256 Mb/512 Mb/1 Gb SEMPER™ Flash

Quad SPI, 1.8 V/3.0 V

Features

- Infineon 45-nm MIRRORBIT™ technology that stores two data bits in each memory array cell
- Sector architecture options
  - Uniform: Address space consists of all 256 KB sectors
  - Hybrid Configuration 1: Address space consists of thirty-two 4 KB sectors grouped either on the top or the bottom while the remaining sectors are all 256 KB
  - Hybrid Configuration 2: Address space consists of thirty-two 4 KB sectors equally split between top and bottom while the remaining sectors are all 256 KB
- Page programming buffer of 256 or 512 bytes
- OTP secure silicon array of 1024 bytes (32 × 32 bytes)
- Quad SPI
  - Supports 1S-1S-4S, 1S-4S-4S, 1S-4D-4D, 4S-4S-4S, 4S-4D-4D protocols
  - SDR option runs up to 83-MBps (166 MHz clock speed)
  - DDR option runs up to 102-MBps (102 MHz clock speed)
- Dual SPI
  - Supports 1S-2S-2S protocol
  - SDR option runs up to 41.5-MBps (166 MHz clock speed)
- SPI
  - Supports 1S-1S-1S protocol
  - SDR option runs up to 21-MBps (166 MHz clock speed)
- Functional safety features
  - Functional safety with the industry's first ISO26262 ASIL B compliant and ASIL D ready NOR Flash
  - Infineon Endurance Flex architecture provides high-endurance and long retention partitions
  - Data integrity CRC detects errors in memory array
  - SafeBoot reports device initialization failures, detects configuration corruption, and provides recovery options
  - Built-in error correcting code (ECC) corrects single-bit error and detects double-bit error (SECDED) on memory array data
  - Sector erase status indicator for power loss during erase
- Protection features
  - Legacy block protection for memory array and device configuration
  - Advanced sector protection for individual memory array sector based protection
- AutoBoot enables immediate access to the memory array following power-on
- Hardware reset through JEDEC Serial Flash Reset Signaling Protocol / individual RESET# pin / DQ3_RESET# pin
- Serial flash discoverable parameters (SFDP) describing device functions and features
- Device identification, manufacturer identification, and unique identification

Features

- Data Integrity
  - 256Mb devices
    - Minimum 640,000 program-erase cycles for the main array
  - 512Mb devices
    - Minimum 1,280,000 program-erase cycles for the main array
  - 1Gb devices
    - Minimum 2,560,000 program-erase cycles for the main array
  - All devices
    - Minimum 300,000 program-erase cycles for the 4KB sectors
    - Minimum 25 years data retention
- Supply voltage
  - 1.7 V to 2.0 V (HS-T)
  - 2.7 V to 3.6 V (HL-T)
- Grade / temperature range
  - Industrial (–40°C to +85°C)
  - Industrial plus (–40°C to +105°C)
  - Automotive AEC-Q100 grade 3 (–40°C to +85°C)
  - Automotive AEC-Q100 grade 2 (–40°C to +105°C)
  - Automotive AEC-Q100 grade 1 (–40°C to +125°C)
- Packages
  - 256MB and 512MB
    - 16-lead SOIC (300 mil) - SO3016
    - 24-ball BGA 6 × 8 mm
    - 16-lead SOIC (300 mil)
    - 8-contact WSON 6 × 8 mm
  - 1GB
    - 16-lead SOIC (300 mil) - SO3016
    - 24-ball BGA 8 × 8 mm
    - 16-lead SOIC (300 mil)

Performance summary

Maximum read rates

Transaction	Initial access latency (Cycles)	Clock rate (MHz)	MBps
SPI Read	0	50	6.25
SPI Fast Read	9	166	20.75
Dual Read SDR	7	166	41.5
Quad Read SDR	10	166	83
Quad Read DDR	7	102	102

Typical program and erase rates

Operation	KBps
256B page programming (4KB sector / 256KB sector)	595 / 533
512B page programming (4KB sector / 256KB sector)	753 / 898
256KB sector erase	331
4KB sector erase	95

Typical current consumption

Operation	Current (mA)
SDR Read 50 MHz	10
SDR Read 166 MHz	53
DDR Read 102 MHz	50
Program	50
Erase	50
Standby (HS-T)	0.011
Standby (HL-T)	0.014
Deep power down (HS-T)	0.0013
Deep power down (HL-T)	0.0022

Data integrity

Program / erase (PE) endurance - High endurance (256 KB sectors)

Sectors in partition	Minimum PE cycles	Minimum retention time	Unit
512 (Default for 1GB devices)	2,560,000	2	Years
508	2,540,000		
504	2,520,000		
...	...		
256 (Default for 512MB devices)	1,280,000		
252	1,260,000		
128 (Default for 256MB devices)	640,000		
...			
28	140,000		
24	120,000		
20	100,000		

Note Minimum cycles is for entire high endurance partition.

Program / erase endurance - Long retention partition (256 KB sectors)

Minimum PE cycles	Minimum retention time	Unit
500	25	Years

Note Minimum cycles is for each sector.

Program / erase endurance 4 KB sector and nonvolatile register array

Flash memory type	Minimum cycles	Unit	Minimum retention time	Unit
Program/Erase cycles per 4KB sector	500	PE cycles	25	Years
	300,000 **Note** It is required to restrict the power loss events to 300 times per sector during program or erase operation to achieve the mentioned endurance cycles.		2	
Program/Erase cycles per persistent protection bits (PPB) array or nonvolatile register array **Note** Each write transaction to a nonvolatile register causes a PE cycle on the entire nonvolatile register array.	500		25	

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1 Pinout and signal description

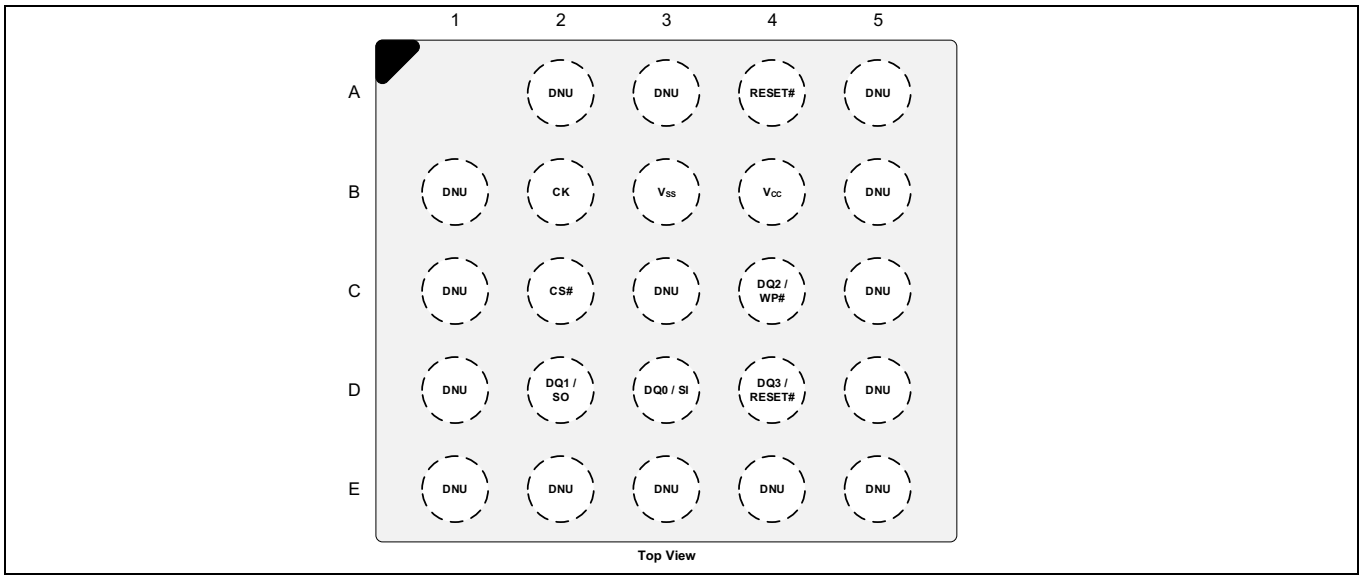


Figure 1 24-ball BGA pinout configuration[1]

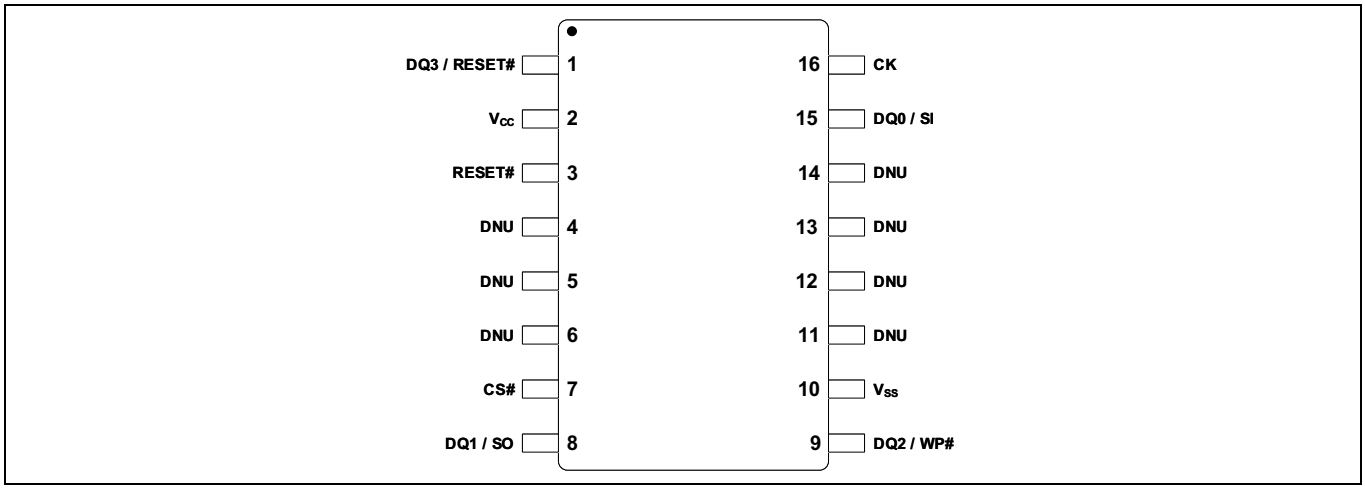


Figure 2 16-lead SOIC package (SO316), top view

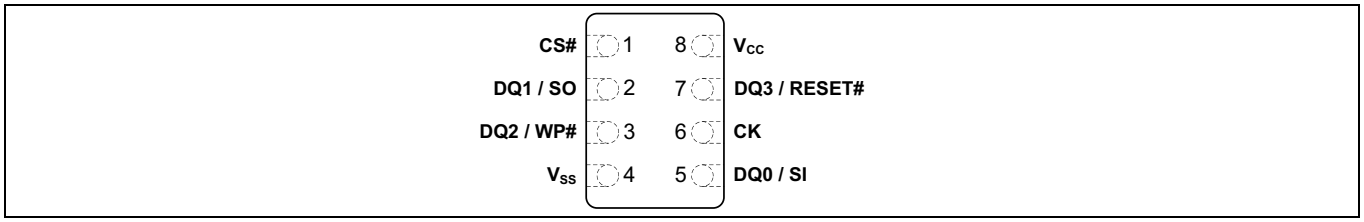


Figure 3 8-connector package (WSON 6 × 8), top view

Note

1. Flash memory devices in BGA packages can be damaged if exposed to ultrasonic cleaning methods. The package, data integrity, or both may be compromised if the package body is exposed to temperatures above 150°C for prolonged periods of time.

Table 1 Signal description

Symbol	Type	Mandatory / optional	Description
CS#	Input	Mandatory	**Chip Select (CS#).** All bus transactions are initiated with a HIGH to LOW transition on CS# and terminated with a LOW to HIGH transition on CS#. Driving CS# LOW enables the device, placing it in the active mode. When CS# is driven HIGH, the device enters standby mode, unless an internal embedded operation is in progress. All other input pins are ignored and the output pins are put in high impedance state. On parts where the pin configuration offers a dedicated RESET# pin, it remains active when CS# is HIGH.
CK			**Clock (CK)**. Clock provides the timing of the serial interface. Transactions are latched on the rising edge of the clock. In SDR protocol, command, address and data inputs are latched on the rising edge of the clock, while data is output on the falling edge of the clock. In DDR protocol, command, address and data inputs are latched on both edges of the clock, and data is output on both edges of the clock.
DQ0 / SI	Input/Output		Serial Input (SI) for single SPI protocol **DQ0 Input/Output** for Dual or Quad SPI protocol
DQ1 / SO			Serial Output (SO) for single SPI protocol **DQ1 Input/Output** for Dual or Quad SPI protocol
DQ2 / WP#	Input/Output (weak Pull-up)		Write Protect (WP#) for single and dual SPI protocol **DQ2 Input/Output** for Quad SPI protocol The signal has an internal pull-up resistor and can be left unconnected in the host system if not used for Quad transactions or write protection. If write protection is enabled, the host system is required to drive WP# HIGH or LOW during write register transactions.
DQ3 / RESET#			**RESET#** for single and dual SPI protocol. This signal can be configured as RESET# when CS# is HIGH or Quad SPI protocol is disabled. **DQ3 Input/Output** for Quad SPI protocol The signal has an internal pull-up resistor and can be left unconnected in the host system if not used for Quad SPI transactions or RESET#
RESET#	Input (weak Pull-up)	Optional	**Hardware Reset (RESET#)**. When LOW, the device will self initialize and return to the array read state. DQ[3:0] are placed into the high impedance state when RESET# is LOW. RESET# includes a weak pull-up, meaning, if RESET# is left unconnected it will be pulled up to the HIGH state on its own.
V_{CC}	Power Supply	Mandatory	Core Power Supply
V_{SS}	Ground Supply		Core Ground
DNU	–	–	Do Not Use.

2 Interface overview

2.1 General description

The Infineon SEMPER™ Flash with Quad SPI family of products are high-speed CMOS, MIRRORBIT™ NOR Flash devices. SEMPER™ Flash is designed for Functional Safety with development according to ISO 26262 standard to achieve ASIL-B compliance and ASIL-D readiness.

