	16363	17500	14347	16000	16086	17500
30	tAA low	0xB0	0x80	0x80	0x5C	0xCD	0x80	0x3E	0x5C	0xA	0x80	0xEB	0x5C	0x0B	0x80	0xD5	0x5C
31	tAA high	0x36	0x3E	0x3E	0x44	0x37	0x3E	0x3F	0x44	0x37	0x3E	0x3F	0x44	0x38	0x3E	0x3E	0x44
SPD #	tRCD (ps)	14000	16000	16000	17500	14285	16000	16190	17500	14090	16000	16363	17500	14347	16000	16086	17500
32	tRCD low	0xB0	0x80	0x80	0x5C	0xCD	0x80	0x3E	0x5C	0xA	0x80	0xEB	0x5C	0x0B	0x80	0xD5	0x5C
33	tRCD high	0x36	0x3E	0x3E	0x44	0x37	0x3E	0x3F	0x44	0x37	0x3E	0x3F	0x44	0x38	0x3E	0x3E	0x44
SPD #	tRP (ps)	14000	16000	16000	17500	14285	16000	16190	17500	14090	16000	16363	17500	14347	16000	16086	17500
34	tRP low	0xB0	0x80	0x80	0x5C	0xCD	0x80	0x3E	0x5C	0xA	0x80	0xEB	0x5C	0x0B	0x80	0xD5	0x5C
35	tRP high	0x36	0x3E	0x3E	0x44	0x37	0x3E	0x3F	0x44	0x37	0x3E	0x3F	0x44	0x38	0x3E	0x3E	0x44
SPD #	tRAS (ps)	32000	32000	32000	32000	32000	32000	32000	32000	32000	32000	32000	32000	32000	32000	32000	32000
36	tRAS low	0x00	0x00	0x00	0x00												
37	tRAS high	0x7D	0x7D	0x7D	0x7D												
SPD #	tRC (ps)	46000	48000	48000	49500	46285	48000	48190	49500	46090	48000	48363	49500	46347	48000	48087	49500
38	tRC low	0xB0	0x80	0x80	0x5C	0xCD	0x80	0x3E	0x5C	0xA	0x80	0xEB	0x5C	0x0B	0x80	0xD7	0x5C
39	tRC high	0xB3	0xBB	0xBB	0xC1	0xB4	0xBB	0xBC	0xC1	0xB4	0xBB	0xBC	0xC1	0xB5	0xBB	0xBB	0xC1
SPD #	tWR (ps)	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000
40	tWR low	0x30	0x30	0x30	0x30												
41	tWR high	0x75	0x75	0x75	0x75												

9.2 Parameters with Lower nCK Limits, DDR5 Monolithic Single Die Package SDRAMs

Table 78 — Example 6: Parameters with Lower nCK Limits, DDR5 Monolithic SDP SDRAMs

		DDR5-3200 Mono	DDR5-3600 Mono	DDR5-4000 Mono	DDR5-4400 Mono	DDR5-4800 Mono	DDR5-5200 Mono	DDR5-5600 Mono	DDR5-6000 Mono	DDR5-6400 Mono
tRRD_L (2K)	ps	5000	5000	5000	5000	5000	5000	5000	5000	5000
tRRD_L (2K)	nCK	8	8	8	8	8	8	8	8	8
tRRD_L (1K)	ps	5000	5000	5000	5000	5000	5000	5000	5000	5000
tRRD_L (1K)	nCK	8	8	8	8	8	8	8	8	8
tCCD_L	ps	5000	5000	5000	5000	5000	5000	5000	5000	5000
tCCD_L	nCK	8	8	8	8	8	8	8	8	8
tCCD_L_WR	ps	20000	20000	20000	20000	20000	20000	20000	20000	20000
tCCD_L_WR	nCK	32	32	32	32	32	32	32	32	32
tCCD_L_WR2	ps	10000	10000	10000	10000	10000	10000	10000	10000	10000
tCCD_L_WR2	nCK	16	16	16	16	16	16	16	16	16
tFAW(2K)	ps	25000	22222	20000	18181	16666	15384	14285	13333	12500
tFAW(2K)	nCK	40	40	40	40	40	40	40	40	40
tFAW(1K)	ps	20000	17777	16000	14545	13333	12307	11428	10666	10000
tFAW(1K)	nCK	32	32	32	32	32	32	32	32	32
tCCD_L_WTR	ps	10000	10000	10000	10000	10000	10000	10000	10000	10000
tCCD_L_WTR	nCK	16	16	16	16	16	16	16	16	16
tCCD_S_WTR	ps	2500	2500	2500	2500	2500	2500	2500	2500	2500
tCCD_S_WTR	nCK	4	4	4	4	4	4	4	4	4
tRTP	ps	7500	7500	7500	7500	7500	7500	7500	7500	7500
tRTP	nCK	12	12	12	12	12	12	12	12	12
tCCD_M	ps	5000	5000	5000	5000	5000	5000	5000	5000	5000
tCCD_M	nCK	8	8	8	8	8	8	8	8	8
tCCD_M_WR	ps	20000	20000	20000	20000	20000	20000	20000	20000	20000
tCCD_M_WR	nCK	32	32	32	32	32	32	32	32	32
tCCD_M_WTR	ps	10000	10000	10000	10000	10000	10000	10000	10000	10000
tCCD_M_WTR	nCK	16	16	16	16	16	16	16	16	16

SPD#		DDR5-3200 Mono	DDR5-3600 Mono	DDR5-4000 Mono	DDR5-4400 Mono	DDR5-4800 Mono	DDR5-5200 Mono	DDR5-5600 Mono	DDR5-6000 Mono	DDR5-6400 Mono
71, 70	tRRD_L (2K)	MSB, LSB	0x13, 0x88							
72	tRRD_L (2K)	nCK	0x08							
71, 70	tRRD_L (1K)	MSB, LSB	0x13, 0x88							
72	tRRD_L (1K)	nCK	0x08							
74, 73	tCCD_L	MSB, LSB	0x13, 0x88							
75	tCCD_L	nCK	0x08							
77, 76	tCCD_L_WR	MSB, LSB	0x4E, 0x20							
78	tCCD_L_WR	nCK	0x20							
80, 79	tCCD_L_WR2	MSB, LSB	0x27, 0x10							
81	tCCD_L_WR2	nCK	0x10							
83, 82	tFAW(2K)	MSB, LSB	0x61, 0xA8	0x56, 0xCE	0x4E, 0x20	0x47, 0x05	0x41, 0x1A	0x3C, 0x18	0x37, 0xCD	0x34, 0x15
84	tFAW(2K)	nCK	0x28							
83, 82	tFAW(1K)	MSB, LSB	0x4E, 0x20	0x45, 0x71	0x3E, 0x80	0x38, 0xD1	0x34, 0x15	0x30, 0x13	0x2C, 0xA4	0x29, 0xAA
84	tFAW(1K)	nCK	0x20							
86, 85	tCCD_L_WTR	MSB, LSB	0x27, 0x10							
87	tCCD_L_WTR	nCK	0x10							
89, 88	tCCD_S_WTR	MSB, LSB	0x09, 0xC4							
90	tCCD_S_WTR	nCK	0x04							
92, 91	tRTP	MSB, LSB	0x1D, 0x4C							
93	tRTP	nCK	0x0C							
94, 95	tCCD_M	MSB, LSB	0x13, 0x88							
96	tCCD_M	nCK	0x08							
97, 98	tCCD_M_WR	MSB, LSB	0x4E, 0x20							
99	tCCD_M_WR	nCK	0x20							
100, 101	tCCD_M_WTR	MSB, LSB	0x27, 0x10							
102	tCCD_M_WTR	nCK	0x10							

9.2 Parameters with Lower nCK Limits, DDR5 Monolithic Single Die Package SDRAMs (cont'd)

Table 79 — Example 7: Parameters with Lower nCK Limits, DDR5 Monolithic SDP SDRAMs

		DDR5-6800 Mono	DDR5-7200 Mono	DDR5-7600 Mono	DDR5-8000 Mono	DDR5-8400 Mono	DDR5-8800 Mono	DDR5-9200 Mono
t _{RRD_L} (2K)	ps	5000	5000	4210	4000	3809	3863	3695
t _{RRD_L} (2K)	nCK	8	8	8	8	8	8	8
t _{RRD_L} (1K)	ps	5000	5000	4210	4000	3809	3863	3695
t _{RRD_L} (1K)	nCK	8	8	8	8	8	8	8
t _{CCD_L}	ps	5000	5000	5000	5000	5000	5000	5000
t _{CCD_L}	nCK	8	8	8	8	8	8	8
t _{CCD_L_WR}	ps	20000	20000	20000	20000	20000	20000	20000
t _{CCD_L_WR}	nCK	32	32	32	32	32	32	32
t _{CCD_L_WR2}	ps	10000	10000	10000	10000	10000	10000	10000
t _{CCD_L_WR2}	nCK	16	16	16	16	16	16	16
t _{FAW} (2K)	ps	11764	11111	10526	10000	9523	9090	8695
t _{FAW} (2K)	nCK	40	40	40	40	40	40	40
t _{FAW} (1K)	ps	9411	8888	8421	8000	7619	7272	6956
t _{FAW} (1K)	nCK	32	32	32	32	32	32	32
t _{CCD_L_WTR}	ps	10000	10000	10000	10000	10000	10000	10000
t _{CCD_L_WTR}	nCK	16	16	16	16	16	16	16
t _{CCD_S_WTR}	ps	2352	2222	2105	2000	1904	1818	1739
t _{CCD_S_WTR}	nCK	4	4	4	4	4	4	4
t _{RTP}	ps	7500	7500	7500	7500	7500	7500	7500
t _{RTP}	nCK	12	12	12	12	12	12	12
t _{CCD_M}	ps	4705	4444	4210	4000	3809	3863	3913
t _{CCD_M}	nCK	8	8	8	8	8	8	8
t _{CCD_M_WR}	ps	18823	17777	16842	16000	15238	14545	14782
t _{CCD_M_WR}	nCK	32	32	32	32	32	32	32
t _{CCD_M_WTR}	ps	9411	8888	8421	8000	7619	7272	6956
t _{CCD_M_WTR}	nCK	16	16	16	16	16	16	16

SPD#		DDR5-6800 Mono	DDR5-7200 Mono	DDR5-7600 Mono	DDR5-8000 Mono	DDR5-8400 Mono	DDR5-8800 Mono	DDR5-9200 Mono
71, 70	t _{RRD_L} (2K)	MSB, LSB	0x13, 0x88	0x13, 0x88	0x10, 0x72	0x0F, 0xA0	0x0E, 0xE1	0x0F, 0x17
72	t _{RRD_L} (2K)	nCK	0x08	0x08	0x08	0x08	0x08	0x08
71, 70	t _{RRD_L} (1K)	MSB, LSB	0x13, 0x88	0x13, 0x88	0x10, 0x72	0x0F, 0xA0	0x0E, 0xE1	0x0F, 0x17
72	t _{RRD_L} (1K)	nCK	0x08	0x08	0x08	0x08	0x08	0x08
74, 73	t _{CCD_L}	MSB, LSB	0x13, 0x88					
75	t _{CCD_L}	nCK	0x08	0x08	0x08	0x08	0x08	0x08
77, 76	t _{CCD_L_WR}	MSB, LSB	0x4E, 0x20					
78	t _{CCD_L_WR}	nCK	0x20	0x20	0x20	0x20	0x20	0x20
80, 79	t _{CCD_L_WR2}	MSB, LSB	0x27, 0x10					
81	t _{CCD_L_WR2}	nCK	0x10	0x10	0x10	0x10	0x10	0x10
83, 82	t _{FAW} (2K)	MSB, LSB	0x2D, 0xF4	0x2B, 0x67	0x29, 0x1E	0x27, 0x10	0x25, 0x33	0x23, 0x82
84	t _{FAW} (2K)	nCK	0x28	0x28	0x28	0x28	0x28	0x28
83, 82	t _{FAW} (1K)	MSB, LSB	0x24, 0xC3	0x22, 0xB8	0x20, 0xE5	0x1F, 0x40	0x1D, 0xC3	0x1C, 0x68
84	t _{FAW} (1K)	nCK	0x20	0x20	0x20	0x20	0x20	0x20
86, 85	t _{CCD_L_WTR}	MSB, LSB	0x27, 0x10					
87	t _{CCD_L_WTR}	nCK	0x10	0x10	0x10	0x10	0x10	0x10
89, 88	t _{CCD_S_WTR}	MSB, LSB	0x09, 0x30	0x08, 0xAE	0x08, 0x39	0x07, 0xD0	0x07, 0x70	0x07, 0x1A
90	t _{CCD_S_WTR}	nCK	0x04	0x04	0x04	0x04	0x04	0x04
92, 91	t _{RTP}	MSB, LSB	0x1D, 0x4C					
93	t _{RTP}	nCK	0x0C	0x0C	0x0C	0x0C	0x0C	0x0C
95, 94	t _{CCD_M}	MSB, LSB	0x12, 0x61	0x11, 0x5C	0x10, 0x72	0x0F, 0xA0	0x0E, 0xE1	0x0F, 0x17
96	t _{CCD_M}	nCK	0x08	0x08	0x08	0x08	0x08	0x08
98, 97	t _{CCD_M_WR}	MSB, LSB	0x49, 0x87	0x45, 0x71	0x41, 0xCA	0x3E, 0x80	0x3B, 0x86	0x38, 0xD1
99	t _{CCD_M_WR}	nCK	0x20	0x20	0x20	0x20	0x20	0x20
101, 100	t _{CCD_M_WTR}	MSB, LSB	0x24, 0xC3	0x22, 0xB8	0x20, 0xE5	0x1F, 0x40	0x1D, 0xC3	0x1C, 0x68
102	t _{CCD_M_WTR}	nCK	0x10	0x10	0x10	0x10	0x10	0x10

9.3 CAS Latency Masks, DDR5 Monolithic Single Die Package SDRAMs

Optional downbins are included. Optional CAS latencies are not included.

Table 80 — CAS Latency Masks, DDR5 Monolithic Single Die Package SDRAMs

Mono Speed Bin	SPD[24]	SPD[25]	SPD[26]	SPD[27]	SPD[28]
3200AN	0x1E	0x00	0x00	0x00	0x00
3200B	0x1A	0x00	0x00	0x00	0x00
3200BN	0x1A	0x00	0x00	0x00	0x00
3200C	0x12	0x00	0x00	0x00	0x00
3600AN	0x7E	0x00	0x00	0x00	0x00
3600B	0x7A	0x00	0x00	0x00	0x00
3600BN	0x72	0x00	0x00	0x00	0x00
3600C	0x52	0x00	0x00	0x00	0x00
4000AN	0x7E	0x01	0x00	0x00	0x00
4000B	0x7A	0x01	0x00	0x00	0x00
4000BN	0x7A	0x01	0x00	0x00	0x00
4000C	0x52	0x01	0x00	0x00	0x00
4400AN	0x7E	0x05	0x00	0x00	0x00
4400B	0x7A	0x05	0x00	0x00	0x00
4400BN	0x72	0x05	0x00	0x00	0x00
4400C	0x52	0x05	0x00	0x00	0x00
4800AN	0xFE	0x0D	0x00	0x00	0x00
4800B	0x7A	0x0D	0x00	0x00	0x00
4800BN	0x72	0x0D	0x00	0x00	0x00
4800C	0x52	0x0D	0x00	0x00	0x00
5200AN	0x7E	0x2F	0x00	0x00	0x00
5200B	0x7A	0x2D	0x00	0x00	0x00
5200BN	0x7A	0x2D	0x00	0x00	0x00
5200C	0x52	0x2D	0x00	0x00	0x00
5600AN	0x7E	0xAF	0x00	0x00	0x00
5600B	0x7A	0xAD	0x00	0x00	0x00
5600BN	0x72	0xAD	0x00	0x00	0x00
5600C	0x52	0xAD	0x00	0x00	0x00
6000AN	0xFE	0xEF	0x02	0x00	0x00
6000B	0x7A	0xED	0x02	0x00	0x00
6000BN	0x7A	0xED	0x02	0x00	0x00
6000C	0x52	0xAD	0x02	0x00	0x00
6400AN	0x7E	0xEF	0x07	0x00	0x00
6400B	0x7A	0xED	0x07	0x00	0x00
6400BN	0x7A	0xED	0x07	0x00	0x00
6400C	0x52	0xAD	0x06	0x00	0x00
6800AN	0xFE	0xEF	0xF7	0x00	0x00
6800B	0x7A	0xED	0x17	0x00	0x00
6800BN	0x72	0xAD	0x16	0x00	0x00
6800C	0x52	0xAD	0x16	0x00	0x00
7200AN	0x7E	0xEF	0x5F	0x00	0x00
7200B	0x7A	0xED	0x5F	0x00	0x00
7200BN	0x7A	0xAD	0x5F	0x00	0x00
7200C	0x52	0xAD	0x56	0x00	0x00
7600AN	0x7E	0xED	0x7F	0x01	0x00
7600B	0x7A	0xED	0x7F	0x01	0x00
7600BN	0x72	0xAD	0x76	0x01	0x00
7600C	0x52	0xAD	0x56	0x01	0x00
8000AN	0xFE	0xEF	0x7F	0x03	0x00
8000B	0x7A	0xED	0x7F	0x03	0x00
8000BN	0x7A	0xED	0x7F	0x03	0x00
8000C	0x52	0xAD	0x56	0x03	0x00
8400AN	0x7E	0xEF	0x7F	0x0B	0x00
8400B	0x7A	0xED	0x7F	0x0B	0x00
8400BN	0x7A	0xAD	0x77	0x0B	0x00
8400C	0x52	0xAD	0x56	0x0B	0x00
8800AN	0xFE	0xEF	0x7F	0x2F	0x00
8800B	0x7A	0xED	0x7F	0x2F	0x00
8800BN	0x72	0xAD	0x56	0x2F	0x00
8800C	0x52	0xAD	0x56	0x2B	0x00
9200AN	0xFE	0xEF	0xFF	0xAF	0x00
9200B	0x7A	0xED	0x7F	0xAF	0x00
9200BN	0x72	0xAD	0x56	0xAF	0x00
9200C	0x52	0xAD	0x56	0xAF	0x00

9.4 Parameters Defined by Device Density, DDR5 Monolithic Single Die Package (SDP) SDRAMs

**Table 81 — Parameters Defined by Device Density,
DDR5 Monolithic Single Die Package (SDP) SDRAMs**

	SPD[43]	SPD[42]	
	ns	MSB	LSB
tRFC1, 8Gb	195	0x00	0xC3
tRFC1, 16Gb	295	0x01	0x27
tRFC1, 24Gb	410	0x01	0x9A
tRFC1, 32Gb	410	0x01	0x9A

	SPD[45]	SPD[44]	
	ns	MSB	LSB
tRFC2, 8Gb	130	0x00	0x82
tRFC2, 16Gb	160	0x00	0xA0
tRFC2, 24Gb	220	0x00	0xDC
tRFC2, 32Gb	220	0x00	0xDC

	SPD[47]	SPD[46]	
	ns	MSB	LSB
tRFCsb, 8Gb	115	0x00	0x73
tRFCsb, 16Gb	130	0x00	0x82
tRFCsb, 24Gb	190	0x00	0xBE
tRFCsb, 32Gb	190	0x00	0xBE