SEMPER™ Flash with Quad SPI devices support traditional SPI single bit serial input and output, optional two bit (Dual I/O or DIO) as well as four bit wide Quad I/O (QIO) and Quad Peripheral Interface (QPI) protocols. In addition, there are DDR read transactions for QIO and QPI that transfer address and read data on both edges of the clock.

Read operations from the device are burst oriented. Read transactions can be configured to use either a wrapped or linear burst. Wrapped bursts read from a single page whereas linear bursts can read the whole memory array.

The erased state of each memory bit is a logic 1. Programming changes a logic 1 (HIGH) to a logic 0 (LOW). Only an erase operation can change a memory bit from a 0 to a 1. An erase operation must be performed on a complete sector (4 KBs or 256 KBs).

SEMPER™ Flash provides a flexible sector architecture. The address space can be configured as either a uniform 256 KB sector array, or a hybrid configuration 1 where thirty-two 4 KB sectors are either grouped at the top or at the bottom while the remaining sectors are all 256 KB, or a hybrid configuration 2 where the thirty-two 4 KB sectors are equally split between the top and the bottom while the remaining sectors are all 256 KB.

The Page Programming Buffer used during a single programming operation is configurable to either 256 bytes or 512 bytes. The 512 byte option provides the highest programming throughput.

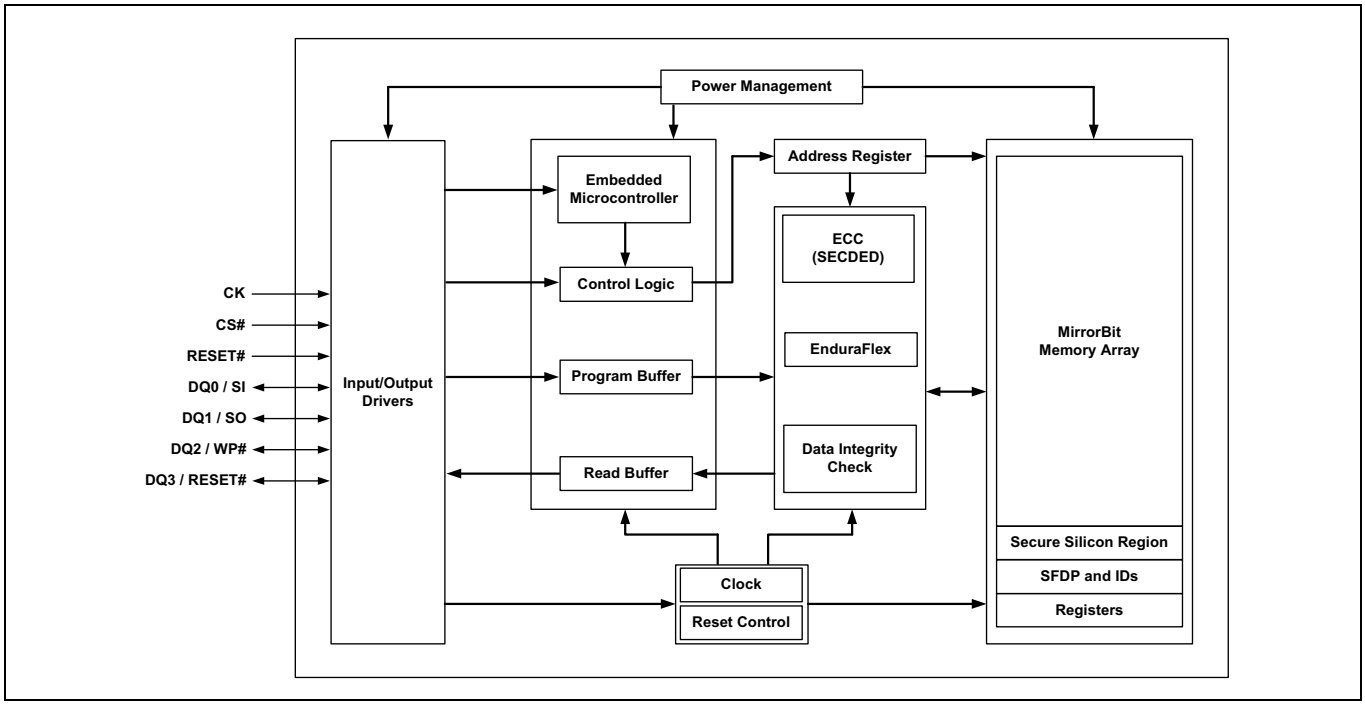


Figure 4 Logic block diagram

The SEMPER™ Flash with Quad SPI family consists of multiple densities with, 1.8 V and 3.0 V core and I/O voltage options.

The device control logic is subdivided into two parallel operating sections: the Host Interface Controller (HIC) and the Embedded Algorithm Controller (EAC). The HIC monitors signal levels on the device inputs and drives outputs as needed to complete read, program, and write data transfers with the host system. The HIC delivers data from the currently entered address map on read transfers; places write transfer address and data information into the EAC command memory, and notifies the EAC of power transition, and write transfers. The EAC interrogates the command memory, after a program or write transfer, for legal command sequences and performs the related Embedded Algorithms.

Changing the nonvolatile data in the memory array requires a sequence of operations that are part of Embedded Algorithms (EA). The algorithms are managed entirely by the internal EAC. The main algorithms perform programming and erase of the main flash array data. The host system writes command codes to the flash device. The EAC receives the command, performs all the necessary steps to complete the transaction, and provides status information during the progress of an EA.

Executing code directly from flash memory is often called Execute-In-Place (XIP). By using XIP with SEMPER™ Flash devices at the higher clock rates with Quad or DDR Quad SPI transactions, the data transfer rate can match or exceed traditional parallel or asynchronous NOR Flash memories while reducing signal count dramatically.

Infineon Endurance Flex architecture provides system designers the ability to customize the NOR Flash endurance and retention for their specific application. The host defines partitions for high endurance or long retention, providing up to 1+ million cycles or 25 years of data retention.

The SEMPER™ Flash with Quad SPI device supports error detection and correction by generating an embedded Hamming error correction code during memory array programming. This ECC code is then used for single-bit and double-bit error detection and single-bit correction during read.

The SEMPER™ Flash with Quad SPI device has built-in diagnostic features providing the host system with the device status.

- Program and Erase Operation: Reporting of program or erase success, failure and suspend status
- Error Detection and Correction: 1-bit and/or 2-bit error status with address trapping and error count
- Data Integrity Check: Error detection over memory array contents
- SafeBoot: Reporting of proper flash device initialization and configuration corruption recovery
- Sector Erase Status: Reporting of erase success or failure status per sector
- Sector Erase Counter: Counts the number of erase cycles per sector

2.2 Signal protocols

2.2.1 SEMPER™ Flash with Quad SPI clock modes

The SEMPER™ Flash with Quad SPI device can be driven by an embedded microcontroller (bus master) in either of the following two clocking modes:

- **Mode 0** with Clock Polarity LOW at the fall of CS# and staying LOW until it goes HIGH at capture input.
- **Mode 3** with Clock Polarity HIGH at the fall of CS# then going LOW to HIGH at capture input.

For these two modes, data is latched into the device on the rising edge of the CK signal in SDR protocol and both edges of the CK signal in DDR protocol. The output data is available on the falling edge of the CK clock signal. For DDR protocol, Mode 3 is not supported.

The difference between the two modes is the clock polarity when the bus master is in Standby mode and not transferring any data.

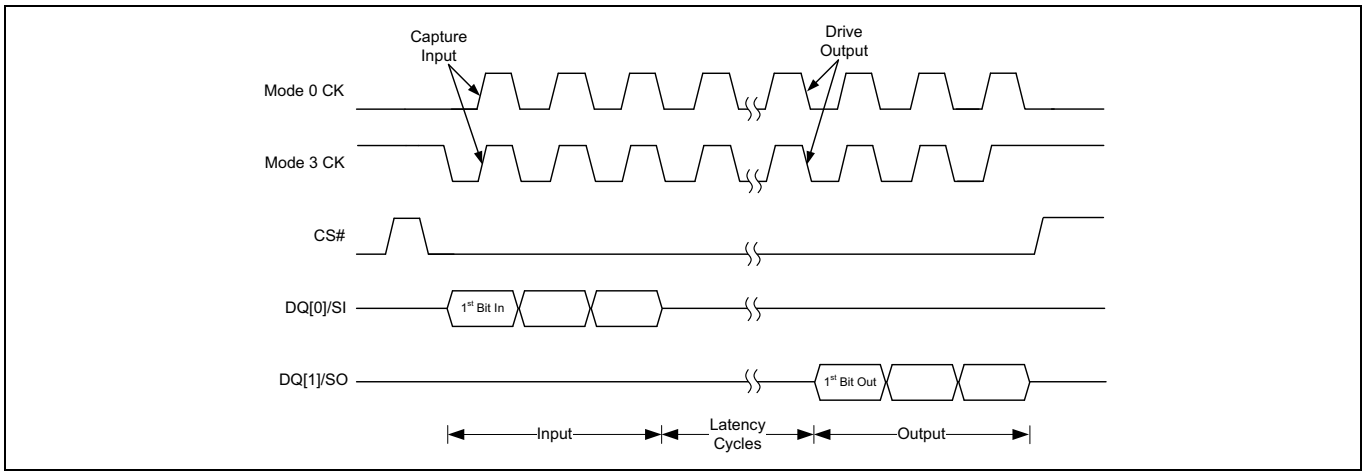


Figure 5 SPI SDR mode support

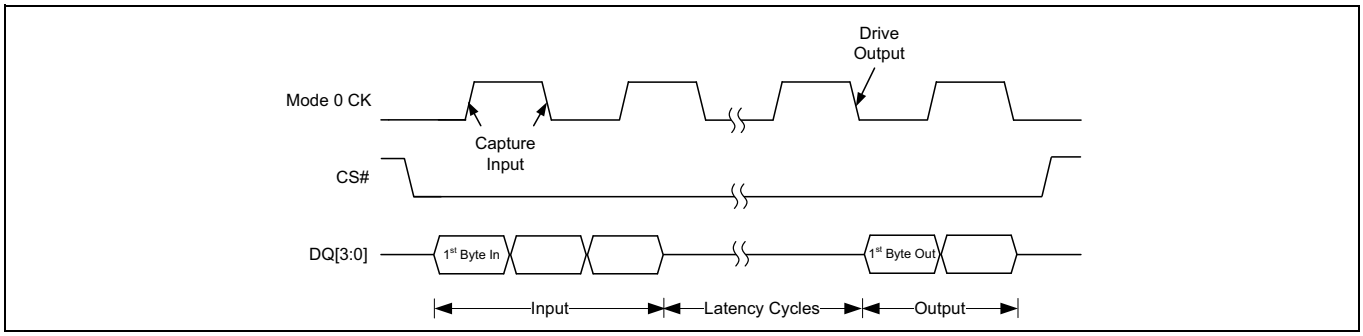


Figure 6 SPI DDR mode support

2.3 Transaction protocol

Transaction

- During the time that CS# is active (LOW) the clock signal (CK) is toggled while command information is first transferred on the data (DQ) signals followed by address and data from the host to the flash device. The clock continues to toggle during the transfer of read data from the flash device to the host or write data from the host to the flash device. When the host has transferred the desired amount of data, the host drives the CS# inactive (HIGH). The period during which CS# is active is called a transaction on the bus.
- While CS# is inactive, the CK is not required to toggle.
- The command transfer occurs at the beginning of every transaction. The address, latency cycles, and data transfer phases are optional and their presence depends on the protocol mode or command transferred.

Transaction capture

- CK marks the transfer of each bit or group of bits between the host and memory. Command, address and write data bits transfer occurs on CK rising edge in SDR transactions, or on every CK edge, in DDR transactions.

Note: All attempts to read the flash memory array during a program or erase (embedded operations) are ignored. The embedded operation will continue to execute without any effect. A very limited set of commands are accepted during an embedded operation. These are discussed in **"Suspend and resume embedded operation"** on page 65.

Protocol terminology

- The number of DQ signals used during the transaction, depends on the current protocol mode or command transferred. The latency cycles do not use the DQ signals for information transfer. The protocol mode options are described by the data rate and the DQ width (number of DQ signals) used during the command, address, and data phases in the following format:

  WR-WR-WR, where:
  - The first WR is the command bit width and rate.
  - The second WR is the address bit width and rate.
  - The third WR is the data bit width and rate.
- The bit width value may be 1, 2 or 4. R has a value of S for SDR or D for DDR. SDR has the same transfer value during the rising and falling edge of a clock cycle. DDR can have different transfer values during the rising and falling edges of each clock.
- Examples:
  - 1S-1S-1S means that the command is 1 bit wide SDR, the address is 1 bit wide SDR, and the data is one bit wide SDR.
  - 4S-4D-4D means that the command is 4 bits wide SDR, address, and data transfers are 4 bits wide DDR.

Protocols definition

- Protocol Modes defined for the SEMPER™ Flash with Quad SPI:
  - 1S-1S-1S: One DQ signal used during command transfer, address transfer, and data transfer. All phases are SDR.
  - 1S-2S-2S: One DQ signal used during command transfer, two DQ signals used during address transfer, and data transfer. All phases are SDR.
  - 1S-1S-4S: One DQ signal used during command and address transfer, four DQ signals used during data transfer. All phases are SDR.
  - 1S-4S-4S: One DQ signal used during command transfer, four DQ signals used during address transfer, and data transfer. All phases are SDR.
  - 1S-4D-4D: One DQ signal used during command transfer at SDR, four DQ signals used during address and data transfer at DDR.

  - 4S-4S-4S: Four DQ signals used during command transfer, address transfer, and data transfer. All phases are SDR.
  - 4S-4D-4D: Four DQ signals used during command transfer at SDR, four DQ signals used during address and data transfer at DDR.

- Each transaction begins with an 8-bit (1-byte) command. The command selects the type of information transfer or device operation to be performed.
- All protocols supports 3 or 4-byte addressing.

1S-1S-1S protocol (single input/output, SIO)

- The 1S-1S-1S mode is the preferred default protocol following Power-on-Reset (POR), but flash devices can be configured to reset into the Quad mode.
- This protocol uses DQ[0]/SI to transfer information from host to flash device and DQ[1]/SO to transfer information from flash device to host. On each DQ, information is placed on the DQ line in Most Significant bit (MSb) to Least Significant bit (LSb) order within each byte. Sequential address bytes are transferred in highest order to lowest order sequence. Sequential data bytes are transferred in lowest address to highest address order.
- In 1S-1S-1S, DQ[3:2] are not used for data transfer period. DQ[2] can be used as a WP# and DQ[3] can be used as a RESET# input. Otherwise, the DQ[3:2] signals will be high impedance.

1S-2S-2S protocol (dual input/output, DIO)

- This protocol uses DQ[1:0] signals. The 8-bit command placed on the DQ[0] in MSb to LSb order. The LSb of address byte is placed on DQ[0] with next order bit on DQ[1] signal ans so on. Sequential address bytes are transferred in highest order to lowest order sequence. Sequential data bytes in SDR are transferred in lowest address to highest address order.
- In 1S-2S-2S, DQ[3:2] are not used for data transfer period. DQ[2] can be used as a WP# and DQ[3] can be used as a RESET# input. Otherwise, the DQ[3:2] signals will be high impedance.

1S-1S-4S protocol (quad output read, QOR)

- This protocol uses DQ[3:0] signals. The 8-bit command and address placed on the DQ[0] in MSb to LSb order. Sequential data bytes in SDR are transferred in lowest address to highest address order.

1S-4S-4S and 1S-4D-4D protocol (quad input/output, QIO)

- This protocol uses DQ[3:0] signals. The 8-bit command placed on the DQ[0] in MSb to LSb order. The LSb of address byte is placed on DQ[0] with each higher order bit on the successively higher numbered DQ signals. Sequential address bytes are transferred in highest order to lowest order sequence. Sequential data bytes in SDR are transferred in lowest address to highest address order. Sequential data bytes in DDR are transferred only in byte pairs (words) where the byte order depends on the order in which the bytes are written or programmed in that protocol mode. Sequential data bytes are transferred in lowest address to highest address order.

4S-4S-4S and 4S-4D-4D protocol (quad peripheral interface, QPI)

- This protocol uses DQ[3:0] signals. The LSb of each byte is placed on DQ[0] with each higher order bit on the successively higher numbered DQ signals. Sequential address bytes are transferred in highest order to lowest order sequence. Sequential data bytes in SDR are transferred in lowest address to highest address order. Sequential data bytes in DDR are transferred only in byte pairs (words) where the byte order depends on the order in which the bytes are written or programmed in that protocol mode. Sequential data bytes are transferred in lowest address to highest address order. **“Serial peripheral interface (SPI, 1S-1S-1S)”** on page 15 through **“Quad peripheral interface (QPI, 4S-4S-4S and 4S-4D-4D)”** on page 21 show all transaction formats by protocol mode.

2.3.1 Serial peripheral interface (SPI, 1S-1S-1S)

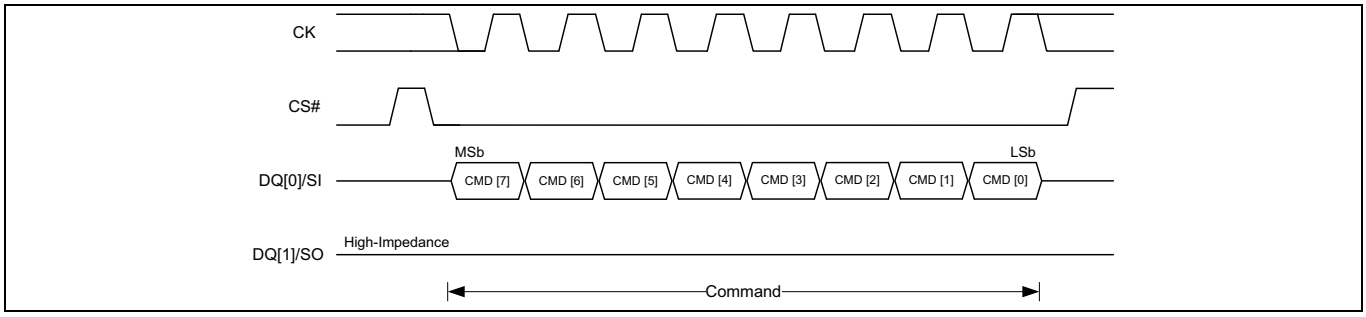


Figure 7 SPI transaction with command input

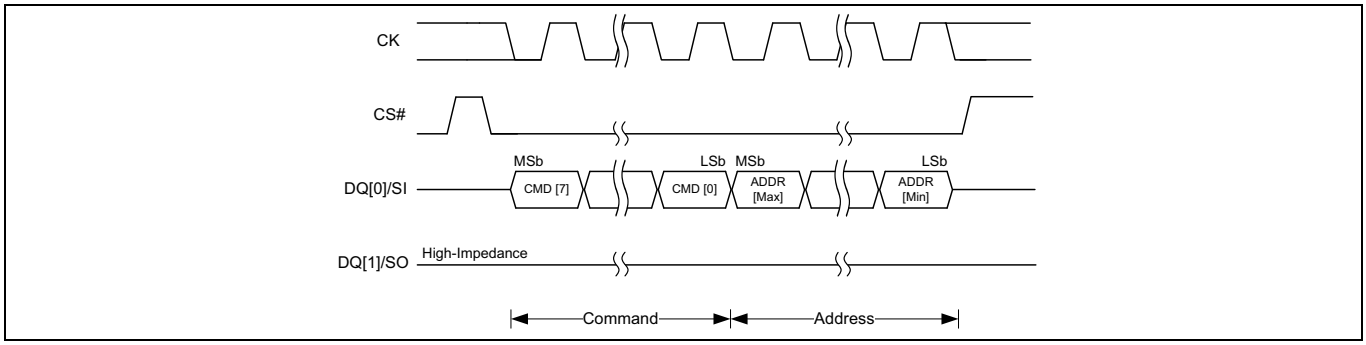


Figure 8 SPI transaction with command and address input

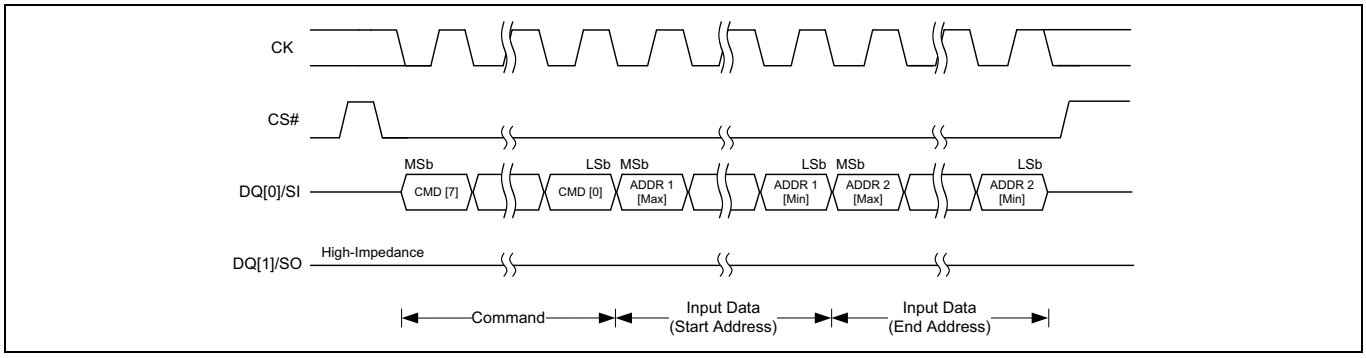


Figure 9 SPI transaction with command and two input addresses

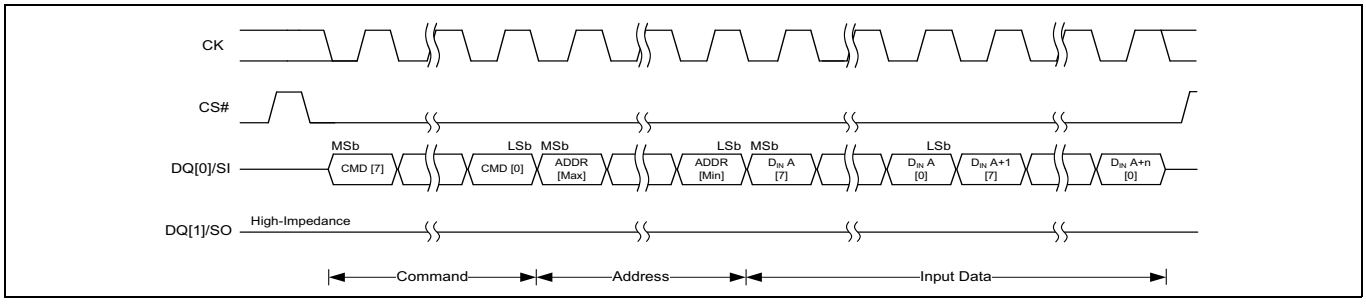


Figure 10 SPI program transaction with command, address, and data input

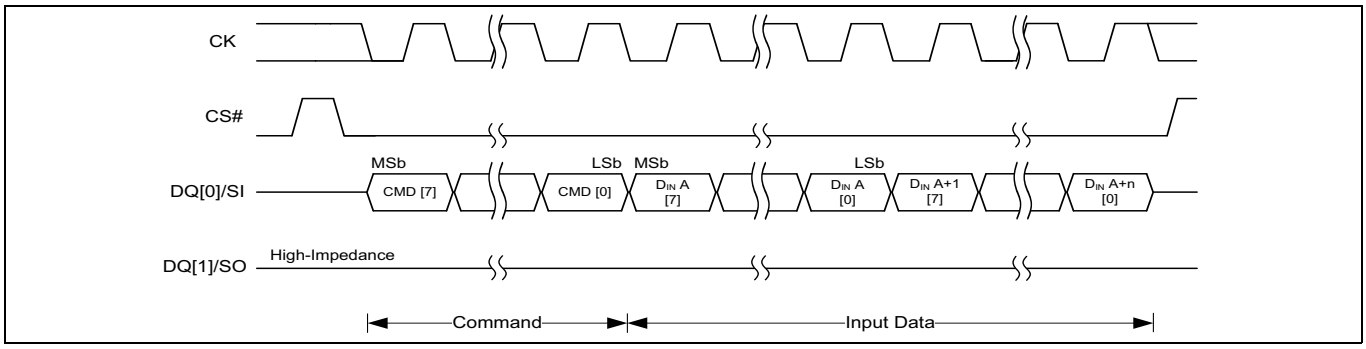


Figure 11 SPI program transaction with command and data input

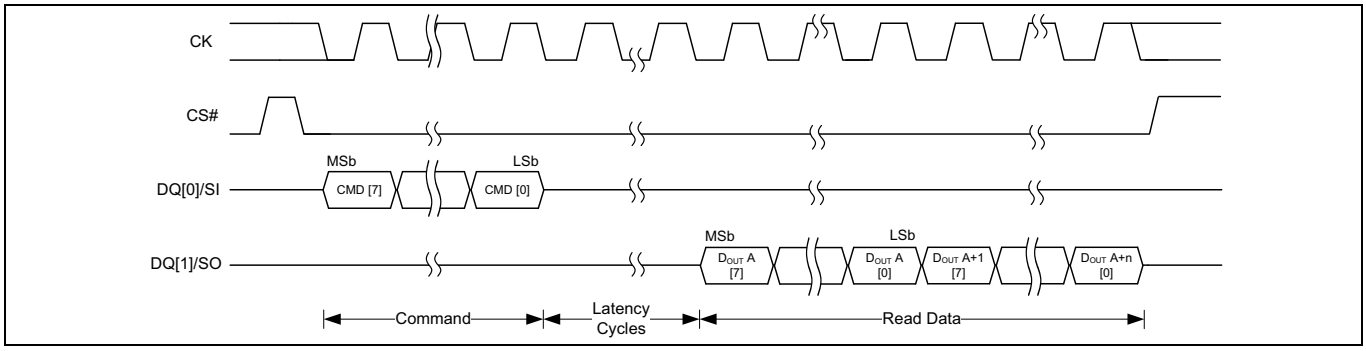


Figure 12 SPI read transaction with command input (output latency)[2, 3]

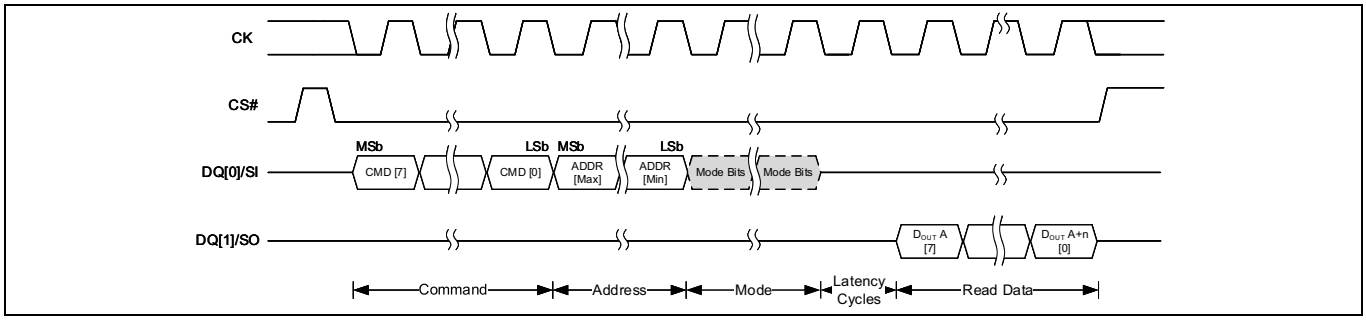


Figure 13 SPI read transaction with command and address input (output latency)[4]

Notes
2. In case of Status Register 1 and 2, Read Byte data out is the updated status.
3. In case of Data Learning Pattern Read, each byte outputs the DLP.
4. In case of RDAY2_4_0 transaction, the host must provide the mode bits.