9.5 Core Parameters, DDR5 Multi-Die Packages (3DS) SDRAMs

Table 82 — Example 1: Core Parameters, DDR5 Multi-Die Packages (3DS) SDRAMs

	3200AN 3DS	3200B 3DS	3200BN 3DS	3200C 3DS	3600AN 3DS	3600B 3DS	3600BN 3DS	3600C 3DS	4000AN 3DS	4000B 3DS	4000BN 3DS	4000C 3DS	
tCKmin	0.625	0.625	0.625	0.625	0.555	0.555	0.555	0.555	0.500	0.500	0.500	0.500	
tCKmax	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	
tAA	16.250	18.750	18.750	20.000	16.666	18.750	18.888	20.000	16.000	18.750	19.000	20.000	
tRCD	15.000	16.250	16.250	17.500	14.444	16.250	16.666	17.500	14.000	16.000	16.000	17.500	
tRP	15.000	16.250	16.250	17.500	14.444	16.250	16.666	17.500	14.000	16.000	16.000	17.500	
tRAS	32.000	32.000	32.000	32.000	32.000	32.000	32.000	32.000	32.000	32.000	32.000	32.000	
tRC	45.750	48.250	48.250	49.500	46.444	48.250	48.666	49.500	46.000	48.000	48.000	49.500	
tWR	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	
SPD #	tCKmin (ps)	625	625	625	625	555	555	555	555	500	500	500	500
20	tCKmin low	0x71	0x71	0x71	0x71	0x2B	0x2B	0x2B	0x2B	0xF4	0xF4	0xF4	0xF4
21	tCKmin high	0x02	0x02	0x02	0x02	0x02	0x02	0x02	0x02	0x01	0x01	0x01	0x01
SPD #	tCKmax (ps)	1010	1010	1010	1010	1010	1010	1010	1010	1010	1010	1010	1010
22	tCKmax low	0xF2	0xF2	0xF2	0xF2								
23	tCKmax high	0x03	0x03	0x03	0x03								
SPD #	tAA (ps)	16250	18750	18750	20000	16666	18750	18888	20000	16000	18750	19000	20000
30	tAA low	0x7A	0x3E	0x3E	0x20	0x1A	0x3E	0xC8	0x20	0x80	0x3E	0x38	0x20
31	tAA high	0x3F	0x49	0x49	0x4E	0x41	0x49	0x49	0x4E	0x3E	0x49	0x4A	0x4E
SPD #	tRCD (ps)	15000	16250	16250	17500	14444	16250	16666	17500	14000	16000	16000	17500
32	tRCD low	0x98	0x7A	0x7A	0x5C	0x6C	0x7A	0x1A	0x5C	0xB0	0x80	0x80	0x5C
33	tRCD high	0x3A	0x3F	0x3F	0x44	0x38	0x3F	0x41	0x44	0x36	0x3E	0x3E	0x44
SPD #	tRP (ps)	15000	16250	16250	17500	14444	16250	16666	17500	14000	16000	16000	17500
34	tRP low	0x98	0x7A	0x7A	0x5C	0x6C	0x7A	0x1A	0x5C	0xB0	0x80	0x80	0x5C
35	tRP high	0x3A	0x3F	0x3F	0x44	0x38	0x3F	0x41	0x44	0x36	0x3E	0x3E	0x44
SPD #	tRAS (ps)	32000	32000	32000	32000	32000	32000	32000	32000	32000	32000	32000	32000
36	tRAS low	0x00	0x00	0x00	0x00								
37	tRAS high	0x7D	0x7D	0x7D	0x7D								
SPD #	tRC (ps)	45750	48250	48250	49500	46444	48250	48666	49500	46000	48000	48000	49500
38	tRC low	0xB6	0x7A	0x7A	0x5C	0x6C	0x7A	0x1A	0x5C	0xB0	0x80	0x80	0x5C
39	tRC high	0xB2	0xBC	0xBC	0xC1	0xB5	0xBC	0xBE	0xC1	0xB3	0xBB	0xBB	0xC1
SPD #	tWR (ps)	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000
40	tWR low	0x30	0x30	0x30	0x30								
41	tWR high	0x75	0x75	0x75	0x75								

9.5 Core Parameters, DDR5 Multi-Die Packages (3DS) SDRAMs (cont'd)

Table 83 — Example 2: Core Parameters, DDR5 Multi-Die Packages (3DS) SDRAMs

	4400AN 3DS	4400B 3DS	4400BN 3DS	4400C 3DS	4800AN 3DS	4800B 3DS	4800BN 3DS	4800C 3DS	5200AN 3DS	5200B 3DS	5200BN 3DS	5200C 3DS	
tCKmin	0.454	0.454	0.454	0.454	0.416	0.416	0.416	0.416	0.384	0.384	0.384	0.384	
tCKmax	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	
tAA	16.363	18.750	19.090	20.000	16.666	18.750	19.166	20.000	16.153	18.750	19.230	20.000	
tRCD	14.545	16.000	16.363	17.500	14.166	16.000	16.666	17.500	14.615	16.000	16.153	17.500	
tRP	14.545	16.000	16.363	17.500	14.166	16.000	16.666	17.500	14.615	16.000	16.153	17.500	
tRAS	32.000	32.000	32.000	32.000	32.000	32.000	32.000	32.000	32.000	32.000	32.000	32.000	
tRC	46.545	48.000	48.363	49.500	46.166	48.000	48.666	49.500	46.615	48.000	49.500	49.500	
tWR	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	
SPD #	tCKmin (ps)	454	454	454	454	416	416	416	416	384	384	384	384
20	tCKmin low	0xC6	0xC6	0xC6	0xC6	0xA0	0xA0	0xA0	0xA0	0x80	0x80	0x80	0x80
21	tCKmin high	0x01	0x01	0x01	0x01								
SPD #	tCKmax (ps)	1010	1010	1010	1010	1010	1010	1010	1010	1010	1010	1010	1010
22	tCKmax low	0xF2	0xF2	0xF2	0xF2								
23	tCKmax high	0x03	0x03	0x03	0x03								
SPD #	tAA (ps)	16363	18750	19090	20000	16666	18750	19166	20000	16153	18750	19230	20000
30	tAA low	0xEB	0x3E	0x92	0x20	0x1A	0x3E	0xDE	0x20	0x18	0x3E	0x1E	0x20
31	tAA high	0x3F	0x49	0x4A	0x4E	0x41	0x49	0x4A	0x4E	0x3F	0x49	0x4B	0x4E
SPD #	tRCD (ps)	14545	16000	16363	17500	14166	16000	16666	17500	14615	16000	16153	17500
32	tRCD low	0xD1	0x80	0xEB	0x5C	0x56	0x80	0x1A	0x5C	0x17	0x80	0x18	0x5C
33	tRCD high	0x38	0x3E	0x3F	0x44	0x37	0x3E	0x41	0x44	0x39	0x3E	0x3F	0x44
SPD #	tRP (ps)	14545	16000	16363	17500	14166	16000	16666	17500	14615	16000	16153	17500
34	tRP low	0xD1	0x80	0xEB	0x5C	0x56	0x80	0x1A	0x5C	0x17	0x80	0x18	0x5C
35	tRP high	0x38	0x3E	0x3F	0x44	0x37	0x3E	0x41	0x44	0x39	0x3E	0x3F	0x44
SPD #	tRAS (ps)	32000	32000	32000	32000	32000	32000	32000	32000	32000	32000	32000	32000
36	tRAS low	0x00	0x00	0x00	0x00								
37	tRAS high	0x7D	0x7D	0x7D	0x7D								
SPD #	tRC (ps)	46545	48000	48363	49500	46166	48000	48666	49500	46615	48000	49500	49500
38	tRC low	0xD1	0x80	0xEB	0x5C	0x56	0x80	0x1A	0x5C	0x17	0x80	0x5C	0x5C
39	tRC high	0xB5	0xBB	0xBC	0xC1	0xB4	0xBB	0xBE	0xC1	0xB6	0xBB	0xC1	0xC1
SPD #	tWR (ps)	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000
40	tWR low	0x30	0x30	0x30	0x30								
41	tWR high	0x75	0x75	0x75	0x75								

9.5 Core Parameters, DDR5 Multi-Die Packages (3DS) SDRAMs (cont'd)

Table 84 — Example 3: Core Parameters, DDR5 Multi-Die Packages (3DS) SDRAMs

	5600AN 3DS	5600B 3DS	5600BN 3DS	5600C 3DS	6000AN 3DS	6000B 3DS	6000BN 3DS	6000C 3DS	6400AN 3DS	6400B 3DS	6400BN 3DS	6400C 3DS	
tCKmin	0.357	0.357	0.357	0.357	0.333	0.333	0.333	0.333	0.312	0.312	0.312	0.312	
tCKmax	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	
tAA	16.428	18.571	18.571	20.000	16.000	18.571	18.666	20.000	16.250	18.571	18.750	20.000	
tRCD	14.285	16.000	16.428	17.500	14.000	16.000	16.000	17.500	14.375	16.000	16.250	17.500	
tRP	14.285	16.000	16.428	17.500	14.000	16.000	16.000	17.500	14.375	16.000	16.250	17.500	
tRAS	32.000	32.000	32.000	32.000	32.000	32.000	32.000	32.000	32.000	32.000	32.000	32.000	
tRC	46.285	48.000	48.428	49.500	46.000	48.000	48.000	49.500	46.375	48.000	48.250	49.500	
tWR	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	
SPD #	tCKmin (ps)	357	357	357	357	333	333	333	333	312	312	312	312
20	tCKmin low	0x65	0x65	0x65	0x65	0x4D	0x4D	0x4D	0x4D	0x38	0x38	0x38	0x38
21	tCKmin high	0x01	0x01	0x01	0x01								
SPD #	tCKmax (ps)	1010	1010	1010	1010	1010	1010	1010	1010	1010	1010	1010	1010
22	tCKmax low	0xF2	0xF2	0xF2	0xF2								
23	tCKmax high	0x03	0x03	0x03	0x03								
SPD #	tAA (ps)	16428	18571	18571	20000	16000	18571	18666	20000	16250	18571	18750	20000
30	tAA low	0x2C	0x8B	0x8B	0x20	0x80	0x8B	0xEA	0x20	0x7A	0x8B	0x3E	0x20
31	tAA high	0x40	0x48	0x48	0x4E	0x3E	0x48	0x48	0x4E	0x3F	0x48	0x49	0x4E
SPD #	tRCD (ps)	14285	16000	16428	17500	14000	16000	16000	17500	14375	16000	16250	17500
32	tRCD low	0xCD	0x80	0x2C	0x5C	0xB0	0x80	0x80	0x5C	0x27	0x80	0x7A	0x5C
33	tRCD high	0x37	0x3E	0x40	0x44	0x36	0x3E	0x3E	0x44	0x38	0x3E	0x3F	0x44
SPD #	tRP (ps)	14285	16000	16428	17500	14000	16000	16000	17500	14375	16000	16250	17500
34	tRP low	0xCD	0x80	0x2C	0x5C	0xB0	0x80	0x80	0x5C	0x27	0x80	0x7A	0x5C
35	tRP high	0x37	0x3E	0x40	0x44	0x36	0x3E	0x3E	0x44	0x38	0x3E	0x3F	0x44
SPD #	tRAS (ps)	32000	32000	32000	32000	32000	32000	32000	32000	32000	32000	32000	32000
36	tRAS low	0x00	0x00	0x00	0x00								
37	tRAS high	0x7D	0x7D	0x7D	0x7D								
SPD #	tRC (ps)	46285	48000	48428	49500	46000	48000	48000	49500	46375	48000	48250	49500
38	tRC low	0xCD	0x80	0x2C	0x5C	0xB0	0x80	0x80	0x5C	0x27	0x80	0x7A	0x5C
39	tRC high	0xB4	0xBB	0xBD	0xC1	0xB3	0xBB	0xBB	0xC1	0xB5	0xBB	0xBC	0xC1
SPD #	tWR (ps)	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000
40	tWR low	0x30	0x30	0x30	0x30								
41	tWR high	0x75	0x75	0x75	0x75								

9.5 Core Parameters, DDR5 Multi-Die Packages (3DS) SDRAMs (cont'd)

Table 85 — Example 4: Core Parameters, DDR5 Multi-Die Packages (3DS) SDRAMs

	6800AN 3DS	6800B 3DS	6800BN 3DS	6800C 3DS	7200AN 3DS	7200B 3DS	7200BN 3DS	7200C 3DS	7600AN 3DS	7600B 3DS	7600BN 3DS	7600C 3DS	
tCKmin	0.294	0.294	0.294	0.294	0.277	0.277	0.277	0.277	0.263	0.263	0.263	0.263	
tCKmax	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	
tAA	16.470	18.571	18.823	20.000	16.111	18.571	18.888	20.000	16.315	18.571	18.947	20.000	
tRCD	14.117	16.000	16.470	17.500	14.444	16.000	16.111	17.500	14.210	16.000	16.315	17.500	
tRP	14.117	16.000	16.470	17.500	14.444	16.000	16.111	17.500	14.210	16.000	16.315	17.500	
tRAS	32.000	32.000	32.000	32.000	32.000	32.000	32.000	32.000	32.000	32.000	32.000	32.000	
tRC	46.117	48.000	48.000	49.500	46.444	48.000	48.111	49.500	46.210	48.000	48.315	49.500	
tWR	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	
SPD #	tCKmin (ps)	294	294	294	294	277	277	277	277	263	263	263	263
20	tCKmin low	0x26	0x26	0x26	0x26	0x15	0x15	0x15	0x15	0x07	0x07	0x07	0x07
21	tCKmin high	0x01	0x01	0x01	0x01								
SPD #	tCKmax (ps)	1010	1010	1010	1010	1010	1010	1010	1010	1010	1010	1010	1010
22	tCKmax low	0xF2	0xF2	0xF2	0xF2								
23	tCKmax high	0x03	0x03	0x03	0x03								
SPD #	tAA (ps)	16470	18571	18823	20000	16111	18571	18888	20000	16315	18571	18947	20000
30	tAA low	0x56	0x8B	0x87	0x20	0xEF	0x8B	0xC8	0x20	0xBB	0x8B	0x03	0x20
31	tAA high	0x40	0x48	0x49	0x4E	0x3E	0x48	0x49	0x4E	0x3F	0x48	0x4A	0x4E
SPD #	tRCD (ps)	14117	16000	16470	17500	14444	16000	16111	17500	14210	16000	16315	17500
32	tRCD low	0x25	0x80	0x56	0x5C	0x6C	0x80	0xEF	0x5C	0x82	0x80	0xBB	0x5C
33	tRCD high	0x37	0x3E	0x40	0x44	0x38	0x3E	0x3E	0x44	0x37	0x3E	0x3F	0x44
SPD #	tRP (ps)	14117	16000	16470	17500	14444	16000	16111	17500	14210	16000	16315	17500
34	tRP low	0x25	0x80	0x56	0x5C	0x6C	0x80	0xEF	0x5C	0x82	0x80	0xBB	0x5C
35	tRP high	0x37	0x3E	0x40	0x44	0x38	0x3E	0x3E	0x44	0x37	0x3E	0x3F	0x44
SPD #	tRAS (ps)	32000	32000	32000	32000	32000	32000	32000	32000	32000	32000	32000	32000
36	tRAS low	0x00	0x00	0x00	0x00								
37	tRAS high	0x7D	0x7D	0x7D	0x7D								
SPD #	tRC (ps)	46117	48000	48000	49500	46444	48000	48111	49500	46210	48000	48315	49500
38	tRC low	0x25	0x80	0x80	0x5C	0x6C	0x80	0xEF	0x5C	0x82	0x80	0xBB	0x5C
39	tRC high	0xB4	0xBB	0xBB	0xC1	0xB5	0xBB	0xBB	0xC1	0xB4	0xBB	0xBC	0xC1
SPD #	tWR (ps)	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000
40	tWR low	0x30	0x30	0x30	0x30								
41	tWR high	0x75	0x75	0x75	0x75								

9.5 Core Parameters, DDR5 Multi-Die Packages (3DS) SDRAMs (cont'd)

Table 86 — Example 5: Core Parameters, DDR5 Multi-Die Packages (3DS) SDRAMs

	8000AN 3DS	8000B 3DS	8000BN 3DS	8000C 3DS	8400AN 3DS	8400B 3DS	8400BN 3DS	8400C 3DS	8800AN 3DS	8800B 3DS	8800BN 3DS	8800C 3DS	9200AN 3DS	9200B 3DS	9200BN 3DS	9200C 3DS	
tCKmin	0.250	0.250	0.250	0.250	0.238	0.238	0.238	0.238	0.227	0.227	0.227	0.227	0.217	0.217	0.217	0.217	
tCKmax	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	
tAA	16.000	18.500	18.500	20.000	16.190	18.500	18.571	20.000	16.363	18.500	18.636	20.000	16.087	18.500	18.695	20.000	
tRCD	14.000	16.000	16.000	17.500	14.285	16.000	16.190	17.500	14.090	16.000	16.363	17.500	14.347	16.000	16.086	17.500	
tRP	14.000	16.000	16.000	17.500	14.285	16.000	16.190	17.500	14.090	16.000	16.363	17.500	14.347	16.000	16.086	17.500	
tRAS	32.000	32.000	32.000	32.000	32.000	32.000	32.000	32.000	32.000	32.000	32.000	32.000	32.000	32.000	32.000	32.000	
tRC	46.000	48.000	48.000	49.500	46.285	48.000	48.190	49.500	46.090	48.000	48.363	49.500	46.347	48.000	48.087	49.500	
tWR	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	
SPD #	tCKmin (ps)	250	250	250	250	238	238	238	238	227	227	227	227	217	217	217	217
20	tCKmin low	0xFA	0xFA	0xFA	0xFA	0xEE	0xEE	0xEE	0xEE	0xE3	0xE3	0xE3	0xE3	0xD9	0xD9	0xD9	0xD9
21	tCKmin high	0x00	0x00	0x00	0x00												
SPD #	tCKmax (ps)	1010	1010	1010	1010	1010	1010	1010	1010	1010	1010	1010	1010	1010	1010	1010	1010
22	tCKmax low	0xF2	0xF2	0xF2	0xF2												
23	tCKmax high	0x03	0x03	0x03	0x03												
SPD #	tAA (ps)	16000	18500	18500	20000	16190	18500	18571	20000	16363	18500	18636	20000	16087	18500	18695	20000
30	tAA low	0x80	0x44	0x44	0x20	0x3E	0x44	0x8B	0x20	0xEB	0x44	0xCC	0x20	0xD7	0x44	0x07	0x20
31	tAA high	0x3E	0x48	0x48	0x4E	0x3F	0x48	0x48	0x4E	0x3F	0x48	0x48	0x4E	0x3E	0x48	0x49	0x4E
SPD #	tRCD (ps)	14000	16000	16000	17500	14285	16000	16190	17500	14090	16000	16363	17500	14347	16000	16086	17500
32	tRCD low	0xB0	0x80	0x80	0x5C	0xCD	0x80	0x3E	0x5C	0xA	0x80	0xEB	0x5C	0xB	0x80	0xD5	0x5C
33	tRCD high	0x36	0x3E	0x3E	0x44	0x37	0x3E	0x3F	0x44	0x37	0x3E	0x3F	0x44	0x38	0x3E	0x3E	0x44
SPD #	tRP (ps)	14000	16000	16000	17500	14285	16000	16190	17500	14090	16000	16363	17500	14347	16000	16086	17500
34	tRP low	0xB0	0x80	0x80	0x5C	0xCD	0x80	0x3E	0x5C	0xA	0x80	0xEB	0x5C	0xB	0x80	0xD5	0x5C
35	tRP high	0x36	0x3E	0x3E	0x44	0x37	0x3E	0x3F	0x44	0x37	0x3E	0x3F	0x44	0x38	0x3E	0x3E	0x44
SPD #	tRAS (ps)	32000	32000	32000	32000	32000	32000	32000	32000	32000	32000	32000	32000	32000	32000	32000	32000
36	tRAS low	0x00	0x00	0x00	0x00												
37	tRAS high	0x7D	0x7D	0x7D	0x7D												
SPD #	tRC (ps)	46000	48000	48000	49500	46285	48000	48190	49500	46090	48000	48363	49500	46347	48000	48087	49500
38	tRC low	0xB0	0x80	0x80	0x5C	0xCD	0x80	0x3E	0x5C	0xA	0x80	0xEB	0x5C	0xB	0x80	0xD7	0x5C
39	tRC high	0xB3	0xBB	0xBB	0xC1	0xB4	0xBB	0xBC	0xC1	0xB4	0xBB	0xBC	0xC1	0xB5	0xBB	0xBB	0xC1
SPD #	tWR (ps)	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000	30000
40	tWR low	0x30	0x30	0x30	0x30												
41	tWR high	0x75	0x75	0x75	0x75												

9.6 Parameters with Lower nCK Limits, DDR5 Multi-Die Packages (3DS) SDRAMs

Table 87 — Example 6: Parameters with Lower nCK Limits, DDR5 Multi-Die Packages (3DS) SDRAMs