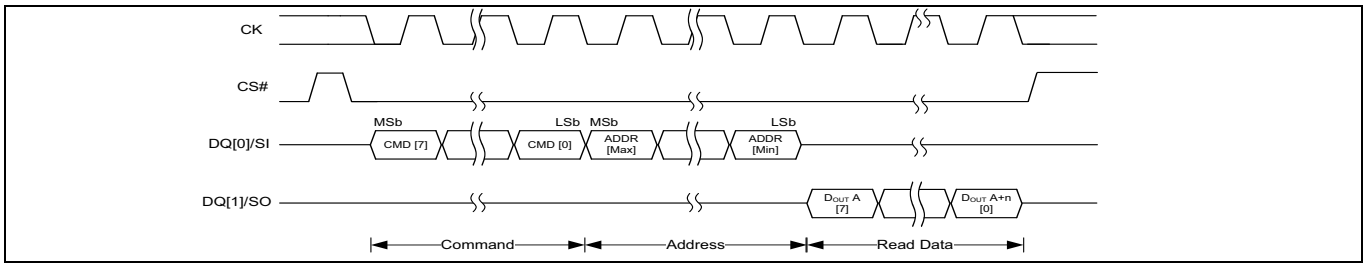


Figure 14 SPI read transaction with command and address input (no output latency)

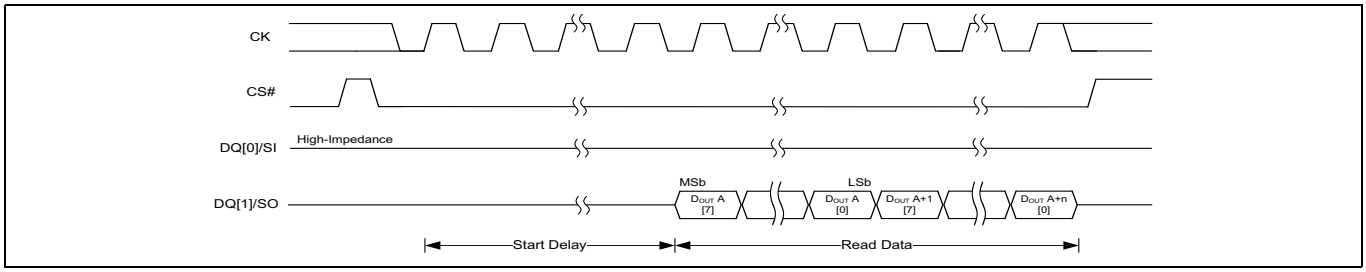


Figure 15 SPI transaction with output data sequence (AutoBoot)

2.3.2 Dual IO SPI (DIO, 1S-2S-2S)

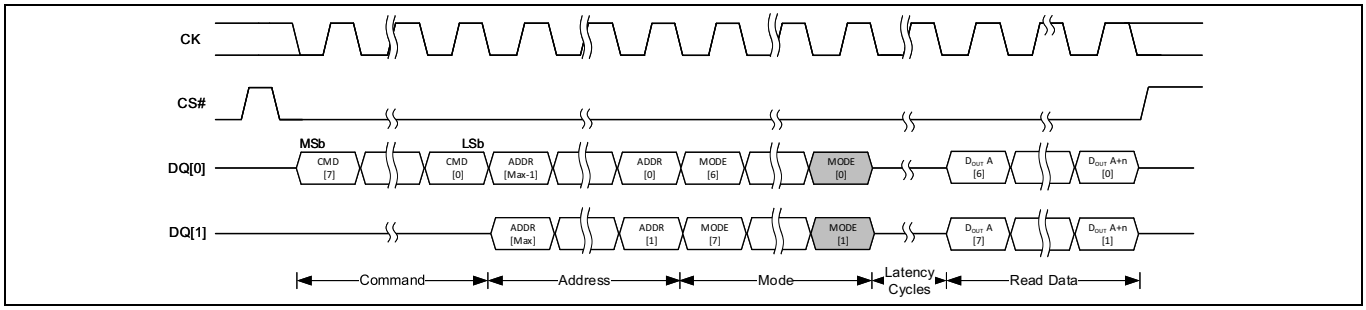


Figure 16 DIO read transaction with command, address, and mode input (output latency)

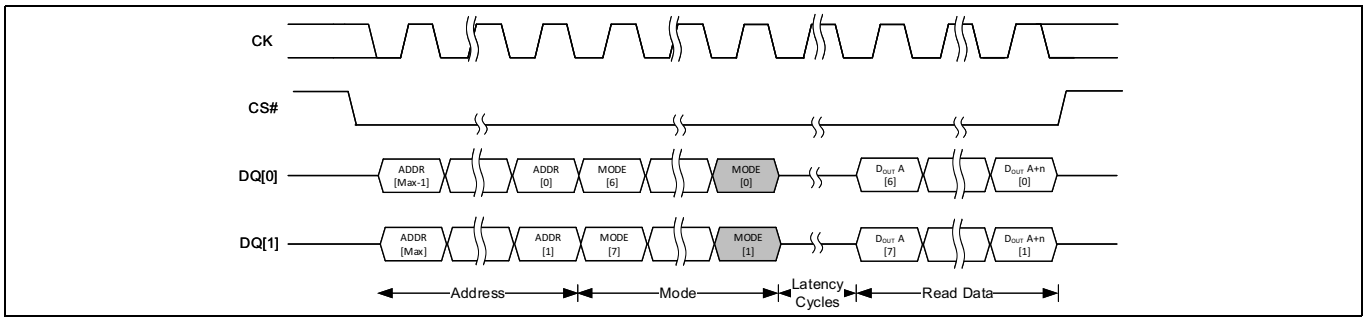


Figure 17 DIO continuous read transaction with address and mode input (output latency)

2.3.3 QUAD output read SPI (QOR, 1S-1S-4S)

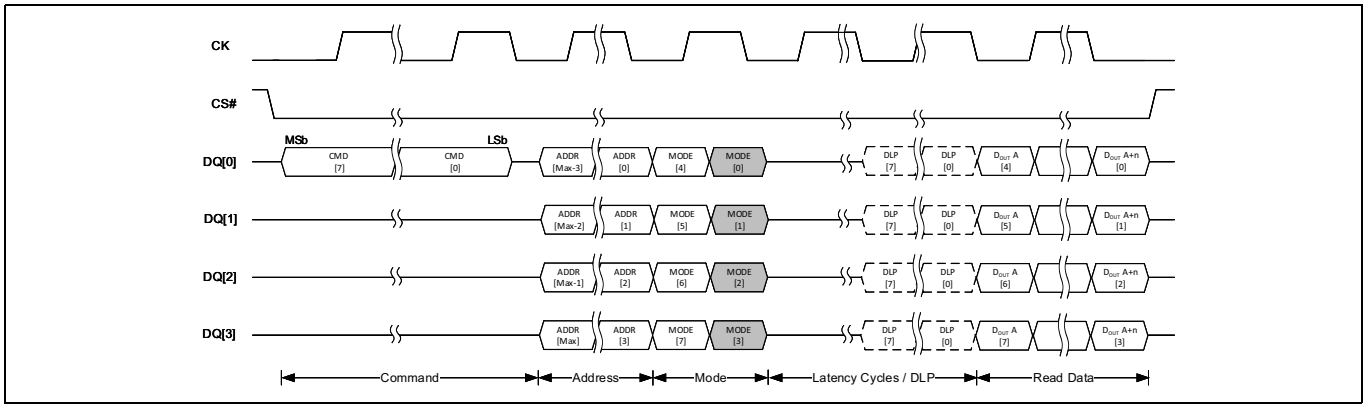


Figure 18 QOR SDR read transaction with command, address, and mode input (output latency)

2.3.4 QUAD IO SPI (QIO, 1S-4S-4S, 1S-4D-4D)

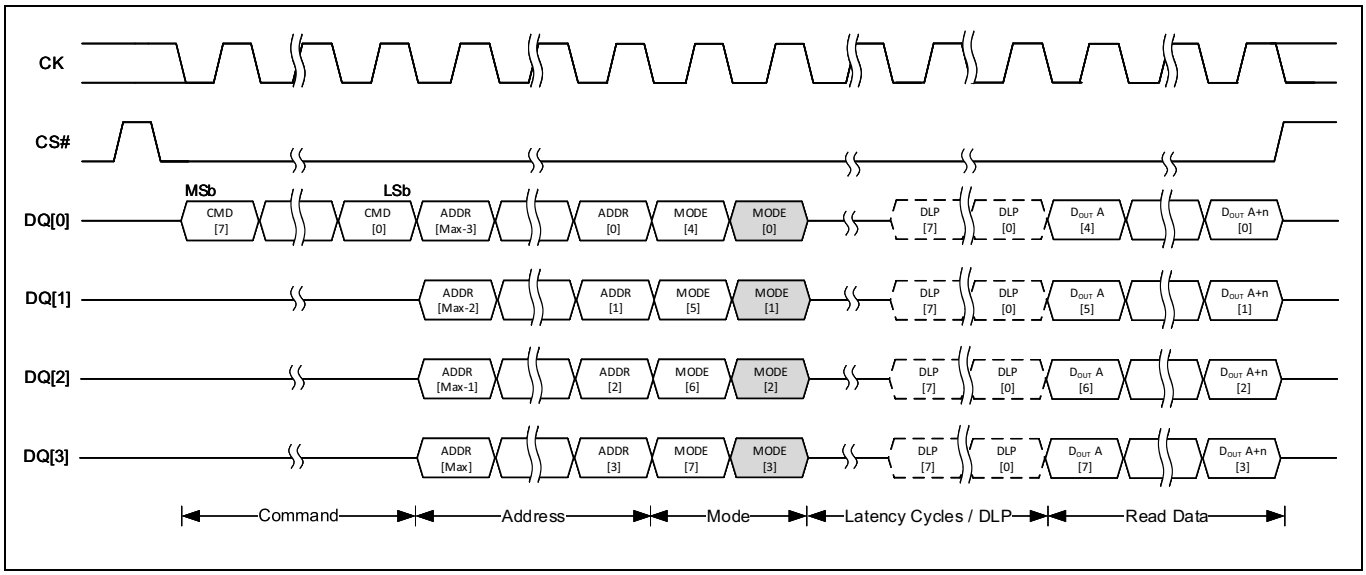


Figure 19 QIO SDR read transaction with command, address, and mode input (output latency)[5]

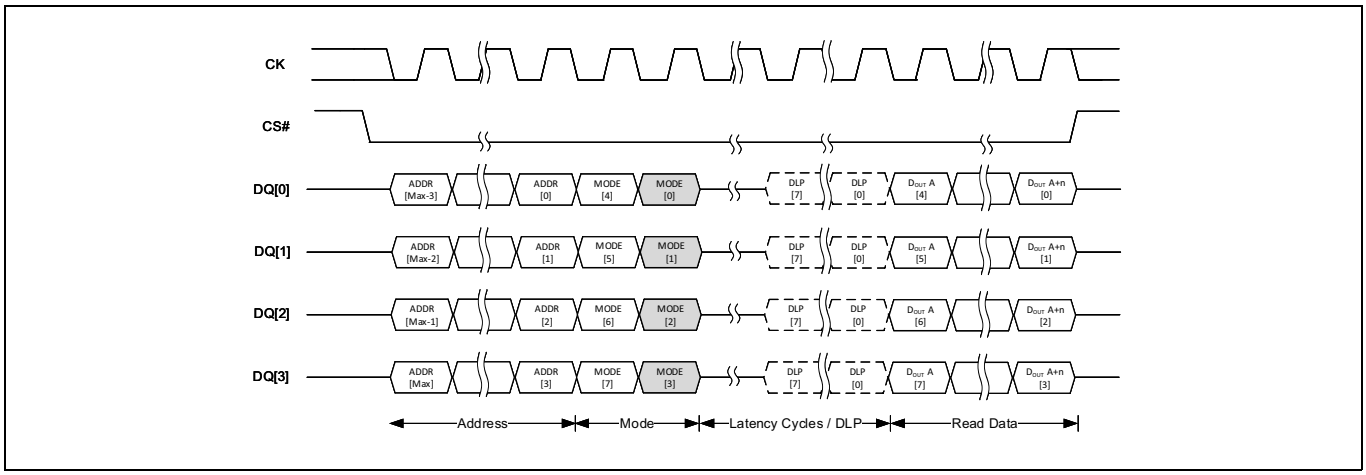


Figure 20 QIO SDR continuous read transaction with address and mode input (output latency)[5]

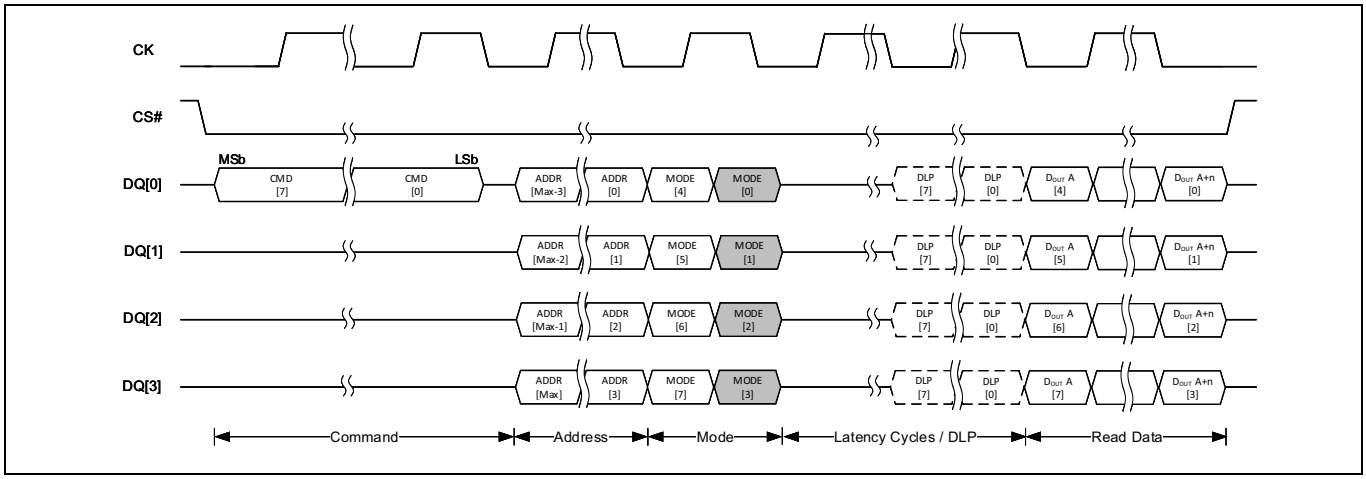


Figure 21 QIO DDR read transaction with command, address, and mode input (output latency)

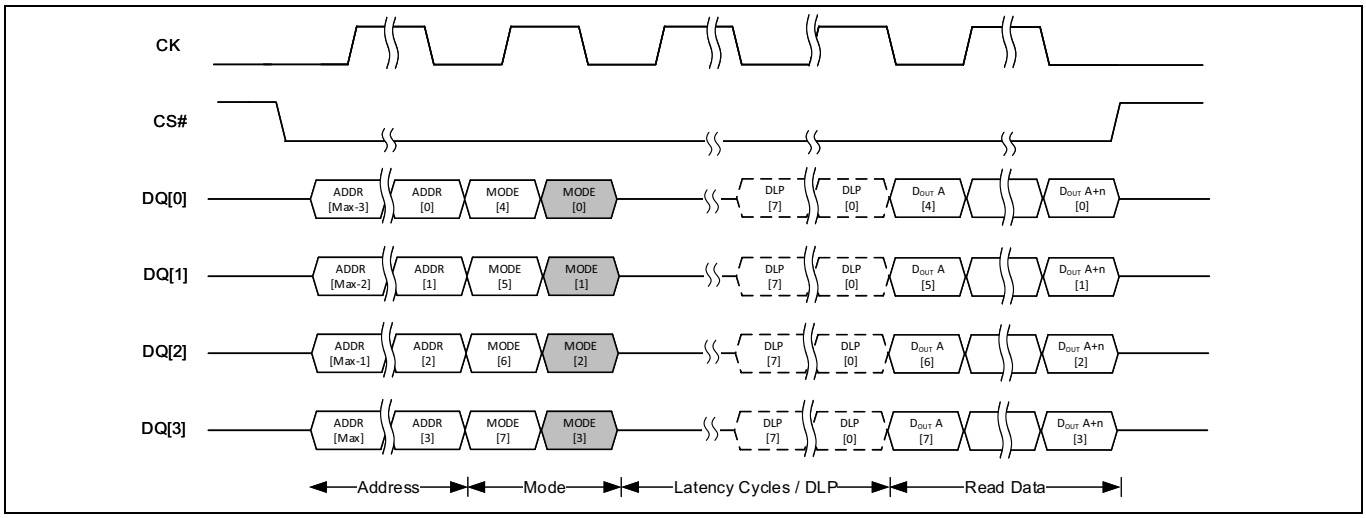


Figure 22 QIO DDR continuous read transaction with address and mode input (output latency)

Note

5. The gray bits data is don't care.

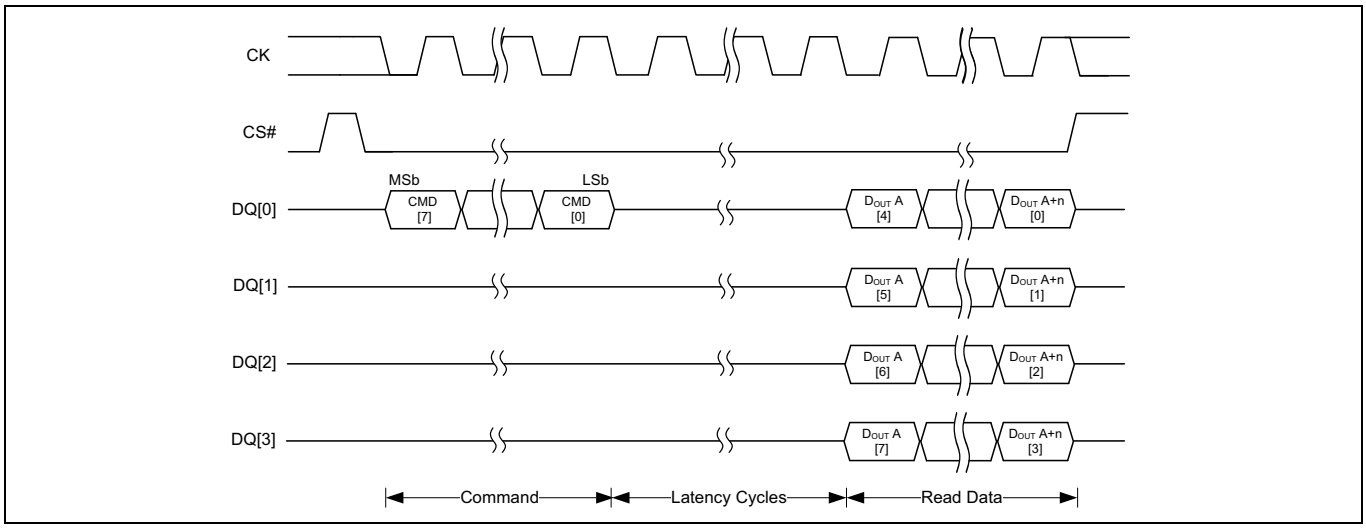


Figure 23 Quad ID read transaction with command input (output latency)

2.3.5 Quad peripheral interface (QPI, 4S-4S-4S and 4S-4D-4D)

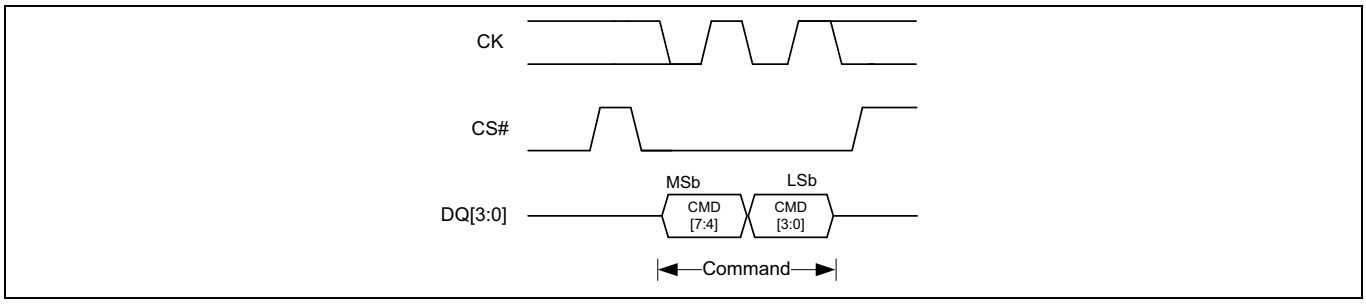


Figure 24 QPI SDR transaction with command input

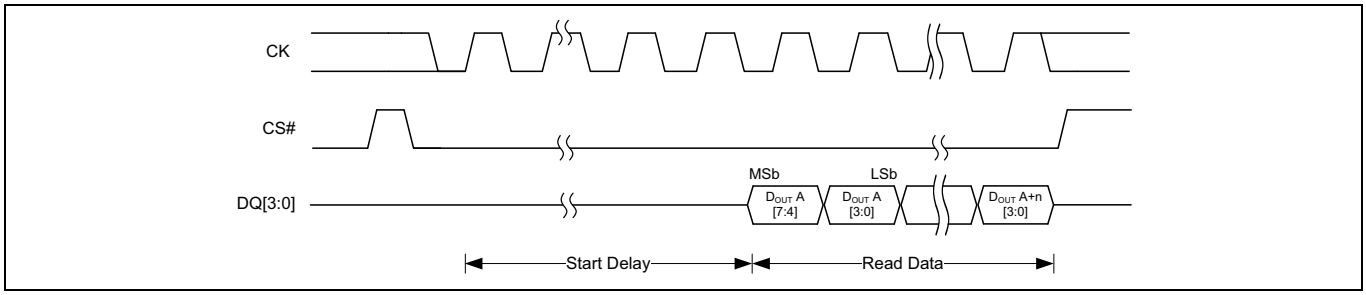


Figure 25 QPI transaction with output data sequence (AutoBoot)

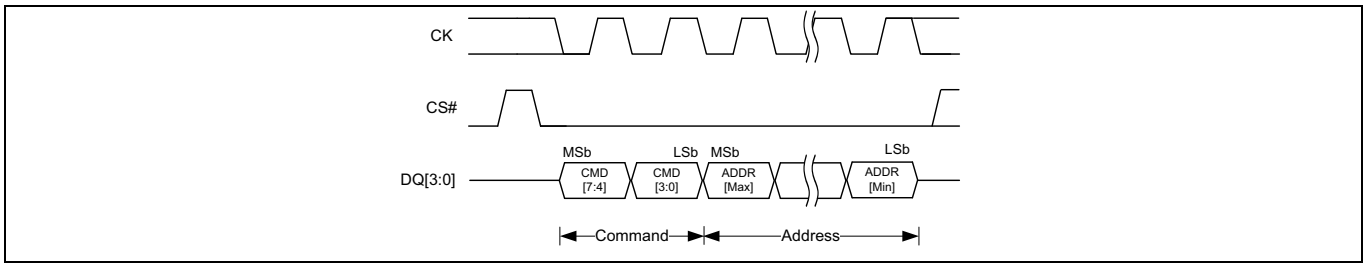


Figure 26 QPI SDR transaction with command and address input

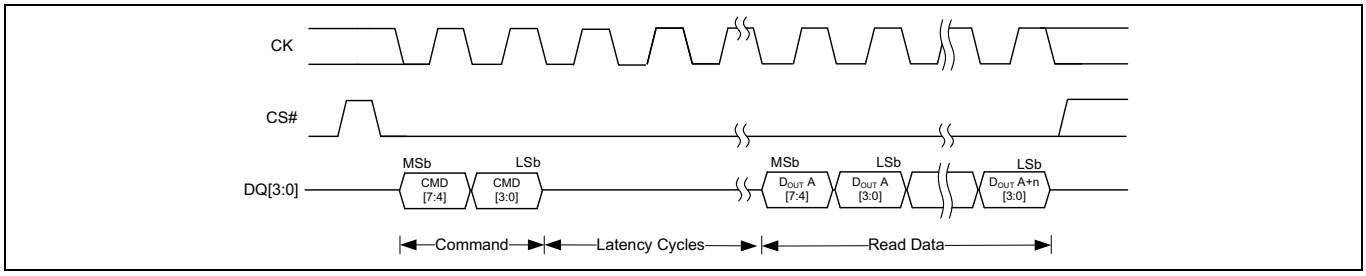


Figure 27 QPI SDR read transaction with command input (output latency)

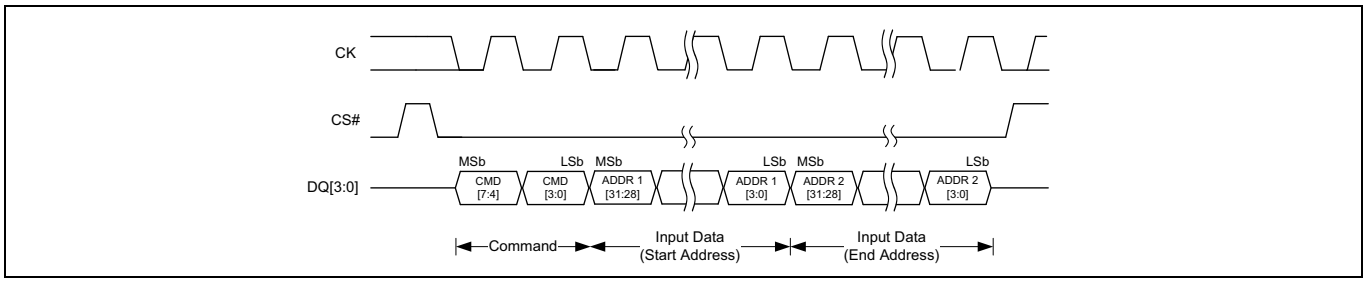


Figure 28 QPI SDR transaction with command and two addresses input

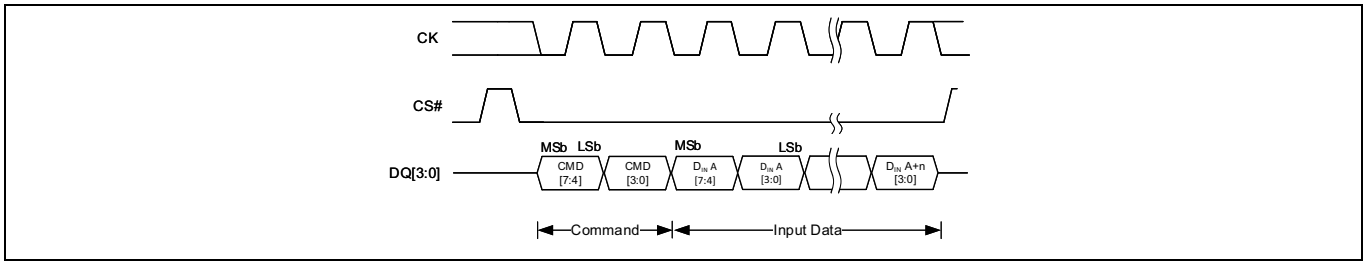


Figure 29 QPI SDR transaction with command and data input

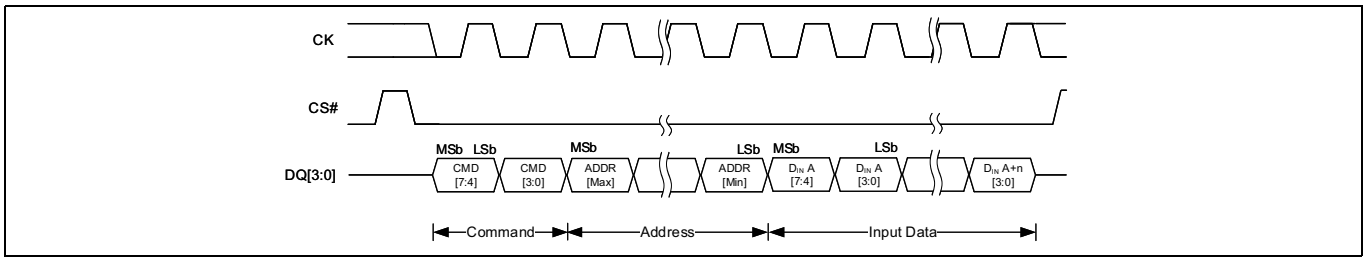


Figure 30 QPI SDR program transaction with command, address, and data input

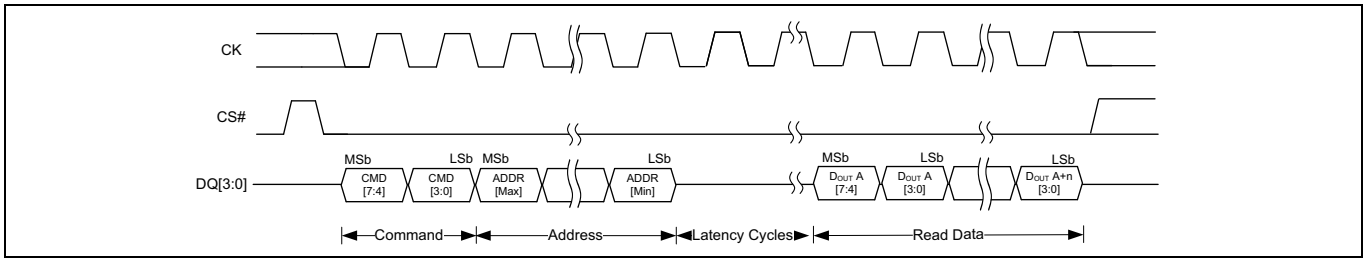


Figure 31 QPI SDR read transaction with command and address input (output latency)