		DDR5-3200 3DS	DDR5-3600 3DS	DDR5-4000 3DS	DDR5-4400 3DS	DDR5-4800 3DS	DDR5-5200 3DS	DDR5-5600 3DS	DDR5-6000 3DS	DDR5-6400 3DS
tRRD_L_slr (1K)	ps	5000	5000	5000	5000	5000	5000	5000	5000	5000
tRRD_L_slr (1K)	nCK	8	8	8	8	8	8	8	8	8
tCCD_L_slr	ps	5000	5000	5000	5000	5000	5000	5000	5000	5000
tCCD_L_slr	nCK	8	8	8	8	8	8	8	8	8
tCCD_L_WR_slr	ps	20000	20000	20000	20000	20000	20000	20000	20000	20000
tCCD_L_WR_slr	nCK	32	32	32	32	32	32	32	32	32
tCCD_L_WR2_slr	ps	10000	10000	10000	10000	10000	10000	10000	10000	10000
tCCD_L_WR2_slr	nCK	16	16	16	16	16	16	16	16	16
tFAW_slr (1K)	ps	20000	17777	16000	14545	13333	12307	11428	10666	10000
tFAW_slr (1K)	nCK	32	32	32	32	32	32	32	32	32
tCCD_L_WTR_slr	ps	10000	10000	10000	10000	10000	10000	10000	10000	10000
tCCD_L_WTR_slr	nCK	16	16	16	16	16	16	16	16	16
tCCD_S_WTR_slr	ps	2500	2500	2500	2500	2500	2500	2500	2500	2500
tCCD_S_WTR_slr	nCK	4	4	4	4	4	4	4	4	4
tRTP_slr	ps	7500	7500	7500	7500	7500	7500	7500	7500	7500
tRTP_slr	nCK	12	12	12	12	12	12	12	12	12
tCCD_M_slr	ps	5000	5000	5000	5000	5000	5000	5000	5000	5000
tCCD_M_slr	nCK	8	8	8	8	8	8	8	8	8
tCCD_M_WR_slr	ps	20000	20000	20000	20000	20000	20000	20000	20000	20000
tCCD_M_WR_slr	nCK	32	32	32	32	32	32	32	32	32
tCCD_M_WTR_slr	ps	10000	10000	10000	10000	10000	10000	10000	10000	10000
tCCD_M_WTR_slr	nCK	16	16	16	16	16	16	16	16	16

SPD#			DDR5-3200 3DS	DDR5-3600 3DS	DDR5-4000 3DS	DDR5-4400 3DS	DDR5-4800 3DS	DDR5-5200 3DS	DDR5-5600 3DS	DDR5-6000 3DS	DDR5-6400 3DS
71, 70	tRRD_L_slr (1K)	MSB, LSB	0x13, 0x88								
72	tRRD_L_slr (1K)	nCK	0x08								
74, 73	tCCD_L_slr	MSB, LSB	0x13, 0x88								
75	tCCD_L_slr	nCK	0x08								
77, 76	tCCD_L_WR_slr	MSB, LSB	0x4E, 0x20								
78	tCCD_L_WR_slr	nCK	0x20								
80, 79	tCCD_L_WR2_slr	MSB, LSB	0x27, 0x10								
81	tCCD_L_WR2_slr	nCK	0x10								
83, 82	tFAW_slr (1K)	MSB, LSB	0x4E, 0x20	0x45, 0x71	0x3E, 0x80	0x38, 0xD1	0x34, 0x15	0x30, 0x13	0x2C, 0xA4	0x29, 0xAA	0x27, 0x10
84	tFAW_slr (1K)	nCK	0x20								
86, 85	tCCD_L_WTR_slr	MSB, LSB	0x27, 0x10								
87	tCCD_L_WTR_slr	nCK	0x10								
89, 88	tCCD_S_WTR_slr	MSB, LSB	0x09, 0xC4								
90	tCCD_S_WTR_slr	nCK	0x04								
92, 91	tRTP_slr	MSB, LSB	0x1D, 0x4C								
93	tRTP_slr	nCK	0x0C								
95, 94	tCCD_M_slr	MSB, LSB	0x13, 0x88								
96	tCCD_M_slr	nCK	0x08								
98, 97	tCCD_M_WR_slr	MSB, LSB	0x4E, 0x20								
99	tCCD_M_WR_slr	nCK	0x20								
101, 100	tCCD_M_WTR_slr	MSB, LSB	0x27, 0x10								
102	tCCD_M_WTR_slr	nCK	0x10								

9.6 Parameters with Lower nCK Limits, DDR5 Multi-Die Packages (3DS) SDRAMs (cont'd)

Table 88 — Example 7: Parameters with Lower nCK Limits, DDR5 Multi-Die Packages (3DS) SDRAM

		DDR5-6800 3DS	DDR5-7200 3DS	DDR5-7600 3DS	DDR5-8000 3DS	DDR5-8400 3DS	DDR5-8800 3DS	DDR5-9200 3DS
tRRD_L_slr (1K)	ps	4705	4444	4210	4000	4000	3863	3695
tRRD_L_slr (1K)	nCK	8	8	8	8	8	8	8
tCCD_L_slr	ps	5000	5000	5000	5000	5000	5000	5000
tCCD_L_slr	nCK	8	8	8	8	8	8	8
tCCD_L_WR_slr	ps	20000	20000	20000	20000	20000	20000	20000
tCCD_L_WR_slr	nCK	32	32	32	32	32	32	32
tCCD_L_WR2_slr	ps	10000	10000	10000	10000	10000	10000	10000
tCCD_L_WR2_slr	nCK	16	16	16	16	16	16	16
tFAW_slr (1K)	ps	9411	8888	8421	8000	7619	7272	6956
tFAW_slr (1K)	nCK	32	32	32	32	32	32	32
tCCD_L_WTR_slr	ps	10000	10000	10000	10000	10000	10000	10000
tCCD_L_WTR_slr	nCK	16	16	16	16	16	16	16
tCCD_S_WTR_slr	ps	2352	2222	2105	2000	1904	1818	1739
tCCD_S_WTR_slr	nCK	4	4	4	4	4	4	4
tRTP_slr	ps	7500	7500	7500	7500	7500	7500	7500
tRTP_slr	nCK	12	12	12	12	12	12	12
tCCD_M_slr	ps	4705	4444	4210	4000	4000	3863	3919
tCCD_M_slr	nCK	8	8	8	8	8	8	8
tCCD_M_WR_slr	ps	18823	17777	16842	16000	15238	14545	14782
tCCD_M_WR_slr	nCK	32	32	32	32	32	32	32
tCCD_M_WTR_slr	ps	9411	8888	8421	8000	7619	7272	6956
tCCD_M_WTR_slr	nCK	16	16	16	16	16	16	16

SPD#		DDR5-6800 3DS	DDR5-7200 3DS	DDR5-7600 3DS	DDR5-8000 3DS	DDR5-8400 3DS	DDR5-8800 3DS	DDR5-9200 3DS	
71, 70	tRRD_L_slr (1K)	MSB, LSB	0x12, 0x61	0x11, 0x5C	0x10, 0x72	0x0F, 0xA0	0x0F, 0xA0	0x0F, 0x17	0x0E, 0x6F
72	tRRD_L_slr (1K)	nCK	0x08	0x08	0x08	0x08	0x08	0x08	0x08
74, 73	tCCD_L_slr	MSB, LSB	0x13, 0x88	0x13, 0x88					
75	tCCD_L_slr	nCK	0x08	0x08	0x08	0x08	0x08	0x08	0x08
77, 76	tCCD_L_WR_slr	MSB, LSB	0x4E, 0x20	0x4E, 0x20					
78	tCCD_L_WR_slr	nCK	0x20	0x20	0x20	0x20	0x20	0x20	0x20
80, 79	tCCD_L_WR2_slr	MSB, LSB	0x27, 0x10	0x27, 0x10					
81	tCCD_L_WR2_slr	nCK	0x10	0x10	0x10	0x10	0x10	0x10	0x10
83, 82	tFAW_slr (1K)	MSB, LSB	0x24, 0xC3	0x22, 0xB8	0x20, 0xE5	0x1F, 0x40	0x1D, 0xC3	0x1C, 0x68	0x1B, 0x2C
84	tFAW_slr (1K)	nCK	0x20	0x20	0x20	0x20	0x20	0x20	0x20
86, 85	tCCD_L_WTR_slr	MSB, LSB	0x27, 0x10	0x27, 0x10					
87	tCCD_L_WTR_slr	nCK	0x10	0x10	0x10	0x10	0x10	0x10	0x10
89, 88	tCCD_S_WTR_slr	MSB, LSB	0x09, 0x30	0x08, 0xAE	0x08, 0x39	0x07, 0xD0	0x07, 0x70	0x07, 0x1A	0x06, 0xCB
90	tCCD_S_WTR_slr	nCK	0x04	0x04	0x04	0x04	0x04	0x04	0x04
92, 91	tRTP_slr	MSB, LSB	0x1D, 0x4C	0x1D, 0x4C					
93	tRTP_slr	nCK	0x0C	0x0C	0x0C	0x0C	0x0C	0x0C	0x0C
95, 94	tCCD_M_slr	MSB, LSB	0x12, 0x61	0x11, 0x5C	0x10, 0x72	0x0F, 0xA0	0x0F, 0xA0	0x0F, 0x17	0x0F, 0x4F
96	tCCD_M_slr	nCK	0x08	0x08	0x08	0x08	0x08	0x08	0x08
98, 97	tCCD_M_WR_slr	MSB, LSB	0x49, 0x87	0x45, 0x71	0x41, 0xCA	0x3E, 0x80	0x3B, 0x86	0x38, 0xD1	0x39, 0xBE
99	tCCD_M_WR_slr	nCK	0x20	0x20	0x20	0x20	0x20	0x20	0x20
101, 100	tCCD_M_WTR_slr	MSB, LSB	0x24, 0xC3	0x22, 0xB8	0x20, 0xE5	0x1F, 0x40	0x1D, 0xC3	0x1C, 0x68	0x1B, 0x2C
102	tCCD_M_WTR_slr	nCK	0x10	0x10	0x10	0x10	0x10	0x10	0x10

9.7 CAS Latency Masks, DDR5 Multi-Die Packages (3DS) SDRAMs

Optional downbins are included. Optional CAS latencies are not included.

Table 89 — CAS Latency Masks, DDR5 Multi-Die Packages (3DS) SDRAMs

3DS Speed Bin	SPD[24]	SPD[25]	SPD[26]	SPD[27]	SPD[28]
3200AN 3DS	0x6A	0x00	0x00	0x00	0x00
3200B 3DS	0x62	0x00	0x00	0x00	0x00
3200BN 3DS	0x62	0x00	0x00	0x00	0x00
3200C 3DS	0x42	0x00	0x00	0x00	0x00
3600AN 3DS	0xE2	0x01	0x00	0x00	0x00
3600B 3DS	0xE2	0x01	0x00	0x00	0x00
3600BN 3DS	0xC2	0x01	0x00	0x00	0x00
3600C 3DS	0x42	0x01	0x00	0x00	0x00
4000AN 3DS	0xEA	0x07	0x00	0x00	0x00
4000B 3DS	0xE2	0x07	0x00	0x00	0x00
4000BN 3DS	0x42	0x07	0x00	0x00	0x00
4000C 3DS	0x42	0x05	0x00	0x00	0x00
4400AN 3DS	0xE2	0x1F	0x00	0x00	0x00
4400B 3DS	0xE2	0x1F	0x00	0x00	0x00
4400BN 3DS	0x42	0x1D	0x00	0x00	0x00
4400C 3DS	0x42	0x15	0x00	0x00	0x00
4800AN 3DS	0xE2	0x7F	0x00	0x00	0x00
4800B 3DS	0xE2	0x7F	0x00	0x00	0x00
4800BN 3DS	0x42	0x75	0x00	0x00	0x00
4800C 3DS	0x42	0x55	0x00	0x00	0x00
5200AN 3DS	0xEA	0xFF	0x01	0x00	0x00
5200B 3DS	0xE2	0xFF	0x01	0x00	0x00
5200BN 3DS	0x42	0xD5	0x01	0x00	0x00
5200C 3DS	0x42	0x55	0x01	0x00	0x00
5600AN 3DS	0xE2	0xFF	0x05	0x00	0x00
5600B 3DS	0xE2	0xFF	0x05	0x00	0x00
5600BN 3DS	0xC2	0x75	0x05	0x00	0x00
5600C 3DS	0x42	0x55	0x05	0x00	0x00
6000AN 3DS	0xEA	0xFF	0x15	0x00	0x00
6000B 3DS	0xE2	0xFF	0x15	0x00	0x00
6000BN 3DS	0xE2	0xFF	0x15	0x00	0x00
6000C 3DS	0x42	0x55	0x15	0x00	0x00
6400AN 3DS	0xEA	0xFF	0x55	0x00	0x00
6400B 3DS	0xE2	0xFF	0x5F	0x00	0x00
6400BN 3DS	0xE2	0x7D	0x55	0x00	0x00
6400C 3DS	0x42	0x55	0x55	0x00	0x00
6800AN 3DS	0xE2	0xFF	0x5D	0x01	0x00
6800B 3DS	0xE2	0xFF	0x55	0x01	0x00
6800BN 3DS	0xC2	0xFD	0x54	0x01	0x00
6800C 3DS	0x42	0x55	0x55	0x01	0x00
7200AN 3DS	0xEA	0xFF	0x5D	0x05	0x00
7200B 3DS	0xE2	0xFF	0x55	0x05	0x00
7200BN 3DS	0xC2	0xFD	0x55	0x05	0x00
7200C 3DS	0x42	0x55	0x55	0x05	0x00
7600AN 3DS	0xE2	0xFF	0x75	0x15	0x00
7600B 3DS	0xE2	0xFF	0x55	0x15	0x00
7600BN 3DS	0x42	0xFD	0x55	0x15	0x00
7600C 3DS	0x42	0x55	0x55	0x15	0x00
8000AN 3DS	0xEA	0xFF	0x7D	0x5D	0x00
8000B 3DS	0xE2	0xFF	0x55	0x5D	0x00
8000BN 3DS	0xE2	0xFF	0x55	0x5D	0x00
8000C 3DS	0x42	0x55	0x55	0x55	0x00
8400AN 3DS	0xEA	0xFF	0x75	0x7D	0x01
8400B 3DS	0xE2	0xFF	0x55	0x75	0x01
8400BN 3DS	0xE2	0xFF	0x55	0x75	0x01
8400C 3DS	0x42	0x55	0x55	0x55	0x01
8800AN 3DS	0xE2	0xFF	0x55	0xFD	0x05
8800B 3DS	0xE2	0xFF	0x55	0xFD	0x05
8800BN 3DS	0xC2	0x7D	0x55	0xD5	0x05

Table 89 — CAS Latency Masks, DDR5 Multi-Die Packages (3DS) SDRAMs (cont'd)

3DS Speed Bin	SPD[24]	SPD[25]	SPD[26]	SPD[27]	SPD[28]
8800C 3DS	0x42	0x55	0x55	0x55	0x05
9200AN 3DS	0xE2	0xFF	0x55	0xFD	0x15
9200B 3DS	0xE2	0xFF	0x55	0xFD	0x17
9200BN 3DS	0xC2	0x7D	0x55	0xD5	0x17
9200C 3DS	0x42	0x55	0x55	0x55	0x15

9.8 Parameters Defined by Device Density, DDR5 Multi-Die Packages (3DS) SDRAMs

Table 90 — Parameters Defined by Device Density, DDR5 Multi-Die Packages (3DS) SDRAMs

	SPD[43]	SPD[42]	
	ns	MSB	LSB
tRFC1_slr 3DS, 8Gb	195	0x00	0xC3
tRFC1_slr 3DS, 16Gb	295	0x01	0x27
tRFC1_slr 3DS, 24Gb	410	0x01	0x9A
tRFC1_slr 3DS, 32Gb	410	0x01	0x9A

	SPD[45]	SPD[44]	
	ns	MSB	LSB
tRFC2_slr 3DS, 8Gb	130	0x00	0x82
tRFC2_slr 3DS, 16Gb	160	0x00	0xA0
tRFC2_slr 3DS, 24Gb	220	0x00	0xDC
tRFC2_slr 3DS, 32Gb	220	0x00	0xDC

	SPD[47]	SPD[46]	
	ns	MSB	LSB
tRFCsb_slr 3DS, 8Gb	115	0x00	0x73
tRFCsb_slr 3DS, 16Gb	130	0x00	0x82
tRFCsb_slr 3DS, 24Gb	190	0x00	0xBE
tRFCsb_slr 3DS, 32Gb	190	0x00	0xBE

	SPD[49]	SPD[48]	
	ns	MSB	LSB
tRFC1_dlr 3DS, 8Gb	65	0x00	0x41
tRFC1_dlr 3DS, 16Gb	99	0x00	0x63
tRFC1_dlr 3DS, 24Gb	137	0x00	0x89
tRFC1_dlr 3DS, 32Gb	137	0x00	0x89

	SPD[51]	SPD[50]	
	ns	MSB	LSB
tRFC2_dlr 3DS, 8Gb	44	0x00	0x2C
tRFC2_dlr 3DS, 16Gb	54	0x00	0x36
tRFC2_dlr 3DS, 24Gb	74	0x00	0x4A
tRFC2_dlr 3DS, 32Gb	74	0x00	0x4A

	SPD[53]	SPD[52]	
	ns	MSB	LSB
tRFCsb_dlr 3DS, 8Gb	39	0x00	0x27
tRFCsb_dlr 3DS, 16Gb	44	0x00	0x2C
tRFCsb_dlr 3DS, 24Gb	64	0x00	0x40
tRFCsb_dlr 3DS, 32Gb	64	0x00	0x40

10 Annex Format (Blocks 3~6, 8~9, and 10~15)

10.1 Blocks 3~6: Module-Specific Section: Bytes 192~447 (0x0C0~0x1BF)

This section contains SPD bytes which are specific to families DDR5 module families. Module Type Key Byte 3 is used as an index for the encoding of bytes 192~447. The content of bytes 192~447 are described in multiple annexes, one for each memory module family. These bytes are write protected.

10.2 Blocks 8~9: Module Supplier's Data: Bytes 512~639 (0x200~0x27F)

These blocks of the SPD contain information specific to the memory module assembly including module manufacturer ID, manufacturing location, and module part number.

10.3 Blocks 10~15: End User Programmable, Bytes 640~1023 (0x280~0x3FF)

These blocks of the SPD are not write protected so that end users may program any values into these bytes during system runtime or for system management.

11 Annex A.0: Common SPD Bytes for All Module Types

(Bytes 192~447, 0x0C0~0x1BF)

This section describes SPD bytes that are common to all module types. Some bytes, as indicated in the table, are documented in separate annexes for each module type:

- A.1: Solder Down
- A.2: Unbuffered DIMMs (UDIMM)
- A.3: Registered DIMMs (RDIMM) and Load Reduced DIMMs (LRDIMM)
- A.4: Multiplexed Rank DIMMs (MRDIMM)
- A.5: Differential DIMMs (DDIMM)
- A.6: Non-Volatile DIMMs, -N (NVDIMM-N)
- A.7: Non-Volatile DIMMs, -P (NVDIMM-P)
- A.8: Compression Attached, (CAMM2)

Table 91 — SPD Bytes Common to All Module Types

Byte Number		Function Described
192	0x0C0	SPD Revision for SPD bytes 192~447
193	0x0C1	Hashing Sequence
194	0x0C2	SPD Manufacturer ID Code, First Byte
195	0x0C3	SPD Manufacturer ID Code, Second Byte
196	0x0C4	SPD Device Type
197	0x0C5	SPD Device Revision Number
198	0x0C6	PMIC 0 Manufacturer ID Code, First Byte
199	0x0C7	PMIC 0 Manufacturer ID Code, Second Byte
200	0x0C8	PMIC 0 Device Type
201	0x0C9	PMIC 0 Revision Number
202	0x0CA	PMIC 1 Manufacturer ID Code, First Byte
203	0x0CB	PMIC 1 Manufacturer ID Code, Second Byte
204	0x0CC	PMIC 1 Device Type
205	0x0CD	PMIC 1 Revision Number
206	0x0CE	PMIC 2 Manufacturer ID Code, First Byte
207	0x0CF	PMIC 2 Manufacturer ID Code, Second Byte
208	0x0D0	PMIC 2 Device Type
209	0x0D1	PMIC 2 Revision Number
210	0x0D2	Thermal Sensor Manufacturer ID Code, First Byte
211	0x0D3	Thermal Sensor Manufacturer ID Code, Second Byte
212	0x0D4	Thermal Sensor Device Type
213	0x0D5	Thermal Sensor Revision Number
214~228	0x0D6~0x0E4	Reserved
229	0x0E5	Additional Support Devices
230	0x0E6	Module Nominal Height
231	0x0E7	Module Maximum Thickness

Table 91 — SPD Bytes Common to All Module Types (cont'd)

Byte Number		Function Described
232	0x0E8	Reference Raw Card Used
233	0x0E9	DIMM Attributes
234	0x0EA	Module Organization
235	0x0EB	Memory Channel Bus Width
236~239	0x0EC~0x0EF	Reserved
240~447	0x0F0~0x1BF	Module Type Specific Information. These SPD bytes are unique to each module type. See the appropriate annex for the module.

11.1 (Common): SPD Revision for Module Information

Byte 192 (0x0C0)

This byte defines the SPD revision for bytes 192~447. See SPD byte 1 for details.

11.2 (Common): Hashing Sequence

Byte 193 (0x0C1)

This byte defines the sequence of device serial numbers used in the hashing of an attribute certificate for the authentication of a memory solution. See JESD316-5 Enhanced Serial Presence Detect Device Specification for details. If authentication is not supported, code as 0x00.

Table 92 — Hashing Sequence

Bits 7~3	Bits 2~0
Reserved	Serial Number Hashing Sequence
Reserved; must be coded as 00000	000 = No authentication 001 = Algorithm 1 ESPDs DRAMs PMICs RCDs/MRCDs/CKDs TSs DBs/MDBs All other codes reserved

11.3 (Common): Module Device Information

Bytes 194~213 (0x0C2~0xD5)

Table 93 lists the SPD byte addresses for the key components on this assembly.

Table 93 — Module Generic Device Information

Device	Manufacturer ID Code, First Byte		Manufacturer ID Code, Second Byte		Device Type		Device Revision	
	Dec	Hex	Dec	Hex	Dec	Hex	Dec	Hex
SPD	194	0x0C2	195	0x0C3	196	0x0C4	197	0x0C5
PMIC 0	198	0x0C6	199	0x0C7	200	0x0C8	201	0x0C9
PMIC 1	202	0x0CA	203	0x0CB	204	0x0CC	205	0x0CD
PMIC 2	206	0x0CE	207	0x0CF	208	0x0D0	209	0x0D1
Thermal Sensors (TS)	210	0x0D2	211	0x0D3	212	0x0D4	213	0x0D5

NOTES:
 SPD = Serial Presence Detect
 PMIC = Power Management Integrated Circuit

Manufacturer ID Code: Per JEP106. See SPD bytes 512~513 for an example.

Device types:

Table 94 — Device Types

	Bit 7	Bit 6	Bits 5 ~ 4	Bits 3 ~ 0
Device	Devices Installed		Reserved	Device Type
SPD	0 = Not installed 1 = Installed	Reserved; must be coded as 0	Reserved. Must be coded as 00	0000: SPD5118 (see JESD300-5) 0001: ESPD5216 (see JESD316-5) All other codes reserved
PMIC 0	0 = Not installed 1 = Installed			0000: PMIC5000 (see JESD301-1) 0001: PMIC5010 (see JESD301-1) 0010: PMIC5100 (see JESD301-2) 0011: PMIC5020 (see JESD301-4) 0100: PMIC5120 (see JESD301-6) 0101: PMIC5200 (see JESD301-3) 0110: PMIC5030 (see JESD301-5) All other codes reserved
PMIC 1	0 = Not installed 1 = Installed			0000: TS5111 (see JESD302-1) 0001: TS5110 (see JESD302-1) 0010: TS5211 (see JESD302-1A) 0011: TS5210 (see JESD302-1A) All other codes reserved
PMIC 2	0 = Not installed 1 = Installed			0000: TS5111 (see JESD302-1) 0001: TS5110 (see JESD302-1) 0010: TS5211 (see JESD302-1A) 0011: TS5210 (see JESD302-1A) All other codes reserved
Thermal Sensors	0 = TS0 Not installed 1 = TS0 Installed	0 = TS1 Not installed 1 = TS1 Installed		

Device revision: This byte is coded as a major revision in bits 7~4 and minor revision in bits 3~0, each nibble expressed in BCD. For example, device stepping 3.2 would be coded as 0x32.

11.4 (Common): Reserved

Bytes 214~228 (0xD6~0xE4)

11.5 (Common): Additional Support Devices

Byte 229 (0xE5)

This byte defines additional support components on the module assembly.

Table 95 — Electrically Induced Physical Damage Protection Device Types

Bits 7~3	Bit 2	Bit 1	Bit 0
Reserved	Vin_mgmt Transient Voltage Suppression (TVS)	Vin_bulk Transient Voltage Suppression (TVS)	Vin_bulk Fuse
Reserved; must be coded as 00000	0 = Not installed 1 = Vin_mgmt TVS installed	0 = Not installed 1 = Vin_bulk TVS installed	0 = Not installed 1 = Vin_bulk Fuse installed

11.6 (Common): Module Nominal Height

Byte 230 (0xE6)

This byte defines the nominal height (A dimension) in millimeters of the fully assembled module including heat spreaders or other added components. Refer to the relevant JEDEC JC-11 module outline (MO) documents for dimension definitions.

Table 96 — Module Nominal Heights

Bits 7~5	Bits 4~0
Reserved	Module Nominal Height max, in mm (baseline height = 15 mm)
Reserved; must be coded as 000	00000 = height ≤ 15 mm 00001 = 15 < height ≤ 16 mm 00010 = 16 < height ≤ 17 mm 00011 = 17 < height ≤ 18 mm 00100 = 18 < height ≤ 19 mm ... 01010 = 24 < height ≤ 25 mm 01011 = 25 < height ≤ 26 mm ... 01111 = 29 < height ≤ 30 mm 10000 = 30 < height ≤ 31 mm 10001 = 31 < height ≤ 32 mm ... 11111 = 45 mm < height

11.6 Electrically Induced Physical Damage Protection Device Types (cont'd)

Examples:

Table 97 — Examples of Module Nominal Heights

Nominal Module Height	Coding, bits 4 ~ 0	Meaning
mm	Binary	mm
18.75	00100	18 < height ≤ 19 mm
25.40	01011	25 < height ≤ 26 mm
30.00	01111	29 < height ≤ 30 mm
30.25	10000	30 < height ≤ 31 mm
31.25	10001	31 < height ≤ 32 mm

11.7 (Common): Module Maximum Thickness

Byte 231 (0xE7)

This byte defines the maximum thickness in millimeters of the fully assembled module including heat spreaders or other added components above the module circuit board surface, rounding up to the next integer. Refer to the relevant JEDEC JC-11 module outline (MO) documents for dimension definitions.

Table 98 — Module Maximum Thickness

Bits 7 ~ 4	Bits 3 ~ 0
Module Maximum Thickness max, Back, in mm (baseline thickness = 1 mm)	Module Maximum Thickness max, Front, in mm (baseline thickness = 1 mm)
0000 = thickness ≤ 1 mm 0001 = 1 < thickness ≤ 2 mm 0010 = 2 < thickness ≤ 3 mm 0011 = 3 < thickness ≤ 4 mm ... 1110 = 14 < thickness ≤ 15 mm 1111 = 15 < thickness	0000 = thickness ≤ 1 mm 0001 = 1 < thickness ≤ 2 mm 0010 = 2 < thickness ≤ 3 mm 0011 = 3 < thickness ≤ 4 mm ... 1110 = 14 < thickness ≤ 15 mm 1111 = 15 < thickness

11.8 (Common): Reference Raw Card Used

Byte 232 (0xE8)

This byte indicates which JEDEC reference design raw card was used as the basis for the module assembly, if any. Special reference raw card indicator, ZZ, is used when no JEDEC standard raw card reference design was used as the basis for the module design. Pre-production modules should be encoded as revision 0 in bits 7~5.

Table 99 — Reference Raw Card Used

Bit 7~5	Bits 4~0
Design Revision	Reference Design
000 = Revision 0	00000 = A
001 = Revision 1	00001 = B
010 = Revision 2	00010 = C
011 = Revision 3	00011 = D
100 = Revision 4	00100 = E
101 = Revision 5	00101 = F
110 = Revision 6	00110 = G
111 = Reserved	00111 = H
	01000 = J
	01001 = K
	01010 = L
	01011 = M
	01100 = N
	01101 = P
	01110 = R
	01111 = T
	10000 = U
	10001 = V
	10010 = W
	10011 = Y
	10100 = AA
	10101 = AB
	10110 = AC
	10111 = AD
	11000 = AE
	11001 = AF
	11010 = AG
	11011 = AH
	11100 = AJ
	11101 = AK
	11110 = Reserved
	11111 = ZZ (No reference used)

NOTE 11111111 = ZZ (no JEDEC reference raw card design used)

11.9 (Common): DIMM Attributes

Byte 233 (0xE9)

This byte indicates the number of rows of DRAM packages (monolithic or 3D stacked) parallel to edge connector (independent of DRAM orientation) on each side of the printed circuit board, and whether the assembly is covered in a heat spreader. The temperature range applies to the SDRAM components on the module. All other support components on the module must remain within their respective operating temperature ranges when the case temperature of the SDRAMs are at the minimum and maximum values.

Table 100 — DIMM Attributes

Bits 7~4	Bit 3	Bit 2	Bits 1~0
Operating Temperature Range ¹	# of rows of DRAMs on Module, MSB	Heat Spreader	# of rows of DRAMs on Module, LSB
0000 = A1T (-40 to +125 °C) 0001 = A2T (-40 to +105 °C) 0010 = A3T (-40 to +85 °C) 0011 = IT (-40 to +95 °C) 0100 = ST (-25 to +85 °C) 0101 = ET (-25 to +105 °C) 0110 = RT (0 to +45 °C) 0111 = NT (0 to +85 °C) 1000 = XT (0 to +95 °C) ² All other codings reserved	See bits 1~0	0 = Not installed 1 = Installed	Bits [3, 1, 0] 000 = Undefined 001 = 1 row 010 = 2 rows 011 = 4 rows 100 = 3 rows All other codes reserved
NOTE 1 See JESD402-1 for details			
NOTE 2 Typical DDR5 SDRAM thermal specification is XT, 0 to +95 °C, code 1000 in bits 7~4			

11.10 (Common): Module Organization

Byte 234 (0xEA)

This byte describes the organization of the SDRAM module. Bits 5~3 encode the number of package ranks on the module. Bit 6 describes whether the assembly has the same SDRAM density on all ranks or has different SDRAM densities on even and odd ranks.

Table 101 — Module Organization

Bit 7	Bit 6	Bits 5~3	Bits 2~0
Reserved	Rank Mix	Number of Package Ranks per Sub-Channel	Reserved
Reserved; must be coded as 0	0 = Symmetrical 1 = Asymmetrical	Bit [5, 4, 3] : 000 = 1 Package Rank 001 = 2 Package Ranks 010 = 3 Package Ranks 011 = 4 Package Ranks 100 = 5 Package Ranks 101 = 6 Package Ranks 110 = 7 Package Ranks 111 = 8 Package Ranks	Reserved; must be coded as 000

11.10 (Common): Module Organization (cont'd)

"Package ranks per DIMM" refers to the collections of devices on the module sharing common chip select signals or copy of a chip select (across the data width of the DIMM sub-channel), either from the edge connector for unbuffered modules or from the outputs of a registering clock driver for RDIMMs and LRDIMMs.

"Logical rank" refers to the individually addressable die in a 3DS stack and has no meaning for monolithic SDRAMs, however, for the purposes of calculating the capacity of the module, one should treat monolithic SDRAMs as having one logical rank per package rank.

"Channel" refers to the data interface at the DIMM edge connector, and "Sub-channel" refers to the interface to the separately addressable groups of SDRAMs. For example, DDR5 DIMMs with an 80-bit channel width are addressable as two 40-bit sub-channels, often referred to as "left" and "right" or "Sub-channel A" and "Sub-channel B".

Byte 242 Bit 6 = 0 defines a memory module as being "symmetrical" where all SDRAM devices on the module are "First SDRAM" type per SPD bytes 4~7.

Examples shown cover 1 and 2 rank modules, i.e., codes 000 or 001 in SPD byte 234 bits 5~3; for higher package rank counts, apply the same logic.

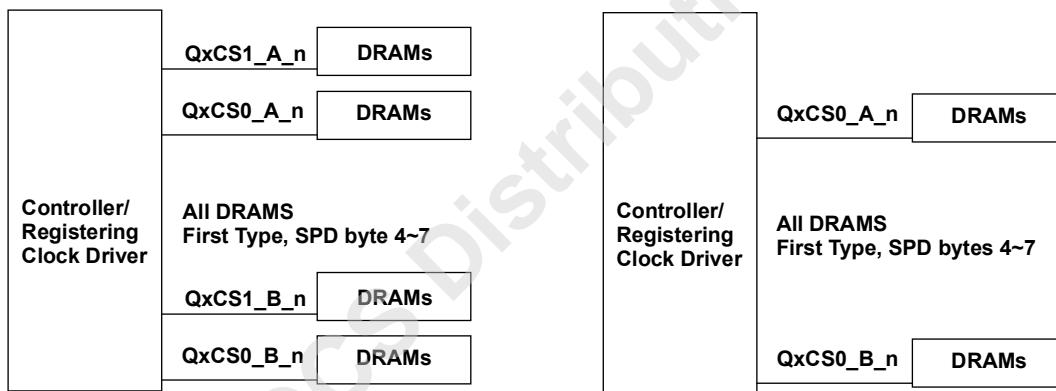


Figure 1 — Symmetrical Configurations (Byte 234 Bit 6 = 0)

11.10 (Common): Module Organization (cont'd)

Table 102 — Rank Matrix for Symmetrical Modules (Byte 234 Bit 6 = 0)

SDRAM Package Type	# Package Ranks per Channel	# Logical Ranks per Channel
SPD Byte 4 Bits 7~5	SPD Byte 234 Bits 5~3	Calculated
SDP	1	1
	2	2
2H 3DS	1	2
	2	4
4H 3DS	1	4
	2	8
8H 3DS	1	8
	2	16
16H 3DS	1	16
	2	32

NOTE Logical Ranks per Channel = # Package Ranks per Channel * # Logical Ranks per Package Rank
Bytes 8~10 coded as 0x00 for all symmetrical configurations

Byte 234 Bit 6 = 1 defines a memory module as being “asymmetrical”, where all DRAMs in even package ranks (0, 2, 4, 6) are of “First SDRAM” type per SPD bytes 4~7, and all DRAMs in odd package ranks (1, 3, 5, 7) are of “Second SDRAM” type as described in SPD bytes 8~11.

The example shown covers the case of a 2 rank module, i.e., code 001 in SPD byte 234 bits 5~3; for higher package rank counts, apply the same logic for even (Primary) and odd (Secondary) ranks.

The I/O width of all ranks (SPD byte 6 bits 7~5 and SPD byte 10 bits 7~5) in an asymmetrical assembly must be the same, e.g., all x4 or all x8.

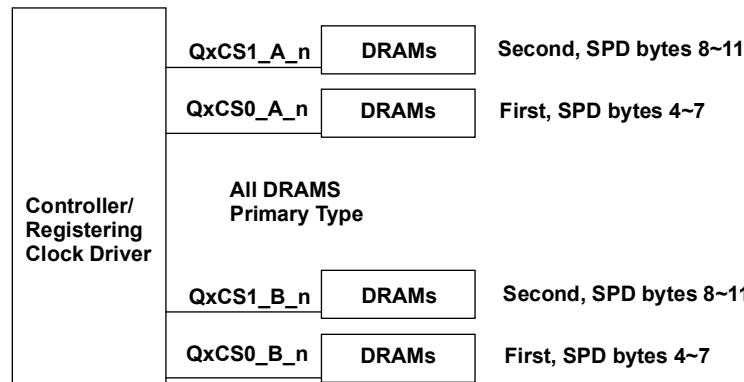


Figure 2 — Asymmetrical Configurations (Byte 234 Bit 6 = 1)

11.10 (Common): Module Organization (cont'd)

Table 103 — Rank Mix for Asymmetrical Modules (Byte 242 Bit 6 = 1)

First SDRAM Package Type	Second SDRAM Package Type	# Package Ranks per Channel	# Logical Ranks per Channel
SPD Byte 4 Bits 7~5	SPD Byte 8 Bits 7~5	SPD Byte 234 Bits 5~3	Calculated
SDP	2H 3DS	2	3
2H 3DS	SDP	2	3
SDP	4H 3DS	2	5
4H 3DS	SDP	2	5
...
8H 3DS	16H 3DS	2	24
16H 3DS	8H 3DS	2	24

NOTE Logical Ranks per DIMM = # Logical Ranks in Primary SDRAM type + # Logical Ranks in Secondary SDRAM type

11.11 (Common): Memory Channel Bus Width

Byte 235 (0x0EB)

This byte describes the width of the SDRAM memory bus on the module. Bits 2~0 encode the primary bus width. Bits 4~3 encode the bus extensions such as parity or ECC. Bits 7~5 defines the number of sub-channels on each module. Though a CAMM2 (compression attached memory module) is not technically a DIMM (dual in-line memory module), for the purposes of documentation a CAMM2 will be treated as a DIMM.

Table 104 — Memory Channel Bus Width

Bits 7~5	Bits 4~3	Bits 2~0
Number of Sub-Channels per DIMM	Bus Width Extension per Sub-Channel, in Bits	Primary Bus Width per Sub-Channel, in Bits
Bits [7, 6, 5] : 000 = 1 sub-channel 001 = 2 sub-channels 010 = 4 sub-channels 011 = 8 sub-channels All others reserved	Bit [4, 3] : 00 = 0 bits (no extension) 01 = 4 bits 10 = 8 bits All others reserved	Bit [2, 1, 0] : 000 = 8 bits 001 = 16 bits 010 = 32 bits 011 = 64 bits All others reserved

11.11 (Common): Memory Channel Bus Width (cont'd)

Examples:

Table 105 — Example Memory Channel Bus Width

Number of Sub-Channels Per DIMM	Bus Width Extension Per Sub-Channel	Primary Bus Width per Sub-Channel	Byte 235 Coding	Total Data Width per DIMM	Standard Usage
2	0	32	001 00 010	64	SODIMM, UDIMM
2	4	32	001 01 010	72	ECC SODIMM, ECC UDIMM
2	8	32	001 10 010	80	EC8 RDIMM, LRDIMM, NVDIMM, MRDIMM
2	4	32	001 01 010	72	EC4 RDIMM
4	0	32	010 00 010	128	Dual-channel DDR CAMM2

Calculating Module DRAM Capacity

The total memory capacity of the DRAM on a DIMM may be calculated from SPD values. Table 106 details the SPD bytes needed for the calculation.

Table 106 — SPD Bytes Needed for Module DRAM Capacity Calculation

Symmetry	Package Ranks per Sub-Channel	SDRAM Density per Die	Die per Package	SDRAM I/O Width	Primary Bus Width per Sub-Channel	Number of Sub-Channels per DIMM
0 = Symmetrical	All	SPD byte 4 Bits 4~0	SPD byte 4 Bits 7~5	SPD byte 6 Bits 7~5	SPD byte 235 Bits 2~0	SPD byte 235 Bits 7~5
1 = Asymmetrical	Even (0, 2, 4, 6)	SPD byte 4 Bits 4~0	SPD byte 4 Bits 7~5	SPD byte 6 Bits 7~5	SPD byte 235 Bits 2~0	SPD byte 235 Bits 7~5
	Odd (1, 3, 5, 7)	SPD byte 8 Bits 4~0	SPD byte 8 Bits 7~5	SPD byte 10 Bits 7~5	SPD byte 235 Bits 2~0	SPD byte 235 Bits 7~5

To calculate the total capacity in bytes for a symmetric module, the following math applies:

Capacity in bytes =

Number of sub-channels per DIMM *
Primary bus width per sub-channel / SDRAM I/O Width *
Die per package *
SDRAM density per die / 8 *
Package ranks per sub-channel

To calculate the total capacity in bytes for an asymmetric module, the following math applies:

Capacity in bytes =

Capacity of even ranks (first SDRAM type) +
Capacity of odd ranks (second SDRAM type)

Commonly, parity or ECC are not counted in total module capacity, though they can also be included by adding the bus width extension in SPD byte 235 bits 4~3 to the primary bus width in the previous examples.