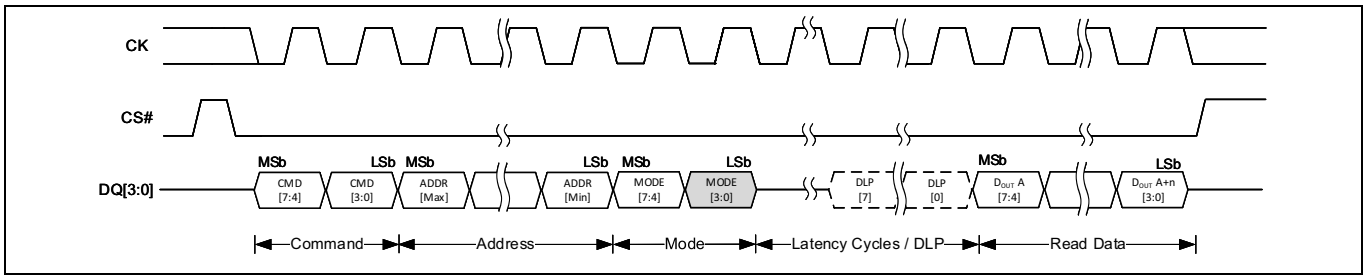


Figure 32 QPI SDR read transaction with command, address, and mode input (output latency)[6]

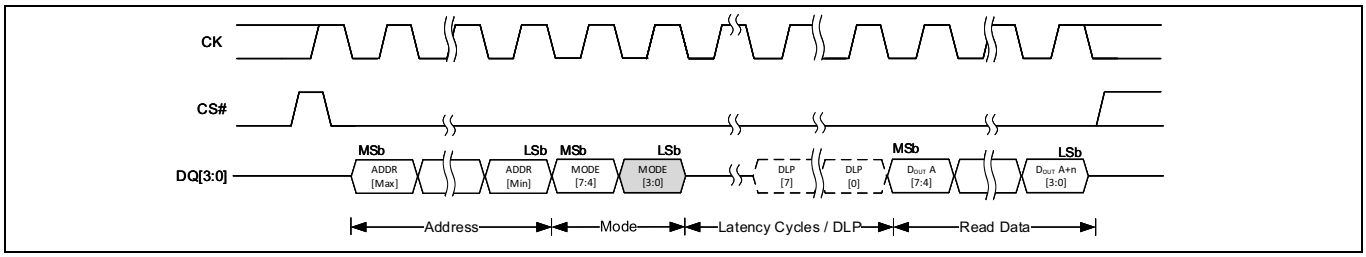


Figure 33 QPI SDR continuous read transaction with address and mode input (output latency)[6]

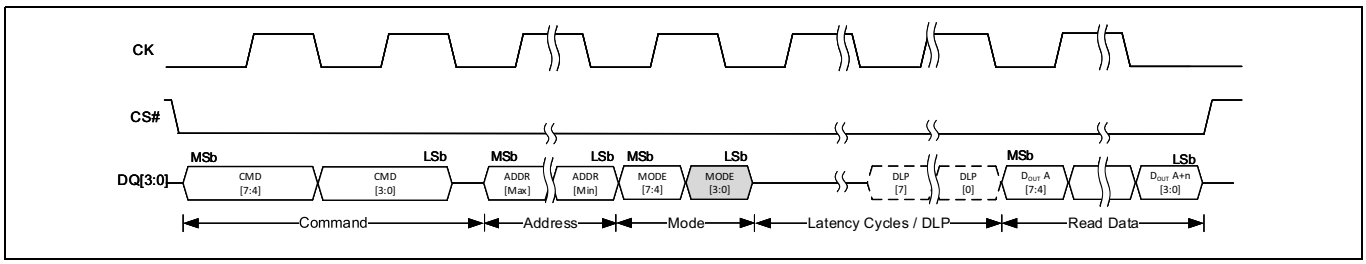


Figure 34 QPI DDR read transaction with command, address, and mode input (output latency)[6]

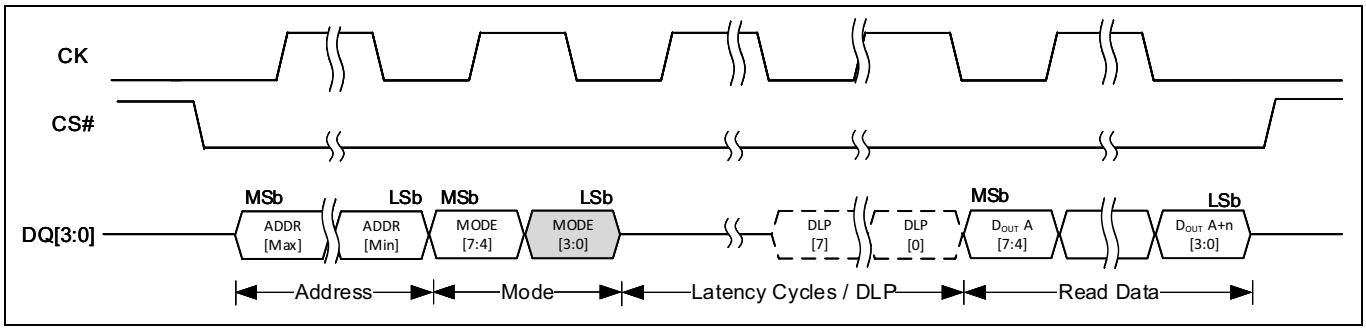


Figure 35 QPI DDR continuous read transaction with address and mode input (output latency)[6]

Note
6. The gray bits data is don't care.

2.4 Register naming convention

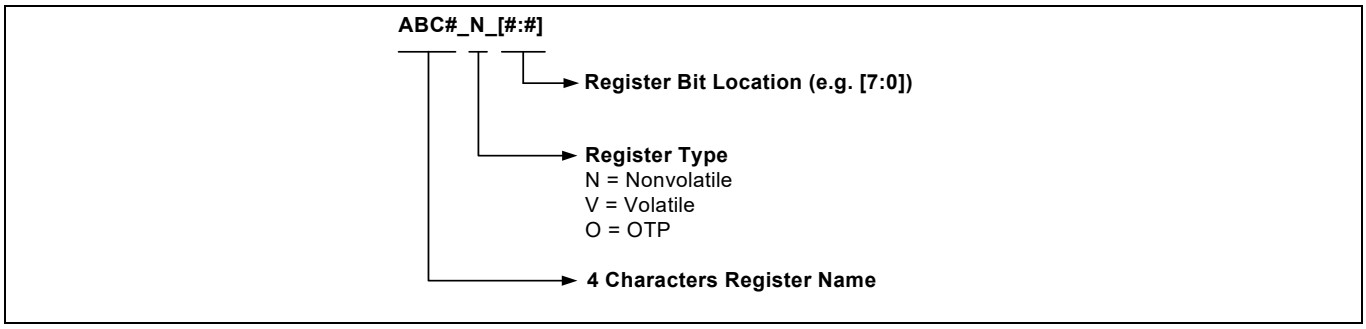


Figure 36 Register naming convention

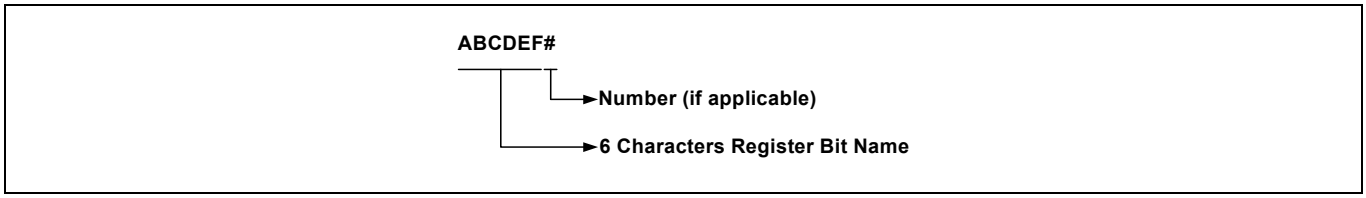


Figure 37 Register bit naming convention

2.5 Transaction naming convention

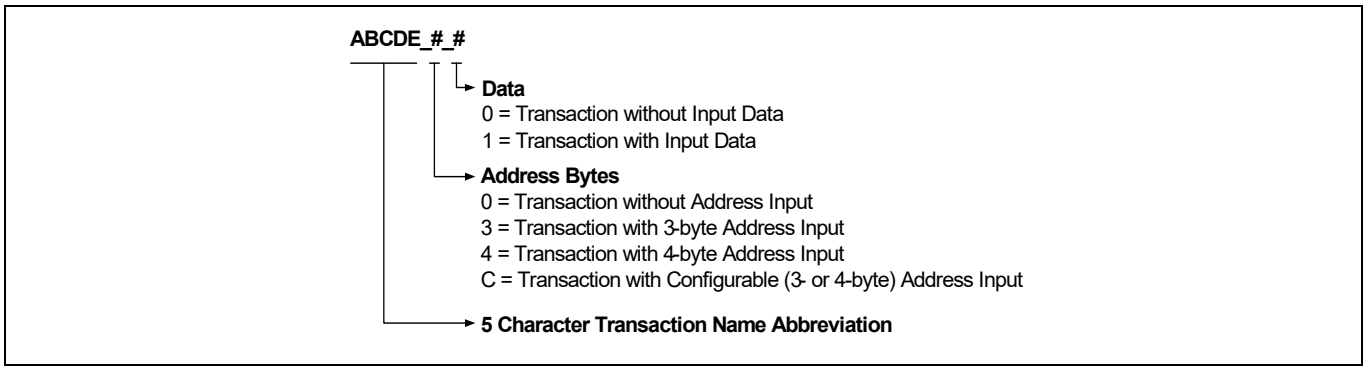


Figure 38 Transaction naming convention

3 Address space maps

The HL-T/HS-T family supports 24-bit as well as 32-bit (4-Byte) addresses, to enable 256 Mb or 512 Mb or 1 Gb density devices. 4-Byte addresses allow direct addressing of up to 4 GB (32 Gb) address space. The address byte option can be changed by writing the respective configuration registers OR there are separate transactions also available to enter (EN4BA_0_0) and exit (EX4BA_0_0) the 4-byte address mode.

Besides flash memory array, HL-T/HS-T family includes separate address spaces for Manufacturer ID, Device ID, Unique ID, Serial Flash Discoverable Parameters (SFDP), Secure Silicon Region (SSR), and Registers.

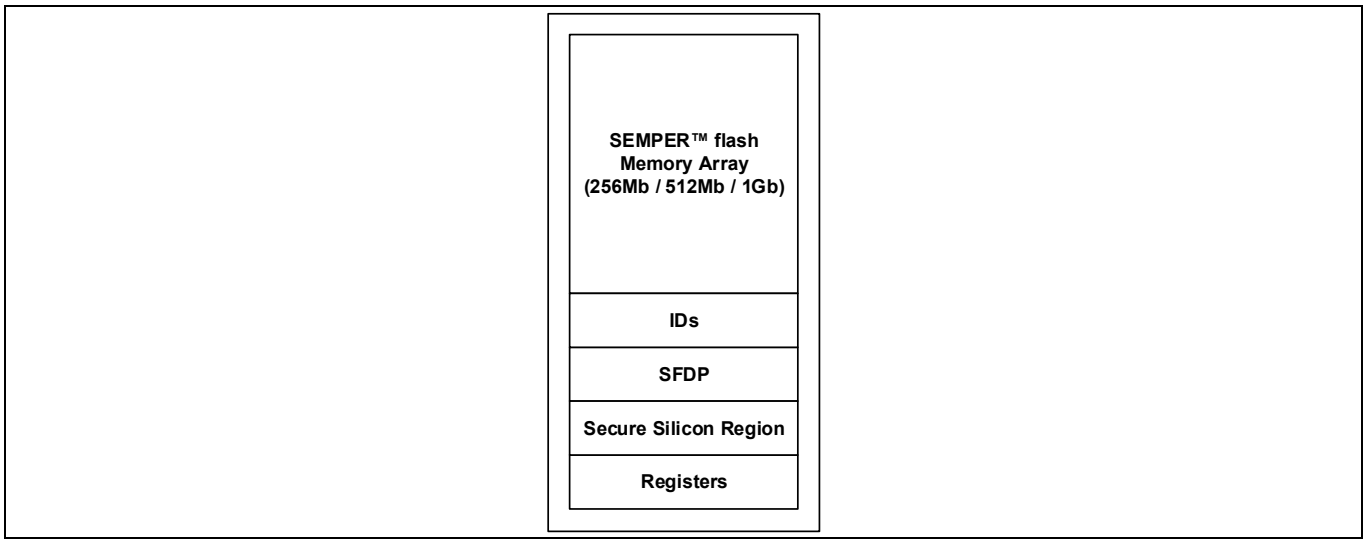


Figure 39 HL-T/HS-T address space map overview

3.1 SEMPER™ Flash memory array

The main flash array is divided into units called physical sectors.

The HL-T/HS-T family sector architecture supports the following options:

- 256 Mb, 512 Mb, 1 Gb supports 256 KB Uniform sector options
- 256 Mb, 512 Mb, 1 Gb Hybrid sector options
  - Physical set of thirty-two 4 KB sectors and one 128 KB sector at the top or bottom of address space with all remaining sectors of 256 KB
  - Physical set of sixteen 4 KB sectors and one 192 KB sector at both the top and bottom of the address space with all remaining sectors of 256 KB

The combination of the sector architecture selection bits in Configuration Register-1 and Configuration Register-3 support the different sector architecture options of the HL-T/HS-T family. See **"Registers"** on page 77 for more information.

Table 2 256 KB uniform sector address map[7]

Sector size (KB)	S25HL01GT and S25HS01GT			S25HL512T and S25HS512T			S25HL256T and S25HS256T		
	Sector count	Sector range	Byte address range (sector starting address–sector ending address)	Sector count	Sector range	Byte address range (sector starting address–sector ending address)	Sector count	Sector range	Byte address range (sector starting address–Sector ending address)
256	512	SA00	00000000h–0003FFFFh	256	SA00	00000000h–0003FFFFh	128	SA00	00000000h–0003FFFFh
		:	:		:	:		:	:
		SA511	07FC0000h–07FFFFFFh		SA255	03FC0000h-03FFFFFFh		SA127	01FC0000h–01FFFFFFh

Note
7. Configuration: CFR3N[3] = 1.

Table 3 Bottom hybrid configuration 1 thirty-two 4 KB sectors and 256 KB uniform sectors address map[8]

Sector size (KB)	S25HL01GT and S25HS01GT			S25HL512T and S25HS512T			S25HL256T and S25HS 256T		
	Sector count	Sector range	Byte address range (sector starting address –sector ending address)	Sector count	Sector range	Byte address range (sector starting address –sector ending address)	Sector count	Sector range	Byte address range (sector starting address–sector ending address)
4	32	SA00	00000000h–00000FFFh	32	SA00	00000000h–00000FFFh	32	SA00	00000000h–00000FFFh
		:	:		:	:		:	:
		SA31	0001F000h–0001FFFFh		SA31	0001F000h–0001FFFFh		SA31	0001F000h–0001FFFFh
128	1	SA32	00020000h–0003FFFFh	1	SA32	00020000h–0003FFFFh	1	SA32	00020000h–0003FFFFh
256	511	SA33	00040000h–0007FFFFh	255	SA33	00040000h–0007FFFFh	127	SA33	00040000h–0007FFFFh
		:	:		:	:		:	:
		SA543	07FC0000h–07FFFFFFh		SA287	03FC0000h–03FFFFFFh		SA159	01FC0000h–01FFFFFFh

Note
8. Configuration: CFR3N[3] = 0, CFR1N[6] = 0, CFR1N[2] = 0.

Table 4 Top hybrid configuration 1 thirty-two 4 KB sectors and 256 KB uniform sectors address map[9]

Sector size (KB)	S25HL01GT and S25HS01GT			S25HL512T and S25HS512T			S25HL256T and S25HS256T		
	Sector count	Sector range	Byte address range (sector starting address –sector ending address)	Sector count	Sector range	Byte address range (sector starting address –sector ending address)	Sector count	Sector range	Byte address range (sector starting address–sector ending address)
256	511	SA00	00000000h–0003FFFFh	255	SA00	00000000h–0003FFFFh	127	SA00	00000000h–0003FFFFh
		:	:		:	:		:	:
		SA510	07F80000h–07FBFFFFh		SA254	03F80000h–03FBFFFFh		SA126	01F80000h–01FBFFFFh
128	1	SA511	07FC0000h–07FDFFFFh	1	SA255	03FC0000h–03FDFFFFh	1	SA127	01FC0000h–01FDFFFFh
4	32	SA512	07FE0000h–07FE0FFFh	32	SA256	03FE0000h–03FE0FFFh	32	SA128	01FE0000h–01FE0FFFh
		:	:		:	:		:	:
		SA543	07FFF000h–07FFFFFFh		SA287	03FFF000h–03FFFFFFh		SA159	01FFF000h–01FFFFFFh

Note
9. Configuration: CFR3N[3] = 0, CFR1N[6] = 0, CFR1N[2] = 1.

Table 5 Hybrid configuration 2 bottom sixteen and top sixteen 4 KB sectors address map[10]

Sector size (KB)	S25HL01GT and S25HS01GT			S25HL512T and S25HS512T			S25HL256T and S25HS256T		
	Sector count	Sector range	Byte address range (sector starting address –sector ending address)	Sector count	Sector range	Byte address range (sector starting address –sector ending address)	Sector count	Sector range	Byte address range (sector starting address–sector ending address)
4	16	SA00	00000000h–00000FFFh	16	SA00	00000000h–00000FFFh	16	SA00	00000000h–00000FFFh
		:	:		:	:		:	:
		SA15	0000F000h–0000FFFFh		SA15	0000F000h–0000FFFFh		SA15	0000F000h–0000FFFFh
192	1	SA16	00010000h–0003FFFFh	1	SA16	00010000h–0003FFFFh	1	SA16	00010000h–0003FFFFh
256	510	SA17	00040000h–0007FFFFh	254	SA17	00040000h–0007FFFFh	126	SA17	00040000h–0007FFFFh
		:	:		:	:		:	:
		SA526	07F80000h–07FBFFFFh		SA270	03F80000h–03FBFFFFh		SA142	01F80000h–01FBFFFFh
192	1	SA527	07FC0000h–07FEFFFFh	1	SA271	03FC0000h–03FEFFFFh	1	SA143	01FC0000h–01FEFFFFh
4	16	SA528	07FF0000h–07FF0FFFh	16	SA272	03FF0000h–03FF0FFFh	16	SA144	01FF0000h–01FF0FFFh
		:	:		:	:		:	:
		SA543	07FFF000h–07FFFFFFh		SA287	03FFF000h–03FFFFFFh		SA159	01FFF000h–01FFFFFFh

Note
10. Configuration: CFR3N[3] = 0, CFR1N[6] = 1.

These are condensed tables that use a couple of sectors as references. There are address ranges that are not explicitly listed. All 4 KB sectors have the pattern xxxxx000h–xxxxxFFFh. All 256 KB sectors have the pattern xxx00000h–xxx3FFFFh, xxx40000h–xxx7FFFFh, xx80000h–xxxCFFFFh, or xxD0000h–xxxFFFFFh.

3.2 ID address space

This particular region of the memory is assigned to manufacturer, device, and unique identification:

- The manufacturer identification is assigned by JEDEC (see **Table 89**).
- The device identification is assigned by Infineon (see **Table 89**).
- A 64-bit unique number is located in 8 bytes of the Unique Device ID address space. This Unique ID can be used as a software readable serial number that is unique for each device (see **Table 90**).

There is no address space defined for these IDs as they can be read by providing the respective transactions only. The transactions do not need the address to read these IDs. The data in this address space is read-only data.

3.3 JEDEC JESD216 serial flash discoverable parameters (SFDP) space

The SFDP standard provides a consistent method of describing the functional and feature capabilities of this serial flash device in a standard set of internal parameter tables. These parameter tables can be interrogated by host system software to enable adjustments needed to accommodate divergent features. The SFDP address space has a header starting at address zero that identifies the SFDP data structure and provides a pointer to each parameter. The SFDP address space is programmed by Infineon and read-only for the host system (see **Table 85** through **Table 88**).

Table 6 SFDP overview address map

Byte address	Description
0000h	Location zero within JEDEC JESD216D SFDP space - start of SFDP header
,,,	Remainder of SFDP header followed by undefined space
0100h	Start of SFDP parameter tables The SFDP parameter table data starting at 0100h
...	Remainder of SFDP parameter tables followed by either more parameters or undefined space

3.4 SSR address space

Each HS/L-T family memory device has a 1024-byte Secure Silicon Region which is OTP address space. This address space is separate from the main flash array. The SSR area is divided into 32 individually lockable, 32-byte aligned and length regions.

In the 32-byte region starting at address zero:

- The 16 lowest bytes contain a 128-bit random number. The random number cannot be written to, erased or programmed and any attempts will return an PRGERR flag.
- The next four bytes are used to provide one bit per secure region (32 bits in total) to permanently protect once set to “0” from writing, erasing or programming.
- All other bytes are reserved.

The remaining regions are erased when shipped from Infineon, and are available for programming of additional permanent data.

Table 7 SSR address map

Region	Byte address range	Contents	Initial delivery state
Region 0	000h	LSB of Infineon Programmed Random Number	Infineon Programmed Random Number
	...	...	
	00Fh	MSB of Infineon Programmed Random Number	
	010h to 013h	Region Locking Bits Byte 10h [bit 0] locks region 0 from programming when = 0 ... Byte 13h [bit 7] locks region 31 from programming when = 0	All Bytes = FFh
	014h to 01Fh	Reserved for future use (RFU)	All Bytes = FFh
Region 1	020h to 03Fh	Available for User Programming	All Bytes = FFh
Region 2	040h to 05Fh	Available for User Programming	All Bytes = FFh
...	...	Available for User Programming	All Bytes = FFh
Region 31	3E0h to 3FFh	Available for User Programming	All Bytes = FFh

3.5 Registers

Registers are small groups of memory cells used to configure how the HS/L-T family memory device operates, or to report the status of device operations. The registers are accessed by specific commands and addresses. **Table 8** shows the address map for every available register in this flash memory device.

Table 8 Register address map

Function	Register type	Register name	Volatile component address (hex)	Nonvolatile component address (hex)
Device Status	Status Register 1	STR1N[7:0], STR1V[7:0]	0x00800000	0x00000000
	Status Register 2	STR2V[7:0]	0x00800001	N/A
Device Configuration	Configuration Register 1	CFR1N[7:0], CFR1V[7:0]	0x00800002	0x00000002
	Configuration Register 2	CFR2N[7:0], CFR2V[7:0]	0x00800003	0x00000003
	Configuration Register 3	CFR3N[7:0], CFR3V[7:0]	0x00800004	0x00000004
	Configuration Register 4	CFR4N[7:0], CFR4V[7:0]	0x00800005	0x00000005
Infineon Endurance Flex architecture	Infineon Endurance Flex architecture Selection Register 0 [1:0]	EFX0O[1:0]	N/A	0x00000050
	Infineon Endurance Flex architecture Selection Register 1 [7:0]	EFX1O[7:0]		0x00000052
	Infineon Endurance Flex architecture Selection Register 1 [10:8]	EFX1O[10:8]		0x00000053
	Infineon Endurance Flex architecture Selection Register 2 [7:0]	EFX2O[7:0]		0x00000054
	Infineon Endurance Flex architecture Selection Register 2 [10:8]	EFX2O[10:8]		0x00000055
	Infineon Endurance Flex architecture Selection Register 3 [7:0]	EFX3O[7:0]		0x00000056
	Infineon Endurance Flex architecture Selection Register 3 [10:8]	EFX3O[10:8]		0x00000057
	Infineon Endurance Flex architecture Selection Register 4 [7:0]	EFX4O[7:0]		0x00000058
	Infineon Endurance Flex architecture Selection Register 4 [10:8]	EFX4O[10:8]		0x00000059
Error Correction	ECC Status Register	ESCV[7:0]	0x00800089	N/A
	ECC Error Detection Count Register [7:0]	ECTV[7:0]	0x0080008A	
	ECC Error Detection Count Register [15:8]	ECTV[15:8]	0x0080008B	
	ECC Address Trap Register [7:0]	EATV[7:0]	0x0080008E	
	ECC Address Trap Register [15:8]	EATV[15:8]	0x0080008F	
	ECC Address Trap Register [23:16]	EATV[23:16]	0x00800040	
	ECC Address Trap Register [31:24]	EATV[31:24]	0x00800041	
AutoBoot	AutoBoot Register [7:0]	ATBN[7:0]	N/A	0x00000042
	AutoBoot Register [15:8]	ATBN[15:8]		0x00000043
	AutoBoot Register [23:16]	ATBN[23:16]		0x00000044
	AutoBoot Register [31:24]	ATBN[31:24]		0x00000045
Data Learning	Data Learning Register [7:0]	DLPN[7:0], DLPV[7:0]	0x00800010	0x00000010
Erase Count	Sector Erase Count Register [7:0]	SECV[7:0]	0x00800091	N/A
	Sector Erase Count Register [15:8]	SECV[15:8]	0x00800092	
	Sector Erase Count Register [23:16]	SECV[23:16]	0x00800093	
Data Integrity Check	Data Integrity Check CRC Register [7:0]	DCRV[7:0]	0x00800095	
	Data Integrity Check CRC Register [15:8]	DCRV[15:8]	0x00800096	
	Data Integrity Check CRC Register [23:16]	DCRV[23:16]	0x00800097	
	Data Integrity Check CRC Register [31:24]	DCRV[31:24]	0x00800098	

Table 8 Register address map *(continued)*

Function	Register type	Register name	Volatile component address (hex)	Nonvolatile component address (hex)
Protection and Security	Advanced Sector Protection Register [7:0]	ASPO[7:0]	N/A	0x00000030
	Advanced Sector Protection Register [15:8]	ASPO[15:8]		0x00000031
	ASP PPB Lock Register (Persistent Protection Block)	PPLV[7:0]	0x0080009B	N/A
	ASP Password Register [7:0]	PWDO[7:0]	N/A	0x00000020
	ASP Password Register [15:8]	PWDO[15:8]		0x00000021
	ASP Password Register [23:16]	PWDO[23:16]		0x00000022
	ASP Password Register [31:24]	PWDO[31:24]		0x00000023
	ASP Password Register [39:32]	PWDO[39:32]		0x00000024
	ASP Password Register [47:40]	PWDO[47:40]		0x00000025
	ASP Password Register [55:48]	PWDO[55:48]		0x00000026
	ASP Password Register [63:56]	PWDO[63:56]		0x00000027

4 Features

4.1 Error detection and correction

HL-T/HS-T family devices support error detection and correction by generating an embedded Hamming error correction code during memory array programming. This ECC code is then used for error detection and correction during read operations. The ECC is based on a 16-byte data unit. When the 16-byte data unit is loaded into the Program Buffer and is transferred to the 128-bits flash memory array Line for programming (after an erase), an 8-bit ECC for each data unit is also programmed into a portion of the memory array that is not visible to the host system software. This ECC information is then checked during each flash array read operation. Any 1-bit error within the data unit will be corrected by the ECC logic. The 16-byte data unit is the smallest program granularity on which ECC is enabled.

When any amount of data is first programmed within a 16-byte data unit, the ECC value is set for the entire data unit. If additional data is subsequently programmed into the same data unit, without an erase, then the ECC for that data unit is disabled and the 1-bit ECC disable bit is set. A sector erase is needed to again enable ECC on that data unit.

These are automatic operations transparent to the user. The transparency of the ECC feature enhances data reliability for typical programming operations which write data once to each data unit while also facilitating software compatibility with previous generations of products by still allowing for single-byte programming and bit-walking (in this case, ECC will be disabled) in which the same data unit is programmed more than once.