11.12 (Common): Reserved

Bytes 236~239 (0x0EC~0xEF)

Reserved -- must be coded as 0x00

11.13 (Common): Module Type Specific Information

Bytes 240~447 (0x0F0~0x1BF)

These bytes are specific to each module type. See the appropriate annex for definition.

12 Annex A.1: Module Specific Bytes for Solder Down

(Bytes 192~447, 0x0C0~0x1BF)

Revision 1.1: Byte 192 coded as 0x11

This section defines the encoding of SPD bytes 192~447 when Memory Technology Key Byte 2 contains the value 0x12 and Module Type Key Byte 3 contains any of the following:

- 0xHB, Solder Down

where H refers to the hybrid memory architecture, if any present

See Annex A.0 for common SPD bytes 192~239 (0x0C0~0xEF).

Table 107 — Module Specific SPD Bytes for Solder Down Memory

Byte Number	Function Described	
240~447	0x0F0~0x1BF	Reserved

Bytes 240~447 (0x0F8~0x1BF) (Solder Down):

Reserved -- must be coded as 0x00.

13 Annex A.2: Module Specific Bytes for Clocked or Unbuffered Memory Module Types

(Bytes 192~447, 0x0C0~0x1BF)

Revision 1.1: Byte 192 coded as 0x11

This section defines the encoding of SPD bytes 192~447 when Memory Technology Key Byte 2 contains the value 0x12 and Module Type Key Byte 3 contains any of the following:

- 0x02, UDIMM
- 0x03, SODIMM
- 0x05, CUDIMM
- 0x06: CSODIMM

See Annex A.0 for common SPD bytes 192~239 (0x0C0~0EF).

Table 108 — Module Specific SPD Bytes for Unbuffered Module Types

Byte Number		Function Described
240	0x0F0	Clock Driver Manufacturer ID Code, First Byte
241	0x0F1	Clock Driver Manufacturer ID Code, Second Byte
242	0x0F2	Clock Driver Device Type
243	0x0F3	Clock Driver Revision Number
244	0x0F4	CKD-RW00 CKD Configuration
245	0x0F5	CKD-RW02 QCK Signals Driver Characteristics
246	0x0F6	CKD-RW03 QCK Output Differential Slew Rate
247~447	0x0F7~0x1BF	Reserved

13.1 (Unbuffered): Module Specific Device Information

Bytes 240~243 (0x0F0~0x0F3)

Table 109 lists the SPD byte addresses for the key components on this assembly.

Table 109 — Unbuffered Module Specific Device Information

Device	Manufacturer ID Code, First Byte		Manufacturer ID Code, Second Byte		Device Type		Device Revision	
	Dec	Hex	Dec	Hex	Dec	Hex	Dec	Hex
Clock Driver (CKD)	240	0x0F0	241	0x0F1	242	0x0F2	243	0x0F3

13.1 (Unbuffered): Module Specific Device Information (cont'd)

Manufacturer ID Code: Per JEP106. See SPD bytes 512~513 for an example.

Device types:

Table 110 — Unbuffered Module Specific Device Types

	Bit 7	Bit 6	Bits 5 ~ 4	Bits 3 ~ 0
Device	Devices Installed		Reserved	Device Type
Clock Driver (CKD)	0 = Not installed 1 = Installed	Reserved; must be coded as 0	Reserved. Must be coded as 00	0000: DDR5CKD01 (see JESD82-531) All other codes reserved

Device revision: This byte is coded as a major revision in bits 7~4 and minor revision in bits 3~0, each nibble expressed in BCD. For example, device stepping 3.2 would be coded as 0x32.

13.2 (Unbuffered): CKD-RW00 CKD Configuration

Byte 244 (0x0F4)

Byte defined as per JESD82-531 DDR5CKD01 specification.

Table 111 — Unbuffered CKD-RW00: CKD Configuration

Bit 7	Bit 6	Bit 5	Bit 4	Bits 3 ~ 2	Bits 1 ~ 0
CHB QCK1_B	CHB QCK0_B	CHA QCK1_B	CHA QCK0_B	ICT Input Clock Termination Settings	PLL Mode
0 = Enabled 1 = Disabled	Reserved; must be coded in the SPD as 00; modified by the host controller via MRW to select the ICT Setting.	Reserved; must be coded in the SPD as 00; modified by the host controller via MRW to select the PLL Mode.			

13.3 (Unbuffered): CKD-RW02 QCK Driver Characteristics

Byte 245 (0x0F5)

Byte defined as per JESD82-531 DDR5CKD01 specification.

Table 112 — Unbuffered CKD-RW02: QCK Driver Characteristics

Bits 7 ~ 6	Bits 5 ~ 4	Bits 3 ~ 2	Bits 1 ~ 0
CHB QCK_1_B_t/QCK_1_B_c	CHB QCK_0_B_t/QCK_0_B_c	CHA QCK_1_A_t/QCK_1_A_c	CHA QCK_0_A_t/QCK_0_A_c
00 = Light Drive 01 = Moderate Drive 10 = Strong Drive 11 = Weak Drive	00 = Light Drive 01 = Moderate Drive 10 = Strong Drive 11 = Weak Drive	00 = Light Drive 01 = Moderate Drive 10 = Strong Drive 11 = Weak Drive	00 = Light Drive 01 = Moderate Drive 10 = Strong Drive 11 = Weak Drive

13.4 (Unbuffered): CKD-RW03 QCK Output Differential Slew Rate

Byte 246 (0x0F6)

Byte defined as per JESD82-531 DDR5CKD01 specification.

Table 113 — Unbuffered CKD-RW03: QCK Output Differential Slew Rate

Bits 7 ~ 6	Bits 5 ~ 4	Bits 3 ~ 2	Bits 1 ~ 0
Reserved	CHB QCK[1:0]_B	Reserved	CHA QCK[1:0]_A
Reserved; must be coded as 00	00 = Moderate 01 = Fast 10 = Reserved 11 = Reserved	Reserved; must be coded as 00	00 = Moderate 01 = Fast 10 = Reserved 11 = Reserved

13.5 (Unbuffered): Reserved

Bytes 247~447 (0x0F7~0x1BF)

Reserved -- must be coded as 0x00.

14 Annex A.3: Module Specific Bytes for Registered (RDIMM) and Load Reduced (LRDIMM) Memory Module Types

(Bytes 192~447, 0x0C0~0x1BF)

Revision 1.2: Byte 192 coded as 0x12

This section defines the encoding of SPD bytes 192~447 when Memory Technology Key Byte 2 contains the value 0x12 and Module Type Key Byte 3 contains any of the following:

- 0xH1, RDIMM
- 0xH4, LRDIMM

where H refers to the hybrid memory architecture, if any present on the module

Table entries highlighted in light blue are LRDIMM specific.

The ECC data width for RDIMMs may vary from design to design. Some RDIMMs support 8-bit ECC per channel (EC8: 2 channels of 40 bits wide each) while other RDIMMs support 4-bit ECC per channel (EC4: 2 channels of 36 bits wide each). To determine which configuration of ECC is supported by this module design, look to the following SPD bytes:

- SPD byte 232: Reference Raw Card Used
- SPD byte 235: Memory Channel Bus Width, especially bits 4~3, bus width extension

RDIMMs and LRDIMMs may support symmetrical or asymmetrical memory ranks. Symmetrical means that all ranks on the DIMM are identical. Asymmetrical means that even ranks and odd ranks may contain SDRAMs of different per-device capacity. This rule applies across both A and B channels; all devices on both A and B channels within any rank must be identical. See Annex A.0 Common SPD Bytes for details. In particular, symmetry is defined by the following SPD byte:

- SPD byte 234: Module Organization, especially bit 6, Rank Mix

All note that other SDRAM characteristics may vary between even and odd ranks in asymmetrical designs, such as Refresh Management (RFM) settings.

See Annex A.0 for common SPD bytes 192~239 (0x0C0~0EF).

14 Annex A.3: Module Specific Bytes for Registered (RDIMM) and Load Reduced (LRDIMM) Memory Module Types (cont'd)

Table 114 — Module Specific SPD Bytes for Registered and Load Reduced Module Types

Byte Number		Function Described
240	0x0F0	Registering Clock Driver Manufacturer ID Code, First Byte
241	0x0F1	Registering Clock Driver Manufacturer ID Code, Second Byte
242	0x0F2	Register Device Type
243	0x0F3	Register Revision Number
244	0x0F4	Data Buffer Manufacturer ID Code, First Byte
245	0x0F5	Data Buffer Manufacturer ID Code, Second Byte
246	0x0F6	Data Buffer Device Type
247	0x0F7	Data Buffer Revision Number
248	0x0F8	RCD-RW08 Clock Driver Enable
249	0x0F9	RCD-RW09 Output Address and Control Enable
250	0x0FA	RCD-RW0A QCK Driver Characteristics
251	0x0FB	RCD-RW0B
252	0x0FC	RCD-RW0C QxCA and QxCS_n Driver Characteristics
253	0x0FD	RCD-RW0D Data Buffer Interface Driver Characteristics
254	0x0FE	RCD-RW0E QCK, QCA and QCS Output Slew Rate
255	0x0FF	RCD-RW0F BCK, BCOM, and BCS Output Slew Rate
256	0x100	DB-RW86 DQS RTT Park Termination
257~447	0x101~0x1BF	Reserved

14.1 (RDIMM/LRDIMM): Module Specific Device Information

Bytes 240~247 (0x0F0~0x0F7)

Table 115 lists the SPD byte addresses for the key components on this assembly.

Table 115 — RDIMM/LRDIMM Module Specific Device Information

Device	Manufacturer ID Code, First Byte		Manufacturer ID Code, Second Byte		Device Type		Device Revision	
	Dec	Hex	Dec	Hex	Dec	Hex	Dec	Hex
Registering Clock Driver (RCD)	240	0x0F0	241	0x0F1	242	0x0F2	243	0x0F3
Data Buffers (DB)	244	0x0F4	245	0x0F5	246	0x0F6	247	0x0F7

14.1 (RDIMM/LRDIMM): Module Specific Device Information (cont'd)

Manufacturer ID Code: Per JEP106. See SPD bytes 512~513 for an example.

Device types:

Table 116 — RDIMM/LRDIMM Module Specific Device Types

Device	Bit 7	Bit 6	Bits 5 ~ 4	Bits 3 ~ 0
	Devices Installed		Reserved	Device Type
Registering Clock Driver (RCD)	0 = Not installed 1 = Installed	Reserved; must be coded as 0	Reserved. Must be coded as 00	0000: DDR5RCD01 (see JESD82-511) 0001: DDR5RCD02 (see JESD82-512) 0010: DDR5RCD03 (see JESD82-513) 0011: DDR5RCD04 (see JESD82-514) 0100: DDR5RCD05 (see JESD82-515) All other codes reserved
Data Buffers (DB)	0 = Not installed (RDIMM) 1 = Installed (LRDIMM)			0000: DDR5DB01 (see JESD82-521) 0001: DDR5DB02 (see JESD82-522) All other codes reserved RDIMM: code as 0000

Device revision: This byte is coded as a major revision in bits 7~4 and minor revision in bits 3~0, each nibble expressed in BCD. For example, device stepping 3.2 would be coded as 0x32.

14.2 (RDIMM/LRDIMM): RCD-RW08 Clock Driver Enable

Byte 248 (0x0F8)

Byte defined as per JESD82-51x DDR5RCD0x specification.

Table 117 — RDIMM/LRDIMM RCD-RW08: Clock Driver Enable

Bits 7~6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved	BCK_t/ BCK_c	Reserved	QDCK_t/ QDCK_c	QCCK_t/ QCCK_c	QBCK_t/ QBCK_c	QACK_t/ QACK_c
Reserved; must be coded as 00	0 = Enabled 1 = Disabled	Reserved; must be coded as 0	0 = Enabled 1 = Disabled			

14.3 (RDIMM/LRDIMM): RCD-RW09 Output Address and Control Enable Byte 249 (0x0F9)

Byte defined as per JESD82-51x DDR5RCD0x specification.

Table 118 — RDIMM/LRDIMM RCD-RW09: Output Address and Control Enables

Bit 7	Bit 6	Bit 5	Bit 4
Reserved	QBCS[1:0]_n output	QACS[1:0]_n output	Q[B:A]CA13 output driver
Reserved; must be coded as 0	0 = Enabled 1 = Disabled	0 = Enabled 1 = Disabled	0 = Enabled 1 = Disabled
Bit 3	Bit 2	Bit 1	Bit 0
BCS_n, BCOM[2:0] and BRST_n outputs	DCS1_n input buffer and QxCS1_n outputs	QBCA outputs	QACA outputs
0 = Enabled (LRDIMM) 1 = Disabled (RDIMM)	0 = Enabled 1 = Disabled	0 = Enabled 1 = Disabled	0 = Enabled 1 = Disabled

14.4 (RDIMM/LRDIMM): RCD-RW0A QCK Driver Characteristics

Byte 250 (0x0FA)

Byte defined as per JESD82-51x DDR5RCD0x specification.

Table 119 — RDIMM/LRDIMM RCD-RW0A: QCK Driver Characteristics

Bits 7~6	Bits 5~4	Bits 3~2	Bits 1~0
QDCK_t/QDCK_c	QCCK_t/QCCK_c	QBCK_t/QBCK_c	QACK_t/QACK_c
00 = Light drive 01 = Moderate drive 10 = Strong drive 11 = Reserved	00 = Light drive 01 = Moderate drive 10 = Strong drive 11 = Reserved	00 = Light drive 01 = Moderate drive 10 = Strong drive 11 = Reserved	00 = Light drive 01 = Moderate drive 10 = Strong drive 11 = Reserved

14.5 (RDIMM/LRDIMM): RCD-RW0B

Byte 251 (0x0FB)

Table 120 — RDIMM/LRDIMM RCD-RW0B

Bits 7~0
Reserved
Reserved. Must be coded as 0x00

14.6 (RDIMM/LRDIMM): RCD-RW0C QxCA and QxCS_n Driver Characteristics

Byte 252 (0x0FC)

Byte defined as per JESD82-51x DDR5RCD0x specification.

Table 121 — RDIMM/LRDIMM RCD-RW0C: QxCA and QxCS_n Driver Characteristics

Bits 7~6	Bits 5~4	Bits 3~2	Bits 1~0
Reserved	Driver Strength QxCS0_n, QxCS1_n	Reserved	Driver Strength Address/Command for both A and B outputs
Reserved. Must be coded as 00	00 = Light drive 01 = Moderate drive 10 = Strong drive 11 = Reserved	Reserved. Must be coded as 00	00 = Light drive 01 = Moderate drive 10 = Strong drive 11 = Reserved

14.7 (RDIMM/LRDIMM): RCD-RW0D Data Buffer Interface Driver Characteristics

Byte 253 (0x0FD)

Byte defined as per JESD82-51x DDR5RCD0x specification. These values are LRDIMM specific; RDIMMs shall encode as 0x00.

Table 122 — RDIMM/LRDIMM RCD-RW0D: Data Buffer Interface Driver Characteristics

Bits 7~5	Bits 4~3	Bit 2	Bits 1~0
Reserved	Driver Strength BCK_t/BCK_c	Reserved	Driver Strength BCOM[2:0], BCS_n
Reserved. Must be coded as 000	00 = Light drive 01 = Moderate drive 10 = Strong drive 11 = Reserved	Reserved. Must be coded as 0	00 = Light drive 01 = Moderate drive 10 = Strong drive 11 = Reserved

14.8 (RDIMM/LRDIMM): RCD-RW0E QCK, QCA, and QCS Output Slew Rate

Byte 254 (0x0FE)

Byte defined as per JESD82-51x DDR5RCD0x specification.

Table 123 — RDIMM/LRDIMM RCD-RW0E: QCK, QCA, and QCS Output Slew Rate

Bits 7~6	Bits 5~4	Bits 3~2	Bits 1~0
Reserved	Q[B:A]CS[1:0]_n Single Ended Slew Rate	Q[B:A]CA[13:0] Single Ended Slew Rate	QCK[D:A]_t/QCK[D:A]_c Differential Slew Rate
Reserved. Must be coded as 00	00 = Moderate 01 = Fast 10 = Slow 11 = Reserved	00 = Moderate 01 = Fast 10 = Slow 11 = Reserved	00 = Moderate 01 = Fast 10 = Slow 11 = Reserved

14.9 (RDIMM/LRDIMM): RCD-RW0F BCK, BCOM, and BCS Output Slew Rate

Byte 255 (0x0FF)

Byte defined as per JESD82-51x DDR5RCD0x specification. These values are LRDIMM specific; RDIMMs shall encode as 0x00.

Table 124 — RDIMM/LRDIMM RCD-RW0F: BCK, BCOM, and BCS Output Slew Rate

Bits 7~4	Bits 3~2	Bits 1~0
Reserved	BCK_t/BCK_c Differential Slew Rate	BCOM[2:0], BCS_n Single Ended slew rate
Reserved. Must be coded as 0000	00 = Moderate 01 = Fast 10 = Slow 11 = Reserved	00 = Moderate 01 = Fast 10 = Slow 11 = Reserved

14.10 (RDIMM/LRDIMM): DB-RW86 DQS RTT Park Termination

Byte 256 (0x100)

Byte defined as per JESD82-52x DDR5DB0x specification. These values are LRDIMM specific; RDIMMs shall encode as 0x00.

Table 125 — RDIMM/LRDIMM DB-RW86: DQS RTT Park Termination

Bits 7~3	Bits 2~0
Reserved	DQS RTT Park Termination
Reserved. Must be coded as 00000	<p>000 = RTT_OFF (default) 001 = RZQ/1 (240 Ω) 010 = RZQ/2 (120 Ω) 011 = RZQ/3 (80 Ω) 100 = RZQ/4 (60 Ω) 101 = RZQ/5 (48 Ω) 110 = RZQ/6 (40 Ω) 111 = RZQ/7 (34 Ω)</p>

14.11 (RDIMM/LRDIMM): Reserved

Bytes 257~447 (0x101~0x1BF)

Reserved -- must be coded as 0x00

15 Annex A.4: Module Specific Bytes for Multiplexed Rank (MRDIMM) Memory Module Types

(Bytes 192~447, 0x0C0~0x1BF)

Revision 1.2: Byte 192 coded as 0x12

This section defines the encoding of SPD bytes 192~447 when Memory Technology Key Byte 2 contains the value 0x12 and Module Type Key Byte 3 contains any of the following:

- 0x07, MRDIMM

Table 126 — MRDIMM Terminology

Rank or Package Rank	Collection of DRAMs on an MRDIMM sharing a chip select or a copy of a chip select.
Logical rank	Individually addressable die within a 3DS stacked DRAM. Addressed using DRAM command CID bits.
Channel	Data interface as seen at the module edge connector; for MRDIMMs, the channel width is 72 or 80 bits.
Sub-channel	Separately addressable groups of DRAMs on the module; for MRDIMMs, the sub-channel width is 36 or 40 bits.
Rank mode	MRDIMM mode without time multiplexing of ranks. Formerly referred to as “1:1 mode” or “1x mode”.
Mux mode	MRDIMM mode where two pseudo-channels are time multiplexed through the MDB onto the host sub-channel interface. Formerly referred to as “2:1 mode” or “2x mode”.
Pseudo-channel	Applies only to MRDIMM mux mode. Each individually addressed rank of memory that is time multiplexed through the MDB and MRCD forms a conceptual pseudo-channel. Pseudo-channels are virtual constructs which are paired such that rank 0 and rank 1 are time multiplexed, and rank 2 and rank 3 are separately time multiplexed. Pseudo-channels utilize the existing physical interface and are not a unique physical layer.

The ECC data width for MRDIMMs may vary from design to design. Some MRDIMMs support 8-bit ECC per channel / pseudo-channel (EC8: 2 channels each with 2 pseudo channels of 40 bits wide each) while other MRDIMMs support 4-bit ECC per channel / Pseudo-channel (EC4: 2 channels each with 2 pseudo channels of 36 bits wide each). To determine which configuration of ECC is supported by this module design, look to the following SPD bytes:

- SPD byte 232: Reference Raw Card Used
- SPD byte 235: Memory Channel Bus Width, especially bits 4~3, bus width extension

MRDIMMs may support symmetrical or asymmetrical memory ranks. Symmetrical means that all ranks on the DIMM are identical. Asymmetrical means that even ranks and odd ranks may contain SDRAMs of different per-device capacities. This rule applies across both A and B channels and across both pseudo-channels of a channel; all devices on both A and B channels within any rank must be identical and all devices on both pseudo-channels within a rank must be identical. See Annex A.0 Common SPD Bytes for details. In particular, symmetry is defined by the following SPD byte:

15 Annex A.4: Module Specific Bytes for Multiplexed Rank (MRDIMM) Memory Module Types (cont'd)

- SPD byte 234: Module Organization, especially bit 6, Rank Mix

All note that other SDRAM characteristics may vary between even and odd ranks in asymmetrical designs, such as Refresh Management (RFM) settings.

See Annex A.0 for common SPD bytes 192~239 (0x0C0~0EF).

Table 127 — Module Specific SPD Bytes for Multiplexed Rank Module Types

Byte Number		Function Described
240	0x0F0	Multiplex Registering Clock Driver Manufacturer ID Code, First Byte
241	0x0F1	Multiplex Registering Clock Driver Manufacturer ID Code, Second Byte
242	0x0F2	Register Device Type
243	0x0F3	Register Revision Number
244	0x0F4	Multiplex Data Buffer Manufacturer ID Code, First Byte
245	0x0F5	Multiplex Data Buffer Manufacturer ID Code, Second Byte
246	0x0F6	Data Buffer Device Type
247	0x0F7	Data Buffer Revision Number
248	0x0F8	MRCD-RW08 Clock Driver Enable
249	0x0F9	MRCD-RW09 Output Address and Control Enable
250	0x0FA	MRCD-RW0A QCK Driver Characteristics
251	0x0FB	MRCD-RW0B
252	0x0FC	MRCD-RW0C QxCA and QxCS_n Driver Characteristics
253	0x0FD	MRCD-RW0D Data Buffer Interface Driver Characteristics
254	0x0FE	MRCD-RW0E QCK, QCA and QCS Output Slew Rate
255	0x0FF	MRCD-RW0F BCK, BCOM, and BCS Output Slew Rate
256	0x100	MDB-PG[C]RWE0 Duty Cycle Adjuster Configuration
257	0x101	MDB-PG[70]RWE1 DRAM Interface Receiver Type
258~447	0x102~0x1BF	Reserved

15.1 (MRDIMM): Module Specific Device Information

Bytes 240~247 (0x0F0~0x0F7)

Table 128 lists the SPD byte addresses for the key components on this assembly.

Table 128 — MRDIMM Module Specific Device Information

Device	Manufacturer ID Code, First Byte		Manufacturer ID Code, Second Byte		Device Type		Device Revision	
	Dec	Hex	Dec	Hex	Dec	Hex	Dec	Hex
Multiplex Registering Clock Driver (MRCD)	240	0x0F0	241	0x0F1	242	0x0F2	243	0x0F3
Multiplex Data Buffers (MDB)	244	0x0F4	245	0x0F5	246	0x0F6	247	0x0F7

Manufacturer ID Code: Per JEP106. See SPD bytes 512~513 for an example.

Device types:

Table 129 — MRDIMM Module Specific Device Types

Device	Bit 7	Bit 6	Bits 5 ~ 4	Bits 3 ~ 0	
	Devices Installed		Reserved	Device Type	
Multiplex Registering Clock Driver (MRCD)	Must be coded as 1 (installed)	Reserved; must be coded as 0	Reserved. Must be coded as 00	0000: DDR5MRCD01 (see JESD82-541) 0001: DDR5MRCD02 (see JESD82-542) All other codes reserved	0000: DDR5MDB01 (see JESD82-551) 0001: DDR5MDB02 (see JESD82-552) All other codes reserved
Multiplex Data Buffers (MDB)	Must be coded as 1 (installed)				

Device revision: This byte is coded as a major revision in bits 7~4 and minor revision in bits 3~0, each nibble expressed in BCD. For example, device stepping 3.2 would be coded as 0x32.

15.2 (MRDIMM): MRCD-RW08 Clock Driver Enable

Byte 248 (0x0F8)

Byte defined as per JESD82-54x DDR5MRCD0x specification.

Table 130 — MRDIMM MRCD-RW08: Clock Driver Enable

Bits 7~6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved	BCK_t/ BCK_c	Reserved	QDCK_t/ QDCK_c	QCCK_t/ QCCK_c	QBCK_t/ QBCK_c	QACK_t/ QACK_c
Reserved; must be coded as 00	0 = Enabled 1 = Disabled	Reserved; must be coded as 0	0 = Enabled 1 = Disabled			

15.3 (MRDIMM): MRCD-RW09 Output Address and Control Enable Byte 249 (0x0F9)

Byte defined as per JESD82-54x DDR5MRCD0x specification.

Table 131 — MRDIMM MRCD-RW09: Output Address and Control Enables

Bit 7	Bit 6	Bit 5	Bit 4
DCS1_n input	QBCS[1:0]_n output	QACS[1:0]_n output	Q[B:A]CA13 output driver
0 = Enabled 1 = Disabled	0 = Enabled 1 = Disabled	0 = Enabled 1 = Disabled	0 = Enabled 1 = Disabled
Bit 3	Bit 2	Bit 1	Bit 0
BCS_n, BCOM[2:0] and BRST_n outputs	DCS1_n input buffer and QxCS1_n outputs	QBCA outputs	QACA outputs
0 = Enabled (LRDIMM) 1 = Disabled (RDIMM)	0 = Enabled 1 = Disabled	0 = Enabled 1 = Disabled	0 = Enabled 1 = Disabled

15.4 (MRDIMM): MRCD-RW0A QCK Driver Characteristics

Byte 250 (0x0FA)

Byte defined as per JESD82-54x DDR5MRCD0x specification.

Table 132 — MRDIMM MRCD-RW0A: QCK Driver Characteristics

Bits 7~6	Bits 5~4	Bits 3~2	Bits 1~0
QDCK_t/QDCK_c	QCCK_t/QCCK_c	QBCK_t/QBCK_c	QACK_t/QACK_c
00 = Light Drive 01 = Moderate Drive 10 = Strong Drive 11 = Reserved	00 = Light Drive 01 = Moderate Drive 10 = Strong Drive 11 = Reserved	00 = Light Drive 01 = Moderate Drive 10 = Strong Drive 11 = Reserved	00 = Light Drive 01 = Moderate Drive 10 = Strong Drive 11 = Reserved

15.5 (MRDIMM): MRCD-RW0B

Byte 251 (0x0FB)

Table 133 — MRDIMM MRCD-RW0B

Bits 7~0
Reserved
Reserved. Must be coded as 0x00

15.6 (MRDIMM): MRCD-RW0C QxCA and QxCS_n Driver Characteristics

Byte 252 (0x0FC)

Byte defined as per JESD82-54x DDR5MRCD0x specification.

Table 134 — MRDIMM MRCD-RW0C: QxCA and QxCS_n Driver Characteristics

Bits 7~6	Bits 5~4	Bits 3~2	Bits 1~0
Q[B:A]CS1_n Output Control	Driver Strength QxCS0_n, QxCS1_n	Reserved	Driver Strength Address/Command for both A and B outputs
00: Normal Rank/Mux Mode Operation 01: Disabled 10: Driven LOW 11: Reserved	00 = Light Drive 01 = Moderate Drive 10 = Strong Drive 11 = Reserved	Reserved. Must be coded as 00	00 = Light Drive 01 = Moderate Drive 10 = Strong Drive 11 = Reserved

15.7 (MRDIMM): MRCD-RW0D Data Buffer Interface Driver Characteristics

Byte 253 (0x0FD)

Byte defined as per JESD82-54x DDR5MRCD0x specification.

Table 135 — MRDIMM MRCD-RW0D: Data Buffer Interface Driver Characteristics

Bits 7~5	Bits 4~3	Bit 2	Bits 1~0
Reserved	Driver Strength BCK_t/BCK_c	Reserved	Driver Strength BCOM[2:0], BCS_n
Reserved. Must be coded as 000	00 = Light Drive 01 = Moderate Drive 10 = Strong Drive 11 = Reserved	Reserved. Must be coded as 0	00 = Light Drive 01 = Moderate Drive 10 = Strong Drive 11 = Reserved

15.8 (MRDIMM): MRCD-RW0E QCK, QCA, and QCS Output Slew Rate

Byte 254 (0x0FE)

Byte defined as per JESD82-54x DDR5MRCD0x specification.

Table 136 — MRDIMM MRCD-RW0E: QCK, QCA, and QCS Output Slew Rate

Bits 7~6	Bits 5~4	Bits 3~2	Bits 1~0
Reserved	Q[B:A]CS[1:0]_n Single Ended Slew Rate	Q[B:A]CA[13:0] Single Ended Slew Rate	QCK[D:A]_t/QCK[D:A]_c Differential Slew Rate
Reserved. Must be coded as 00	00 = Moderate 01 = Fast 10 = Slow 11 = Reserved	00 = Moderate 01 = Fast 10 = Slow 11 = Reserved	00 = Moderate 01 = Fast 10 = Slow 11 = Reserved

15.9 (MRDIMM): MRCD-RW0F BCK, BCOM, and BCS Output Slew Rate

Byte 255 (0x0FF)

Byte defined as per JESD82-54x DDR5MRCD0x specification.

Table 137 — MRDIMM MRCD-RW0F: BCK, BCOM, and BCS Output Slew Rate

Bits 7~4	Bits 3~2	Bits 1~0
Reserved	BCK_t/BCK_c Differential Slew Rate	BCOM[2:0], BCS_n Single Ended slew rate
Reserved. Must be coded as 0000	00 = Moderate 01 = Fast 10 = Slow 11 = Reserved	00 = Moderate 01 = Fast 10 = Slow 11 = Reserved

15.10 (MRDIMM): MDB-PG[C]RWE0 Duty Cycle Adjuster Configuration

Byte 256 (0x100)

Byte defined as per JESD82-55x DDR5MDB0x specification.

Table 138 — MRDIMM MDB-PG[C]RWE0: Duty Cycle Adjuster Configuration

Bits 7~1	Bit 0
Reserved	Duty Cycle Adjuster Configuration
Reserved. Must be coded as 0	0 = DCA Configuration 0 1 = DCA Configuration 1 Note: This is a copy of the Read-Only register in the MDB, which is vendor-specific.

15.11 (MRDIMM): MDB-PG[70]RWE1 DRAM Interface Receiver Type

Byte 257 (0x101)

Byte defined as per JESD82-55x DDR5MDB0x specification.

Table 139 — MRDIMM MDB-PG[70]RWE1: DRAM Interface Receiver Type

Bits 7~1	Bit 0
Reserved	DRAM Interface Receiver Type
Reserved. Must be coded as 0	0 = Unmatched 1 = Matched Note: This is a copy of the Read-Only register in the MDB, which is vendor-specific.

**15.12 (MRDIMM): Reserved
Bytes 258~447 (0x102~0x1BF)**

Reserved -- must be coded as 0x00

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16 Annex A.5: Module Specific Bytes for Differential Memory Module Types

(Bytes 192~447, 0x0C0~0x1BF)

Revision 1.1: Byte 192 coded as 0x11

This section defines the encoding of SPD bytes 192~447 when Memory Technology Key Byte 2 contains the value 0x0C and Module Type Key Byte 3 contains any of the following:

- 0xHA, DDIMM

where H refers to the hybrid memory architecture, if any present on the module

See Annex A.0 for common SPD bytes 192~239 (0x0C0~0EF).

Table 140 — Module Specific SPD Bytes for Differential Module Types

Byte Number		Function Described
240	0x0F0	Differential Memory Buffer Manufacturer ID Code, First Byte
241	0x0F1	Differential Memory Buffer Manufacturer ID Code, Second Byte
242	0x0F2	Differential Memory Buffer Device Type
243	0x0F3	Differential Memory Buffer Revision Number
244~447	0x0F6~0x1BF	Reserved

16.1 (Differential): Module Specific Device Information

Bytes 240~243 (0x0F0~0x0F3)

Table 141 lists the SPD byte addresses for the key components on this assembly.

Table 141 — (Differential) Module Specific Device Information

Device	Manufacturer ID Code, First Byte		Manufacturer ID Code, Second Byte		Device Type		Device Revision	
	Dec	Hex	Dec	Hex	Dec	Hex	Dec	Hex
Differential Memory Buffer (DMB)	240	0x0F0	241	0x0F1	242	0x0F2	243	0x0F3

16.1 (Differential): Module Specific Device Information (cont'd)

Manufacturer ID Code: Per JEP106. See SPD bytes 512~513 for an example.

Device types:

Table 142 — (Differential) Module Specific Device Types

	Bit 7	Bit 6	Bits 5 ~ 4	Bits 3 ~ 0
Device	Devices Installed		Reserved	Device Type
Differential Memory Buffer (DMB)	0 = Not installed 1 = Installed	Reserved; must be coded as 0	Reserved. Must be coded as 00	0000: DMB501 (see JESD303-1) All other codes reserved

Device revision: This byte is coded as a major revision in bits 7~4 and minor revision in bits 3~0, each nibble expressed in BCD. For example, device stepping 3.2 would be coded as 0x32.

16.2 (Differential): Reserved

Bytes 244~447 (0x0F4~0x1BF)

Reserved -- must be coded as 0x00

17 Annex A.6: Non-Volatile (NVDIMM-N) Hybrid Memory Parameters

(Bytes 192~447, 0x0C0~0x1BF)

Revision 0.2: Byte 192 coded as 0x02

This section defines the encoding of SPD bytes 192~447 when Module Type Key Byte 3 contains the following:

- 0x9M, NVDIMM-N

where M refers to the base memory architecture

NVDIMM types defined at this time are:

Table 143 — NVDIMM Types Currently Defined

Type	Definition
NVDIMM-N	Persistent DRAM using NAND flash

See Annex A.0 for common SPD bytes 192~239 (0x0C0~0EF).

Table 144 — Module Specific SPD Bytes for NVDIMM-N Module Types

Byte Number		Function Described
240	0x0F0	Registering Clock Driver Manufacturer ID Code, First Byte
241	0x0F1	Registering Clock Driver Manufacturer ID Code, Second Byte
242	0x0F2	Register Device Type
243	0x0F3	Register Revision Number
244	0x0F4	Data Buffer Manufacturer ID Code, First Byte
245	0x0F5	Data Buffer Manufacturer ID Code, Second Byte
246	0x0F6	Data Buffer Device Type
247	0x0F7	Data Buffer Revision Number
248~447	0x0F8~0x1BF	Reserved

17.1 (NVDIMM-N): Module Specific Device Information

Bytes 240~247 (0x0F0~0x0F7)

Table 145 lists the SPD byte addresses for the key components on this assembly.

Table 145 — NVDIMM-N Module Specific Device Information

Device	Manufacturer ID Code, First Byte		Manufacturer ID Code, Second Byte		Device Type		Device Revision	
	Dec	Hex	Dec	Hex	Dec	Hex	Dec	Hex
Registering Clock Driver (RCD)	240	0x0F0	241	0x0F1	242	0x0F2	243	0x0F3
Data Buffers (DB)	244	0x0F4	245	0x0F5	246	0x0F6	247	0x0F7

Manufacturer ID Code: Per JEP106. See SPD bytes 512~513 for an example.

Device types:

Table 146 — NVDIMM-N Module Specific Device Types

	Bit 7	Bit 6	Bits 5 ~ 4	Bits 3 ~ 0
Device	Devices Installed		Reserved	Device Type
Registering Clock Driver (RCD)	0 = Not installed 1 = Installed	Reserved; must be coded as 0	Reserved. Must be coded as 00	0000: DDR5RCD01 (see JESD82-511) All other codes reserved
Data Buffers (DB)	0 = Not installed 1 = Installed			0000: DDR5DB01 (see JESD82-521) All other codes reserved

Device revision: This byte is coded as a major revision in bits 7~4 and minor revision in bits 3~0, each nibble expressed in BCD. For example, device stepping 3.2 would be coded as 0x32.

17.2 (NVDIMM-N): Reserved

Bytes 248~447 (0x0F8~0x1BF)

Reserved -- must be coded as 0x00.

18 Annex A.7: Non-Volatile (NVDIMM-P) Hybrid Memory Parameters

(Bytes 192~447, 0x0C0~0x1BF)

Revision 1.1: byte 192 coded as 0x11

This section defines the encoding of SPD bytes 192~447 when Module Type Key Byte 3 contains the following:

- 0xAM, NVDIMM-P

where M refers to the base memory architecture

NVDIMM types defined at this time are:

Table 147 — NVDIMM Types Currently Defined

Type	Definition	Specification
NVDIMM-P	Transactional credit based memory module	JESD304-5

See Annex A.0 for common SPD bytes 192~239 (0x0C0~0EF).

Table 148 — Module Specific SPD Bytes for NVDIMM-P Module Types

Byte Number		Function Described
240	0x0F0	Registering Clock Driver Manufacturer ID Code, First Byte
241	0x0F1	Registering Clock Driver Manufacturer ID Code, Second Byte
242	0x0F2	Register Device Type
243	0x0F3	Register Revision Number
244	0x0F4	Data Buffer Manufacturer ID Code, First Byte
245	0x0F5	Data Buffer Manufacturer ID Code, Second Byte
246	0x0F6	Data Buffer Device Type
247	0x0F7	Data Buffer Revision Number
248	0x0F8	Module Storage Capacity, Least Significant Byte
249	0x0F9	Module Storage Capacity, Most Significant Byte
250	0x0FA	Protocol Profile
251~447	0x0FB~0x1BF	Reserved

18.1 (NVDIMM-P): Module Specific Device Information

Bytes 240~247 (0x0F0~0x0F7)

Table 149 lists the SPD byte addresses for the key components on this assembly.

Table 149 — NVDIMM-P Module Specific Device Information

Device	Manufacturer ID Code, First Byte		Manufacturer ID Code, Second Byte		Device Type		Device Revision	
	Dec	Hex	Dec	Hex	Dec	Hex	Dec	Hex
Registering Clock Driver (RCD)	240	0x0F0	241	0x0F1	242	0x0F2	243	0x0F3
Data Buffers (DB)	244	0x0F4	245	0x0F5	246	0x0F6	247	0x0F7

Manufacturer ID Code: Per JEP106. See SPD bytes 512~513 for an example.

Device types:

Table 150 — NVDIMM-P Module Specific Device Types

Device	Bit 7	Bit 6	Bits 5 ~ 4	Bits 3 ~ 0	
	Devices Installed	Reserved	Reserved.	Device Type	
Registering Clock Driver (RCD)	0 = Not installed 1 = Installed	Reserved; must be coded as 0	Reserved. Must be coded as 00	0000: DDR5RCD01 (see JESD82-511) All other codes reserved	
Data Buffers (DB)	0 = Not installed 1 = Installed			0000: DDR5DB01 (see JESD82-521) All other codes reserved	

Device revision: This byte is coded as a major revision in bits 7~4 and minor revision in bits 3~0, each nibble expressed in BCD. For example, device stepping 3.2 would be coded as 0x32.

18.2 (NVDIMM-P): Module Storage Capacity

Bytes 248~249 (0x0F8~0x0F9)

These bytes form a 16-bit word which defines the capacity of the non-volatile storage on the NVDIMM-P accessible via the transactional protocol.

Table 151 — NVDIMM-P Module Storage Capacity

Byte 249		Byte 248
Bits 15~14	Bits 13~4	Bits 3~0
Capacity, Base	Capacity, Digits	Capacity, Tenth
00 = Megabytes 01 = Gigabytes 10 = Terabytes 11 = Petabytes	Values from 0 to 999 All other values reserved	0000 = 0 0001 = 0.1 0010 = 0.2 0011 = 0.3 0100 = 0.4 0101 = 0.5 0110 = 0.6 0111 = 0.7 1000 = 0.8 1001 = 0.9 All other codes reserved

Examples:

Table 152 — Example NVDIMM-P Module Storage Capacity

Code	Hex	Meaning
01 00 1000 0000 0000	0x2800	Module storage capacity = 128 GB
10 00 0000 0001 0000	0x8010	Module storage capacity = 1 TB
10 00 0000 0001 0101	0x8015	Module storage capacity = 1.5 TB
00 11 0010 0000 0000	0x3200	Module storage capacity = 800 MB

18.3 (NVDIMM-P): Protocol Profile

Byte 250 (0x0FA)

This byte defines the NVDIMM-P profile for the interface protocol. See JESD304-5 for details on profile characteristics.

Table 153 — NVDIMM-P Protocol Profile

Bits 7~4	Bits 3~0
Reserved	Protocol Profile
Reserved; must be coded as 0000	0000 = NVDIMM-P Profile 0 0001 = NVDIMM-P Profile 1 All other codes reserved

18.4 (NVDIMM-P): Reserved Bytes 251~447 (0x0FB~0x1BF)

Reserved -- must be coded as 0x00.

18.5 Application Notes for Transactional Credit Based NVDIMMs

When programming an SPD for use in an NVDIMM supporting this function, the following guidelines must be followed for programming SPD Block 0 to represent the NVDIMM. All other bytes in block 0 are Reserved and must be programmed to 0x00 for use in an NVDIMM.

Table 154 — SPD Block 0 Programming Guidelines for Representing NVDIMM

Byte	Description	Transactional Credit Based NVDIMM Definition
0	Number of bytes in SPD device	Standard programming
1	SPD Revision	Standard programming
2	Key Byte / Host Bus Command Protocol Type	Must be programmed as 20 (0x14), DDR5 NVDIMM-P
3	Key Byte / Module Type	NVDIMM-P based on RDIMM interface: Programmed as 0xA1 NVDIMM-P based on LRDIMM interface: Programmed as 0xA4
12	SDRAM BL32 and Post Package Repair	Must be programmed as 0x00, Burst length of 16, no PPR support
16	SDRAM Nominal Voltage, VDD	Standard programming
17	SDRAM Nominal Voltage, VDDQ	Standard programming
20	SDRAM Minimum Cycle Time ($t_{CKAVGmin}$) Least Significant Byte	Standard programming
21	SDRAM Minimum Cycle Time ($t_{CKAVGmin}$) Most Significant Byte	Standard programming
22	SDRAM Maximum Cycle Time ($t_{CKAVGmax}$) Least Significant Byte	Standard programming
23	SDRAM Maximum Cycle Time ($t_{CKAVGmax}$) Most Significant Byte	Standard programming
24	CAS Latencies Supported, First Byte	Standard programming
25	CAS Latencies Supported, Second Byte	Standard programming
26	CAS Latencies Supported, Third Byte	Standard programming
27	CAS Latencies Supported, Fourth Byte	Standard programming
28	CAS Latencies Supported, Fifth Byte	Standard programming
30	Minimum CAS Latency Time (t_{AAmin}) Least Significant Byte	Minimum READ SEND time, t_{SEND_RDmin} . Used to calculate t_{SEND_RDmin} , t_{SEND_WRmin} , t_{SEND_SRDmin} .
31	Minimum CAS Latency Time (t_{AAmin}) Most Significant Byte	

18.5 Application notes for Transactional Credit Based NVDIMMs (cont'd)

Table 155 documents bytes in SPD block 3, Standard Module Parameters – Common SPD Bytes, that must be programmed to specific values to represent the NVDIMM. All other bytes are programmed with standard programming values.

Table 155 — SPD Block 3 Programming Guidelines for Representing NVDIMM

Byte	Description	Transactional Credit Based NVDIMM Definition
235	Memory Channel Bus Width	Must be 8-bit extension, 32-bits primary data bus Bits[4~3] = 10 Bits[2~0] = 010

Error logging in the End User blocks of the SPD is not supported in release 1.0 of the NVDIMM-P.

19 Annex A.8: Module Specific Bytes for Compression Attached Memory Module Types

(Bytes 192~447, 0x0C0~0x1BF)

Revision 1.1: byte 192 coded as 0x11

This section defines the encoding of SPD bytes 192~447 when Memory Technology Key Byte 2 contains the value 0x12 and Module Type Key Byte 3 contains any of the following:

- 0x08, CAMM2

See Annex A.0 for common SPD bytes 192~239 (0x0C0~0EF).

Table 156 — Module Specific SPD Bytes for Compression Attached Module Types

Byte Number		Function Described
240	0x0F0	Clock Driver 0 Manufacturer ID Code, First Byte
241	0x0F1	Clock Driver 0 Manufacturer ID Code, Second Byte
242	0x0F2	Clock Driver 0 Device Type
243	0x0F3	Clock Driver 0 Revision Number
244	0x0F0	Clock Driver 1 Manufacturer ID Code, First Byte
245	0x0F1	Clock Driver 1 Manufacturer ID Code, Second Byte
246	0x0F2	Clock Driver 1 Device Type
247	0x0F3	Clock Driver 1 Revision Number
248~255	0x0F4~0x0FF	Reserved
256	0x100	Clock Driver 0 RW00 CKD Configuration
257	0x101	Clock Driver 0 RW02 QCK Driver Characteristics
258	0x102	Clock Driver 0 RW03 QCK Output Differential Slew Rate
259	0x103	Clock Driver 1 RW00 Configuration
260	0x104	Clock Driver 1 RW02 QCK Driver Characteristics
261	0x105	Clock Driver 1 RW03 QCK Output Differential Slew Rate
262~447	0x106~0x1BF	Reserved

19.1 (CAMM2): Module Specific Device Information

Bytes 240~247 (0x0F0~0x0F7)

Table 157 lists the SPD byte addresses for the key components on this assembly.

19.1 (CAMM2): Module Specific Device Information (cont'd)

Table 157 — CAMM2 Module Specific Device Information

Device	Manufacturer ID Code, First Byte		Manufacturer ID Code, Second Byte		Device Type		Device Revision	
	Dec	Hex	Dec	Hex	Dec	Hex	Dec	Hex
Clock Driver (CKD) 0	240	0x0F0	241	0x0F1	242	0x0F2	243	0x0F3
Clock Driver (CKD) 1	244	0x0F4	245	0x0F5	246	0x0F6	247	0x0F7

Manufacturer ID Code: Per JEP106. See SPD bytes 512~513 for an example.

Device types:

Table 158 — CAMM2 Module Specific Device Types

Device	Bit 7	Bit 6	Bits 5 ~ 4	Bits 3 ~ 0	
	Devices Installed		Reserved	Device Type	
Clock Driver (CKD)	0 = Not installed 1 = Installed	Reserved; must be coded as 0	Reserved. Must be coded as 00	0000: DDR5CKD01 (see JESD82-531) All other codes reserved	

Device revision: This byte is coded as a major revision in bits 7~4 and minor revision in bits 3~0, each nibble expressed in BCD. For example, device stepping 3.2 would be coded as 0x32.

19.2 (CAMM2): Reserved

Bytes 248~255 (0x0F8~0x0FF)

Reserved -- must be coded as 0x00.

19.3 (CAMM2): Clock Driver 0 RW00 CKD Configuration

Byte 256 (0x100)

Byte defined as per JESD82-531 DDR5CKD01 specification.

19.3 (CAMM2): Clock Driver 0 RW00 CKD Configuration (cont'd)

Table 159 — Clock Driver 0 RW00 CKD Configuration

Bit 7	Bit 6	Bit 5	Bits 4	Bits 3~2	Bits 1~0
CHB QCK1_B	CHB QCK0_B	CHA QCK1_A	CHA QCK0_A	ICT Input Clock Termination Settings	PLL Mode
0 = Enabled 1 = Disabled	Reserved; must be coded as 00 Modified by host controller via MRW to select the ICT setting.	Reserved; must be coded as 00 Modified by host controller via MRW to select the PLL mode.			

19.4 (CAMM2): Clock Driver 0 RW02 QCK Driver Characteristics

Byte 257 (0x101)

Byte defined as per JESD82-531 DDR5CKD01 specification.

Table 160 — Clock Driver 0 RW02 QCK Driver Characteristics

Bits 7~6	Bits 5~4	Bits 3~2	Bits 1~0
CHB QCK_1_B_t/QCK_1_B_c	CHB QCK_0_B_t/QCK_0_B_c	CHA QCK_1_A_t/QCK_1_A_c	CHA QCK_0_A_t/QCK_0_A_c
00 = Light Drive 01 = Moderate Drive 10 = Strong Drive 11 = Weak Drive	00 = Light Drive 01 = Moderate Drive 10 = Strong Drive 11 = Weak Drive	00 = Light Drive 01 = Moderate Drive 10 = Strong Drive 11 = Weak Drive	00 = Light Drive 01 = Moderate Drive 10 = Strong Drive 11 = Weak Drive

19.5 (CAMM2): Clock Driver 0 RW03 QCK Output Differential Slew Rate

Byte 258 (0x102)

Byte defined as per JESD82-531 DDR5CKD01 specification.

Table 161 — Clock Driver 0 RW03 QCK Output Differential Slew Rate

Bits 7~6	Bits 5~4	Bits 3~2	Bits 1~0
Reserved	CHB QCK[1:0]_B	Reserved	CHA QCK[1:0]_A
Reserved; must be coded as 00	00 = Moderate 01 = Fast All others reserved	Reserved; must be coded as 00	00 = Moderate 01 = Fast All others reserved

19.6 (CAMM2): Clock Driver 1 RW00 CKD Configuration

Byte 259 (0x103)

Byte defined as per JESD82-531 DDR5CKD01 specification.

Table 162 — Clock Driver 1 RW00 CKD Configuration

Bit 7	Bit 6	Bit 5	Bits 4	Bits 3~2	Bits 1~0
CHB QCK1_B	CHB QCK0_B	CHA QCK1_A	CHA QCK0_A	ICT Input Clock Termination Settings	PLL Mode
0 = Enabled 1 = Disabled	Reserved; must be coded as 00 Modified by host controller via MRW to select the ICT setting.	Reserved; must be coded as 00 Modified by host controller via MRW to select the PLL mode.			

19.7 (CAMM2): Clock Driver 1 RW02 QCK Driver Characteristics

Byte 260 (0x104)

Byte defined as per JESD82-531 DDR5CKD01 specification.

Table 163 — Clock Driver 1 RW02 QCK Driver Characteristics

Bits 7~6	Bits 5~4	Bits 3~2	Bits 1~0
CHB QCK_1_B_t/QCK_1_B_c	CHB QCK_0_B_t/QCK_0_B_c	CHA QCK_1_A_t/QCK_1_A_c	CHA QCK_0_A_t/QCK_0_A_c
00 = Light Drive 01 = Moderate Drive 10 = Strong Drive 11 = Weak Drive	00 = Light Drive 01 = Moderate Drive 10 = Strong Drive 11 = Weak Drive	00 = Light Drive 01 = Moderate Drive 10 = Strong Drive 11 = Weak Drive	00 = Light Drive 01 = Moderate Drive 10 = Strong Drive 11 = Weak Drive

19.8 (CAMM2): Clock Driver 1 RW03 QCK Output Differential Slew Rate

Byte 261 (0x105)

Byte defined as per JESD82-531 DDR5CKD01 specification.

Table 164 — Clock Driver 1 RW03 QCK Output Differential Slew Rate

Bits 7~6	Bits 5~4	Bits 3~2	Bits 1~0
Reserved	CHB QCK[1:0]_B	Reserved	CHA QCK[1:0]_A
Reserved; must be coded as 00	00 = Moderate 01 = Fast All others reserved	Reserved; must be coded as 00	00 = Moderate 01 = Fast All others reserved

19.9 (CAMM2): Reserved

Bytes 262~447 (0x106~0x1BF)

Reserved -- must be coded as 0x00.

20 Blocks 8~9: Manufacturing Information: (Bytes 512~639, 0x200~0x27F)

20.1 Byte 512 (0x200): Module Manufacturer ID Code, First Byte Byte 513 (0x201): Module Manufacturer ID Code, Second Byte

This two-byte field indicates the manufacturer of the module, and shall be encoded as follows: the first byte is the number of continuation bytes indicated in JEP-106; the second byte is the last non-zero byte of the manufacturer's ID code, again as indicated in JEP-106.

Table 165 — Encoding of Bytes 512 and 513

Byte 513, Bits 7~0	Byte 512, Bit 7	Byte 512, Bits 6~0
Last non-zero byte, Module Manufacturer	Odd Parity for Byte 512, bits 6~0	Number of continuation codes, Module Manufacturer
See JEP-106		See JEP-106

Examples:

Table 166 — Example Encoding of Bytes 512 and 513

Company	JEP-106		# Continuation Codes	SPD	
	Bank	Code		Byte 512	Byte 513
Fujitsu	1	04	0	0x80	0x04
US Modular	5	A8	4	0x04	0xA8

20.2 Byte 514 (0x202): Module Manufacturing Location

The module manufacturer shall include an identifier that uniquely defines the manufacturing location of the memory module. While the SPD specification will not attempt to present a decode table for manufacturing sites, the individual manufacturer must keep track of manufacturing location and its appropriate decode represented in this byte.

20.3 Bytes 515~516 (0x203~0x204): Module Manufacturing Date

The module manufacturer shall include a date code for the module. The JEDEC definitions for bytes 515 and 516 are year and week respectively. These bytes must be represented in Binary Coded Decimal (BCD). For example, week 47 in year 2014 would be coded as 0x14 (0001 0100) in byte 515 and 0x47 (0100 0111) in byte 516.

20.4 Bytes 517~520 (0x205~0x208): Module Serial Number

The supplier shall include a unique serial number for the module. The supplier may use whatever decode method desired to maintain a unique serial number for each module.

One method of achieving this is by assigning a byte in the field from 517~520 as a tester ID byte and using the remaining bytes as a sequential serial number. Bytes 512~520 will then result in a nine-byte unique module identifier. Note that part number is not included in this identifier: the supplier may not give the same value for Bytes 517~520 to more than one DIMM even if the DIMMs have different part numbers.

20.5 Bytes 521~550 (0x209~0x226): Module Part Number

The manufacturer's part number shall be included and is written in ASCII format within these bytes. Unused digits are coded as ASCII blanks (0x20).

20.6 Byte 551 (0x227): Module Revision Code

This refers to the module revision code. While the SPD specification will not attempt to define the format for this information, the individual manufacturer may keep track of the revision code and its appropriate decode represented in this byte. This revision code refers to the manufacturer's assembly revision level and may be different than the raw card revision in SPD byte 232.

20.7 Byte 552 (0x228): DRAM Manufacturer ID Code, First Byte Byte 553 (0x229): DRAM Manufacturer ID Code, Second Byte

This two-byte field indicates the manufacturer of the DRAM on the module, and shall be encoded as follows: the first byte is the number of continuation bytes indicated in JEP-106; the second byte is the last non-zero byte of the manufacturer's ID code, again as indicated in JEP-106.

Table 167 — Encoding of Bytes 552 and 553

Byte 553, Bits 7~0	Byte 552, Bit 7	Byte 552, Bits 6~0
Last non-zero byte, DRAM Manufacturer	Odd Parity for Byte 552, bits 6~0	Number of continuation codes, DRAM Manufacturer
See JEP-106		See JEP-106

Example: See bytes 512~513 for example manufacturer codes.

20.8 Byte 554 (0x22A): DRAM Stepping

This byte defines the vendor die revision level (often called the "stepping") of the DRAMs on the module. This byte is optional. For modules without DRAM stepping information, this byte should be programmed to 0xFF. For DRAM suppliers who use a single letter ("A", "B", etc.) for the stepping indicator, the coding shall be the uppercase ASCII code for that letter.

Table 168 — Byte 554 DRAM Stepping

Bits 7~0
DRAM Stepping
Programmed in straight Hex format - no conversion needed. 00 - Valid 01 - Valid .. FE - Valid FF - Undefined (No Stepping Number Provided)

20.8 Byte 554 (0x22A): DRAM Stepping (cont'd)

Examples:

Table 169 — Example Byte 554 DRAM Stepping

Code	Meaning
0x00	Stepping 0
0x01	Stepping 1
0x31	Stepping 3.1
0xA3	Stepping A3
0xB1	Stepping B1
0x41	Stepping A
0x4A	Stepping J
0xFF	Stepping information not provided

20.9 Bytes 555~639 (0x22B~27F): Manufacturer's Specific Data

The module manufacturer may include any additional information desired into the module within these locations.

21 Blocks 10~15: End User Programmable, Bytes 640~1023 (0x280~0x3FF)

These blocks of the SPD are not write protected so that end users may program any values into these bytes during system runtime or for system management.

Optionally, end users may choose to save error logging information in these blocks. If so, the standard error logging format is described below.

21.1 Bytes n~n+23: Error Logging Data

Zero or more error logs may appear anywhere in any End User Programmable blocks of the SPD, including over SPD Block boundaries. They may be found by searching for a four byte anchor string. The 20 bytes after the anchor contain information about the error captured. If more than one error log is stored, it is not required to be stored sequentially, nor necessarily at a higher address. The timestamp in the error log may be used to determine the relative order of errors captured.

System BIOSes establish the policy to determine what error types are to be logged, such as only uncorrectable, only correctable, or any error type, and also whether it is the first error found or having exceeding some system specific error count threshold.

Care must be taken not to exceed the write limitations of the SPD device; see JESD300-5 for details.

Error Logging Data format is shown in Table 170 .

Table 170 — Bytes n~n+23 Error Logging Data Format

Bytes	Field	Meaning
n ~ n+3	Anchor	Anchor String to identify the beginning of an error log
n + 4	Header	Error Type
n+5 ~ n+13	Address	Error Location
n+14~n+17	Location	Timestamp
n+18	Refresh	Highest DRAM Refresh Settings on the Module
n+19 ~ n+20	Temperature	Module Measured Temperature
n+21 ~ n+23	Reserved	Reserved for future use

Encoding details, by byte:

21.2 Bytes n~n+3: Anchor String to Indicate Valid Error Log

Bytes n~n+3 contain the string “_FL_”, hex codes 0x5F, 0x46, 0x4C, 0x5F. Parsing the following bytes of the error log and using a “reasonableness” check on the contents may help avoid a false hit on error log data. For example, if the Month field decodes to an invalid Month 15 or the Day field decodes to an invalid Day 0, that indicates a likely false hit on the anchor string.

21.3 Byte n+4: Header to Indicate Error Type

Byte n+4 defines the type(s) of errors detected. For DRAM errors, the host system may interrogate the error logging information in each DRAM in the rank where the error occurred to determine the error type(s), and multiple error types may be possible. Other (non-DRAM) errors may be logged in future releases of the SPD document; all other bytes in the error log may be different depending on the coding of byte n+4 bits 7~6.

Table 171 — Byte n+4 Error Type Header

Bits 7~6	Bits 5~0
Error Log Type	Errors Found(s)
00 = DRAM error log type has been written	Bit code 0 = False, 1 = True Bit 0: At least one DRAM uncorrectable error Bit 1: At least one DRAM correctable error Bit 2: At least one DRAM ECS error Bit 3: An error occurred that required an hPPR Bit 4: At least one Post Package Repair (PPR) resource error Bit 5: Reserved; must be coded as 0
Other codes reserved	Coding dependent on Bits 7~6

NOTES:

ECS errors may be caused by the row or code word error count (DDR5 SDRAM MR20) or errors per row count (MR19) exceeding an OEM-defined limit.

Bits 3 and 4 may be used conjunctively to indicate that an hPPR was necessary and that the required resource was or was not available.

PPR Resource error may indicate that the system detected that a row repair was required using sPPR, hPPR, or mPPR, but insufficient PPR resources remained to complete the repair, or that a device dropped below an OEM-defined minimum resource count. This error could also be caused by a guard key error that prevented a requested repair from completing.

DRAM Error Log Byte Definitions

The following error log bytes are defined when the Error Log Type is 00 (DRAM error log).

It is important to note that conditions described in the DRAM error log capture the state of the memory module at the time that the error log is written. For many reasons, these conditions may or may not apply to the conditions at the time the memory error occurred, such as the difference between when the data was written versus when the data was read. As noted above, users may set error count thresholds before logging, so the log may only represent the last error that occurred. Additional processing is likely required to associate correlation and causation.

21.4 Bytes n+5~n+12 (DRAM error): Error Location

These bytes identify the location(s) where the errors occurred. The error log may only contain information regarding one specific address, however different devices may report different error types regarding that address. The erring devices are identified by a bit map of devices connected on data strobe (DQS) lines.

Table 172 — Bytes n+5~n+12 DRAM Error Location

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
n+5	Reserved	Reserved	CPU2	CPU1	CPU0	Reserved	CPUMC3	CPUMC2
n+6	CPUMC1	CPUMC0	Reserved	DIMM	CS0_A_n	CS1_A_n	CS0_B_n	CS1_B_n
n+7	Reserved	PAR	CID3/R17	CID2	CID1	CID0	BG2	BG1
n+8	BG0	BA1	BA0	R16	R15	R14	R13	R12
n+9	R11	R10	R9	R8	R7	R6	R5	R4
n+10	R3	R2	R1	R0	C10	C9	C8	C7
n+11	C6	C5	C4	C3	DQS9A_n	DQS8A_n	DQS7A_n	DQS6A_n
n+12	DQS54_n	DQS4A_n	DQS3A_n	DQS2A_n	DQS1A_n	DQS0A_n	DQS9B_n	DQS8B_n
n+13	DQS7B_n	DQS6B_n	DQS54_n	DQS4B_n	DQS3B_n	DQS2B_n	DQS1B_n	DQS0B_n

The following data select the location of the SDRAMs and address information for the operation. Note that some signals that are active low (_n) are indicated as active with a 0, inactive with a 1.

Reserved: Must be coded as 0

CPU[2~0]: Identifies the CPU that initiated the operation (0-7)

CPUMC[3~0]: Identifies the memory controller on the CPU that initiated the operation (0-15)

DIMM: Identifies the memory module on the identified memory controller interface (0-1)

0 = DIMM 0 selected

1 = DIMM 1 selected

CS[1~0]_A_n: Rank selected on sub-channel A (0-1)

CS[1~0]_B_n: Rank selected on sub-channel B (0-1)

0 = Rank selected

1 = Rank not selected

PAR: Parity

CID3/R17: Chip identifier or row address

CID[2~0]: Chip identifier

BG[2~0]: Bank group

BA[1~0]: Bank address

R[16~0]: Row address

C[10:3]: Column address

The following signals are a bit map for every device exhibiting an error for the logged operation, as selected by the data strobes for each device.

DQS[9~0]A_n: Device select (data strobes) on sub-channel A

DQS[9~0]B_n: Device select (data strobes) on sub-channel B

0 = Device selected

1 = Device not selected

21.5 Bytes n+14~n+17 (DRAM Error): Timestamp

These bytes identify the time at which the error occurred which triggered error logging. The date is per the Gregorian calendar.

Table 173 — Bytes n+14~n+17 DRAM Error Timestamp

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
n+14	Year					Month MSb		
n+15	Month LSb		Day				Hour MSb	
n+16	Hour LSb				Minute MSb			
n+17	Minute LSb		Second					

NOTES:

Year is coded as [year - 2020], i.e., the range is from 2020 to 2083 on the Gregorian calendar
Month is 1 to 12
Day is 1 to 31
Hour is 0 to 23
Minute is 0 to 59
Second is 0 to 59

Example:

Error logged on March 16, 2025 at 20:15:44

Year = 000101, Month = 0011, Day = 10000, Hour = 10100, Minute = 001111, Second = 101100
Code byte n+14 = 000101 00 (0x14)
Code byte n+15 = 11 10000 1 (0xE1)
Code byte n+16 = 0100 0011 (0x43)
Code byte n+17 = 11 101100 (0xEC)

21.6 Byte n+18 (DRAM Error): Highest DRAM Refresh Settings on the Module

This byte saves the state of the highest refresh rate settings of all DRAMs on the module at the time of error log entry, where “highest” is defined by the value of bits OP[2~0] in DRAM mode register MR4. This byte is coded as 0x00 if this information is not being logged. This MR4 information may or may not come from a DRAM reporting an error as indicated in byte n+5 through n+12.

Table 174 — Byte n+18 (DRAM error): Highest DRAM Refresh Settings on the Module

Bit 7	Bit 6	Bit 5	Bit 4
Temperature Update Flag (TUF)	Reserved	Wide Range	Refresh tRFC Mode
0 = No change in OP[2~0] since last MR4 read 1 = Change in OP[2~0] since last MR4 read	Reserved; must be coded as 0	0 = Wide temperature sense range not supported 1 = Wide temperature sense range supported	0 = Normal (tRFC1) 1 = Fine granularity (tRFC2)
Bit 3	Bits 2~0		
Refresh Interval Rate Indicator	Minimum Refresh Rate		
0 = Not implemented 1 = Implemented	If bit 5 = 0 000 = Reserved 001 = tREFI x1 (1x Refresh Rate), $t \leq 80^{\circ}\text{C}$ 010 = tREFI x1 (1x Refresh Rate), $80^{\circ}\text{C} < t \leq 85^{\circ}\text{C}$ 011 = tREFI /2 (2x Refresh Rate), $85^{\circ}\text{C} < t \leq 90^{\circ}\text{C}$ 100 = tREFI /2 (2x Refresh Rate), $90^{\circ}\text{C} < t \leq 95^{\circ}\text{C}$ 101 = tREFI /2 (2x Refresh Rate), $t > 95^{\circ}\text{C}$ Other codes reserved	If bit 5 = 1 000 = tREFI x1 (1x Refresh Rate), $t \leq 75^{\circ}\text{C}$ 001 = tREFI x1 (1x Refresh Rate), $75^{\circ}\text{C} < t \leq 80^{\circ}\text{C}$ 010 = tREFI x1 (1x Refresh Rate), $80^{\circ}\text{C} < t \leq 85^{\circ}\text{C}$ 011 = tREFI /2 (2x Refresh Rate), $85^{\circ}\text{C} < t \leq 90^{\circ}\text{C}$ 100 = tREFI /2 (2x Refresh Rate), $90^{\circ}\text{C} < t \leq 95^{\circ}\text{C}$ 101 = tREFI /2 (2x Refresh Rate), $95^{\circ}\text{C} < t \leq 100^{\circ}\text{C}$ 110 = tREFI /2 (2x Refresh Rate), $t > 100^{\circ}\text{C}$ 111 = Reserved	
NOTE See the JESD79-5 DDR5 SDRAM definition for mode register MR4. Bit 5, Wide Range, is the same as SPD byte 14 bit 3, included here for simplicity of copying MR4 contents into the error log.			

21.7 Byte n+19~20 (DRAM Error): Module Measured Temperature

These bytes store the module temperature measured at the SPD (or ESPD) and external thermal sensors when the error log is created.

Table 175 — Byte n+19~20 (DRAM Error): Module Measured Temperature

Byte n+19		
Bits 7~5	Bits 4~0	
TS0 Temperature, LSb ^{1,2,4}	SPD/ESPD Temperature ^{1,3,4}	
Byte n+20		
Bit 7	Bits 6~2	Bits 1~0
Reserved; code as 0	TS1 Temperature ^{1,2,4}	TS0 Temperature, MSb ^{1,2,4}

NOTES:

1. All thermal sensors are coded as:
00000 = Not specified or not installed
00001 = $74^{\circ}\text{C} + 1 = 75^{\circ}\text{C}$ or lower
00010 = $74^{\circ}\text{C} + 2 = 76^{\circ}\text{C}$
...
11110 = $74^{\circ}\text{C} + 30 = 104^{\circ}\text{C}$
11111 = $74^{\circ}\text{C} + 31 = 105^{\circ}\text{C}$ or higher
2. See the JESD302-1 TS511X Thermal Sensor Specification for mode registers MR49 and MR50:
TS temperatures are calculated from TS MR49 and MR50
3. See the JESD300-5 SPD5118 or JESD316-5 ESPD5216 Device Specifications for mode registers MR49 and MR50: SPD temperature is calculated from (E)SPD MR49 and MR50
4. Devices not installed shall be reported as 00000

21.8 Bytes n+21~n+23 (DRAM error): Reserved

Must be coded as 0x00 if an error log is stored.

Annex A — (Informative) Differences Between JESD400-5A and JESD400-5

This version incorporated ballots passed at June 2022 meeting as follows:

1. JC-45-136: MRDIMM (changed editorially to MRDIMM after tally)
2. JC-45-137: Add DDP back in
3. JC-45-138: Expanded rounding algorithm
4. JC-45-139: Example tables through 7200
5. Editorial changes per TG45_1^20220816a and approved by the BOD
 - Added support for RCD03, DB03 to RDIMM/LRDIMM annex
 - Clarified definition of “ranks”
 - Cleanup, clarifications for MRDIMM, sub-channels

Detailed changes as follows:

Clause	Changes
Page 1	Changed DDR5 SPD Document Release 1.1, Beta release 0 Changed Base SPD revision 1.1 Added MRDIMM annex revision 1.0
4.4	Added MRDIMM Overlay Schema
8.1.4 (0x003)	Changed 0111:Reserved to 0111:MRDIMM in Key Byte/Module Type Table for Byte 3
8.1.5	Changed 001:Reserved to 001:2 die; Dual-die package (DDP) in First SDRAM Density and Package Table for Byte 4 (0x004)
8.1.9	Changed 001:Reserved to 001:Reserved to 001:2 die; Dual-die package (DDP) in Second SDRAM Density and Package Table for Byte 8 (0x008)
8.3.1	Changed Rounding Algorithm section and added MT/s header in first column of Table 5
8.3.2	Modified pseudocode of CVL Algorithm
9	Added 6800 and 7200 speed grades in the clock period table (tCK)
9.1	Added new Table 9 Example #4, Codes for SPD Contents
9.2	Added new table for DDR5-6800 Mono and DDR5-7200 Mono parameters with Lower nCK Limits
9.3	Added Mono Speed Bins for 6800AN through 7200C in CAS Latency Masks table
9.5	Added new table for 6800AN through 7200C 3DS Core Parameters, DDR5 Multi-die Packages (3DS) SDRAMs
9.6	Added new table for DDR5-6800 through DDR5-7200 3DS Parameters with Lower nCK Limits, DDR5 3DS SDRAMs
9.7	Added 6800AN 3DS through 7200C 3DS speed bins in the CAS Latency Masks, DDR5 3DS SDRAM table
10	Changed from A4:Reserved to A4:Multiplexed Rank DIMMs (MRDIMM) Annex
10.2	Changed RCDs and DBs in the Hashing Sequence Table for Bits 2~0
15	Changed Annex A.4 from Reserved to Module Specific Bytes for Multiplexed Rank

Annex A — (Informative) Differences Between JESD400-5A and JESD400-5 (cont'd)

(MRDIMM) Memory Module Types	
Sec. 6	SPD Revision Progression table revision
Sec. 8.1.4	Modified table for Byte 3 to add MRDIMM
Sec. 11.9	Annex A0:Common SPD Bytes for All Module Types, table modified
Sec. 11.10	Annex A0:Common SPD Bytes for All Module Types, table modified
Sec. 11.10.1	Annex A0:Common SPD Bytes for All Module Types, calculating Module DRAM Capacity
Sec. 14.2	Annex A3:Module Specific Bytes for Registered (RDIMM) and Load Reduced (LRDIMM) Memory Module Types, modified table

Annex B — (Informative) Differences between JESD400-5A.01 and JESD400-5A

Task Group editorial correction from the JC-45 module committee meeting # 77:

Clause 9.1, Table 6 “Example #1, Codes for SPD Contents”: tRC, tRC(ps), tRC low, and tRC high values under the “3600B Mono” column.

Annex C — (Informative) Differences between JESD400-5B and JESD400-5A.01

This clause describes the key changes made to the standard (JESD400-5B) in comparison to its predecessor (JESD400-5A.01). Minor editorial changes and format updates of figures and tables are not included.

Summary:

1. Merged WIP with CAMM, CUDIMM, tCCD_M
2. Accepted all changes, prepared Beta 1 release
3. Incorporated passed ballots 22-136, 22-137, 22-138, 22-139, 23-101, 23-114, 23-165, 23-166.
4. Corrected CUDIMM and CSODIMM definitions in byte 3
5. Eliminated redundant Doc Version variable, replaced with Revision
6. Added buffer support from item 2260.76
7. Address typos for reserved bytes, worked around FrameMaker bug that was replicating table information, promoted Annex A.8 to 1.0 status
8. Corrected typo in UDIMM RW03 byte 246
9. Updated examples table per latest spreadsheet
10. Corrected table header in CAMM2 annex
11. Added new device types
12. Split PMIC5020 into its own spec JESD301-4
13. Fixed typo in UDIMM byte list
14. PMIC503 in new JESD spec, added 4 row support
15. Corrected byte order of tCCD_M parameters
16. Changed PMIC5120 to JESD301-6
17. Fixed typo in hex version of address range for standard module parameters

Details:

<u>Clause</u>	<u>Changes</u>
Page 1	Updated document release numbers for the various Annexes Added CAMM2 Annex
3	Added Annex A.8: CAMM2
4.8	New section "CAMM2 Overlay Schema"
Table 1	Moved from Sec. 7.1 to Sec. 8 Defined Byte #s 94 to 102, remaining byte #s 103-127 Reserved for Future Use
8.1	Added (DDR5) in the description for Byte 0 through 127
8.1.4	Modified table for DDR5 Byte 3
8.1.48	New section for Bytes 94, 95, and 96
8.1.49	New section for Bytes 97, 98, and 99
8.1.50	New section for Bytes 100, 101, and 102
9.1	Modified Table 76 Example 4: Core Parameters, DDR5 Monolithic Single Die Package SDRAMs Added Table 77 Example 5: Core Parameters, DDR5 Monolithic Single Die Package SDRAMs Added Table 78 Example 6: Core Parameters, DDR5 Monolithic Single Die Package SDRAMs

Annex C — (Informative) Differences between JESD400-5B and JESD400-5A.01 (cont'd)

- 9.2 Modified Table 79 Example 7 Parameters with Lower nCK Limits, DDR5 Monolithic Single Die Package SDRAMs
Modified Table 80 Example 8 Parameters with Lower nCK Limits, DDR5 Monolithic Single Die Package SDRAMs
- 9.3 Modified Table 81 CAS Latency Masks, DDR5 Monolithic Single Die Package SDRAMs
- 9.5 Modified Table 85 Example 3: Core Parameters, DDR5 Multi-Die Packages (3DS)
SDRAMs
Modified Table 86 Example 4: Core Parameters, DDR5 Multi-Die Packages (3DS)
SDRAMs
Added Table 87 Example 5: Core Parameters, DDR5 Multi-Die Packages (3DS) SDRAMs
- 9.7 Modified table for CAS Latency Masks, DDR5 Multi-Die Package SDRAMs
- 11 Modified Annex A.0 to add A.8 CAMM2
- 11.2 Modified Table for (Common) Hashing Sequence
- 11.3 Modified Table for Device Types PMIC 1, PMIC 2, and Thermal Sensors
- 11.10 Modified (Common) Memory Channel Bus Width description for Byte 235, Table for Memory Channel Bus Width, Examples, and Calculating Module DRAM Capacity
- 13 Modified Annex A.2 Table on Module Specific SPD Bytes for Unbuffered Module Types
Added new sections for Bytes 244 through 246
- 14.1 Modified table for Module Specific Device Types
- 14.4 Modified Table for Byte 250
- 14.6 Modified Table for Byte 252
- 14.7 Modified Table for Byte 253
- 14.8 Modified Table for Byte 254
- 14.9 Modified Table for Byte 255
- 15 Modified Table for Annex A.4 on Module Specific SPD Bytes for Multiplexed Rank Module Types
Modified Table for Bytes 240~247 on Module Specific Device Types
- 15.2 New section for Byte 248
- 15.3 New section for Byte 249
- 15.4 New section for Byte 250
- 15.5 New section for Byte 251
- 15.6 New section for Byte 252
- 15.7 New section for Byte 253
- 15.8 New section for Byte 254
- 15.9 New section for Byte 255
- 15.10 New section for Byte 256
- 15.11 New section for Byte 257
- 19.1 Modified Table for Bytes 240~243

Annex D — (Informative) Differences between JESD400-5C and JESD400-5B

This clause describes the key changes made to the standard (JESD400-5C) in comparison to its predecessor (JESD400-5B). Minor editorial changes and format updates of figures and tables are not included.

- Page 1: Updated the JC-45 item number and the revision numbers of the various clauses
- Page 5: Clause 4.2 — added the values for CUDIMM and CSODIMM for Key Byte 3
- Page 15: Clause 8.1, Table 17 — modified DDR5 function described for Byte 14 (0x00E)
- Page 28: Clause 8.1.15, Table 32 — modified the entire table, changed caption to “SDRAM Per Row Activation Counting, Fault Handling, and Temperature Sense”
- Page 34: Clause 8.1.20, CL Algorithm — replaced “..8400” with “...9200” (4 instances)
- Page 52: Clause 9, Table 72 — added 5 new rows (Grade 7600 through 9200)
- Page 57: Clause 9.1, Table 77 — added 4 new columns (9200AN Mono through 9200C Mono)
- Page 59: Clause 9.2, Table 79 — added 2 new columns (DDR5-8800 Mono through DDR5-9200 Mono)
- Page 60: Clause 9.3, Table 80 — added 4 new rows (9200AN through 9200C)
- Page 66: Clause 9.5, Table 86 — added 4 new columns (9200AN 3DS through 9200C 3DS)
- Page 68: Clause 9.6, Table 88 — added 5 new columns (DDR5-7600 3DS through DDR5-9200 3DS) and 6 new rows (tCCD_M_slr through tCCD_M_WTR_slr)
- Page 69: Clause 9.7, Table 89 — added 4 new rows (9200AN 3DS through 9200C 3DS)
- Page 72: Clause 11, Table 91 — split Byte number 214-229 into 214-228 and 229
- Page 75: Clause 11.4 — redefined Bytes 214 - 229 to Byte 214-228;
Added Clause 11.5 Byte 229 and a new Table 95 and adjusted the numbering of the succeeding clauses and table numbers
- Page 78: Clause 11.9, Table 100 — modified the columns for Bit 3 and Bits 1~0
- Page 84: Clause 12, Annex A.1 — modified the revision # and coding for Bytes 192~447
- Page 88: Clause 14, Annex A.3 — modified the revision # and coding for Bytes 192~447
- Page 95: Clause 15, Annex A.4 — modified the revision # and coding for Bytes 192~447
- Page 102: Clause 16, Annex A.5 — modified the revision # and coding for Bytes 192~447
- Page 104: Clause 17, Annex A.6 — modified the revision # and coding for Bytes 192~447
- Page 106: Clause 18, Annex A.7 — modified the revision # and coding for Bytes 192~447
- Page 111: Clause 19, Annex A.8 — modified the revision # and coding for Bytes 192~447;
Table 156 — split Byte number 248~447 into 8 rows (248~255, 256, 257, 258, 259, 260, 261, and 262~447);
Clause 19.1 — redefined Byte 240~243 (0x0F0~0xF3) to Byte 240~247 (0x0F0~0xF7)
- Page 112: Clause 19.2 — redefined Bytes 248~447 (0x0F8~0x1BF) to Bytes 248~255 (0x0F8~0xFF)
Added Clause 19.3 — Byte 256 (0x100) and new Table 159
- Page 113: Added Clause 19.4 — Byte 257 (0x101) and new Table 160;
Added Clause 19.5 — Byte 258 (0x102) and new Table 161
- Page 114: Added Clause 19.6 — Byte 259 (0x103) and new Table 162;
Added Clause 19.7 — Byte 260 (0x104) and new Table 163;
Added Clause 19.8 — Byte 261 (0x105) and new Table 164;
Added Clause 19.9 — Bytes 262~447 (0x106~0x1BF)

Editorial updates of the following:

- “Notice” and “Do Not Violate the Law” pages
- Table of Contents to add the document title to every page
- Back page



Standard Improvement Form**JEDEC Standard JESD400-5C, Release 1.3**

The purpose of this form is to provide the Technical Committees of JEDEC with input from the industry regarding usage of the subject standard. Individuals or companies are invited to submit comments to JEDEC. All comments will be collected and dispersed to the appropriate committee(s).

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1. I recommend changes to the following:

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Test method number _____ Clause number _____

The referenced clause number has proven to be:

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