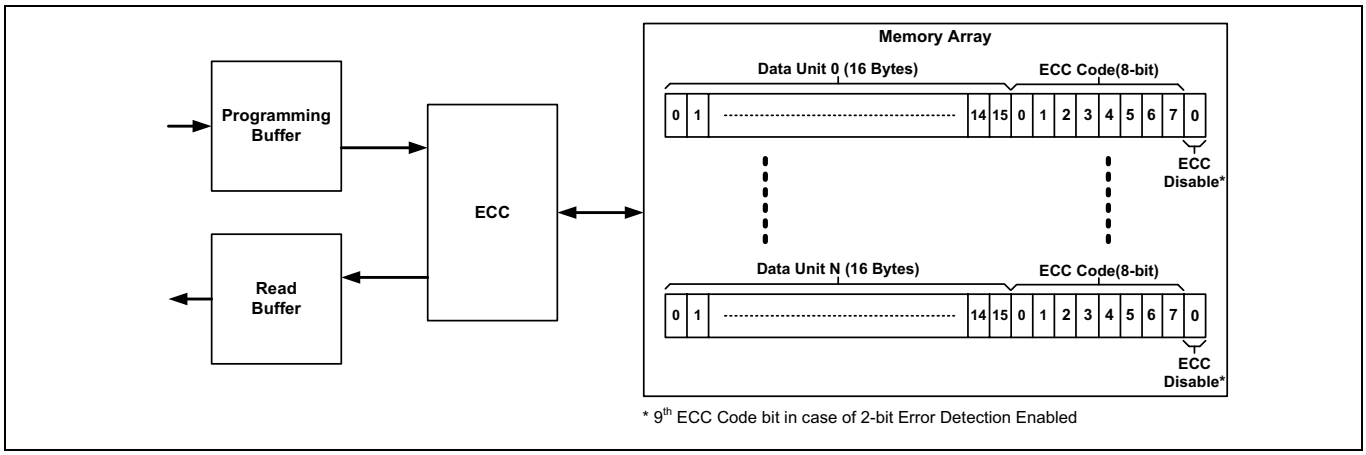


Figure 40 16-byte ECC data unit example

SEMPER™ NOR Flash supports 2-bit error detection as the default ECC configuration. In this configuration, any 1-bit error in a data unit is corrected and any 2-bit error is detected and reported. The 16-byte unit data requires a 9-bit Error Correction Code for 2-bit error detection. When 2-bit error detection is enabled, byte-programming, bit-walking, or multiple program operations to the same data unit (without an erase) are not allowed and will result in a Program Error. Changing the ECC mode from 1-bit error detection to 2-bit error detection, or from 2-bit error detection to 1-bit error detection will invalidate all data in the memory array. When changing the ECC mode, the host must first erase all sectors in the device. If the ECC mode is changed without erasing programmed data, subsequent read operations will result in undefined behavior.

4.1.1 ECC error reporting

There are four methods for reporting to the host system when ECC errors are detected.

- ECC Data Unit Status provides the status of 1-bit or 2-bit errors in data units.
- ECC Status Register provides the status of 1-bit or 2-bit errors since the last ECC clear or reset.
- The Address Trap Register captures the address location of the first ECC error encountered after POR or reset during memory array read.
- An ECC Error Detection counter keeps a tally of the number of 1-bit or 2-bit errors that have occurred in data units during reads.

4.1.1.1 ECC Data Unit status (EDUS)

- The status of ECC in each data unit is provided by the 8-bit ECC Data Unit Status.
- The ECC status transaction outputs the ECC status of the addressed data unit. The contents of the ECC Data Unit status then indicate, for the selected data unit, whether there is a 1-bit error corrected, 2-bit error detected, or the ECC is disabled for that data unit.

Table 9 ECC Data Unit status

Bits	Field name	Function	Read/Write N = Nonvolatile V = Volatile	Factory default (binary)	Description
EDUS[7:4]	RESRVD	Reserved For future use	V => R	0000	These bits are Reserved for future use.
EDUS[3]	ECC2BD	ECC Error 2-bit Error Detection Flag	V => R	0	This bit indicates whether a two bit error is detected in the data unit, if two bit ECC error detection is enabled CFR4V[3] = 1. When CFR4V[3] = 0 and 2-bit error detection is disabled, ECC2BD bit will always be '0'. **Note** If 2 bit error detection is enabled (CFR4V[3] = 1), the ECCOFF bit will not be set to 1b while performing single byte programming or bit walking in a data unit that was already partially programmed. An attempt to do such byte programming or bit walking will result in a Program Error. Selection options: 1 = Two Bit Error detected 0 = No error
EDUS[2]	RESRVD	Reserved For future use	V => R	0	This bit is Reserved for future use.
EDUS[1]	ECC1BC	ECC Error 1-bit Error Detection and Correction Flag	V => R	0	This bit indicates whether an error was corrected in the data unit. Selection options: 1 = Single Bit Error corrected in the addressed data unit 0 = No single bit error was corrected in the addressed data unit
EDUS[0]	ECCOFF	Data Unit ECC OFF/ON Flag	V => R	0	This bit indicates whether the ECC syndrome is OFF in the data unit. Selection options: 1 = ECC is OFF in the selected data unit 0 = ECC is ON in the selected data unit Dependency: CFR4x[3]

4.1.1.2 ECC Status Register (ECSV)

- An 8-bit ECC Status Register provides the status of 1-bit or 2-bit errors during normal reads since last ECC clear or reset. ECC Status Register does not have user programmable nonvolatile bits, all defined bits are volatile read only bits. The default state of these bits are set by hardware.
- ECC Status Register can be accessed through the Read Any Register transaction. The correct sequence for Read Any Register based ECSV is read as follows:
  - Read data from memory array using any of the Read transaction
  - ECSV is updated by the device
  - Read Any Register transaction of ECSV provides the status of any ECC event since the last clear or reset.
- ECSV is cleared by POR, JEDEC Serial Flash Reset Signaling Protocol, Hardware/Software reset, or a Clear ECC Status Register transaction.

4.1.1.3 ECC Error Address Trap (EATV)

- A 32-bit register is provided to capture the ECC data unit address where an ECC error is first encountered during a read of the flash array. Only the address of the first enabled error type (“2-bit only” or “1-bit or 2-bit” as selected in CFR4N[3]) encountered after POR, hardware reset, or the ECC Clear transaction is captured. The EATV Register is only updated during Read transactions.

  The EATV Register contains the address that was accessed when the error was detected. The failing bits may not be located at the exact address indicated in the register, but will be located within the aligned 16-byte ECC data unit where the error was detected. If errors are found in multiple ECC data units during a single read operation, only the address of the first failing ECC unit address is captured in the EATV Register.

  When 2-bit error detection is not enabled and the same ECC unit is programmed more than once, ECC error detection for that ECC unit is disabled, therefore no error can be recognized to trap the address.

  The Address Trap Register has a valid address when the ECC Status Register (ECSV) bit 3 or 4 = 1.
- The Address Trap Register can be read using the Read Any Register transaction.
- Clear ECC Status Register transaction, POR, or JEDEC signaling protocol/hardware/software reset clears the Address Trap Register.

4.1.1.4 ECC Error Detection Counter (ECTV)

- A 16-bit register is provided to count the number of 1-bit or 2-bit errors that occur as data is read from the flash memory array. Only errors recognized in the main array will cause the Error Detection Counter to increment. ECTV Register is only updated during Read transaction. Read ECC Status transaction does not affect the ECTV Register.

  The 16-bit Error Detection Counter will not increment beyond FFFFh. However, the ECC continues to work.

  Note that during continuous read operations, when a 1-bit or a 2-bit error is detected, the clock may continue toggling and the memory device will continue incrementing the data address and placing new data on the DQ signals; any additional data units with errors that are encountered will be counted until CS# is brought back HIGH.

  During a read transaction only one error is counted for each data unit found with an error. Each read transaction will cause a new read of the target data unit. If multiple read transactions access the same data unit containing an error, the error counter will increment each time that data unit is read.

  When 2-bit error detection is not enabled and the same data unit is programmed more than once, ECC error detection for that data unit is disabled so, no error can be recognized or counted.
- The ECC Error Detection Counter Register can be read using the Read Any Register transaction.
- ECTV Register is set to 0 on POR, JEDEC signaling protocol/hardware/software reset or with Clear ECC Status Register transaction.

4.1.2 ECC related registers and transactions

Table 10 ECC related registers and transactions

Related registers	Related SPI transactions (see Table 73)	Related quad SPI transactions (see Table 77)
Configuration Register - 4 (CFR4N, CFR4V) (see Table 52)	Read Any Register (RDARG_C_0)	Read Any Register (RDARG_C_0)
ECC Status Register (ECSV) (see Table 55)	Write Enable (WRENB_0_0)	Write Enable (WRENB_0_0)
ECC Address Trap Register (EATV) (see Table 56)	Write Any Register (WRARG_C_1)	Write Any Register (WRARG_C_1)
ECC Error Detection Counter Register (ECTV) (see Table 57)	Read ECC Status (RDECC_4_0, RDECC_C_0)	Read ECC Status (RDECC_4_0, RDECC_C_0)
	Clear ECC Status Register (CLECC_0_0)	Clear ECC Status Register (CLECC_0_0)

4.2 Infineon Endurance Flex architecture (wear leveling)

Infineon Endurance Flex architecture allows partitioning of the main memory array into regions which can be configured as either high endurance or long retention. Infineon Endurance Flex architecture implements wear leveling in high endurance regions where program/erase cycles are spread evenly across all the sectors which are part of the wear leveling pool. This greatly improves the reliability of the device by avoiding premature wear-out of an individual sector.

Architecturally, Infineon Endurance Flex architecture's wear leveling algorithm is based on a mapping of logical sectors to physical sectors. During the lifetime of the part, this mapping is changed to maintain a uniform distribution of program/erase cycles over all physical sectors. The logical to physical mapping information is stored in a dedicated flash array which is updated when sectors are swapped. Sector swaps occur when an erase transaction is given.

Infineon Endurance Flex architecture's high endurance region requires a minimum set of 20 sectors. To provide flexibility between configuring long retention, high endurance, or both regions, a four pointer architecture is provided. The factory default setting designates all sectors as high endurance as part of the wear leveling pool with all pointers disabled. The four pointers can be used to form a maximum of five regions which can each be configured as long retention or high endurance.

Figure 41 provides an overview of the Infineon Endurance Flex architecture. It shows the five possible regions based on different sector architecture.

Note
11.4 KB sectors are not part of the Infineon Endurance Flex architecture.

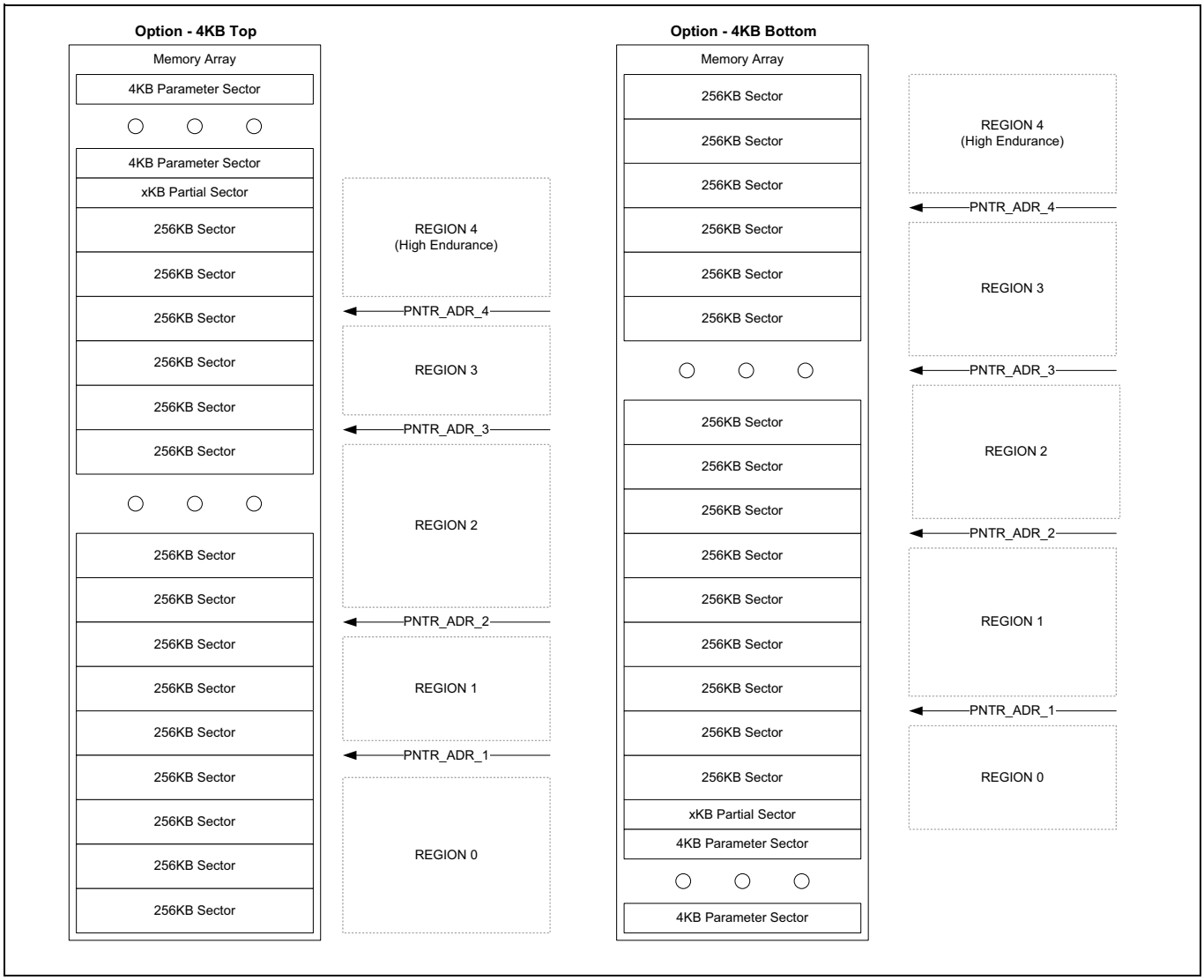


Figure 41 Infineon Endurance Flex architecture overview

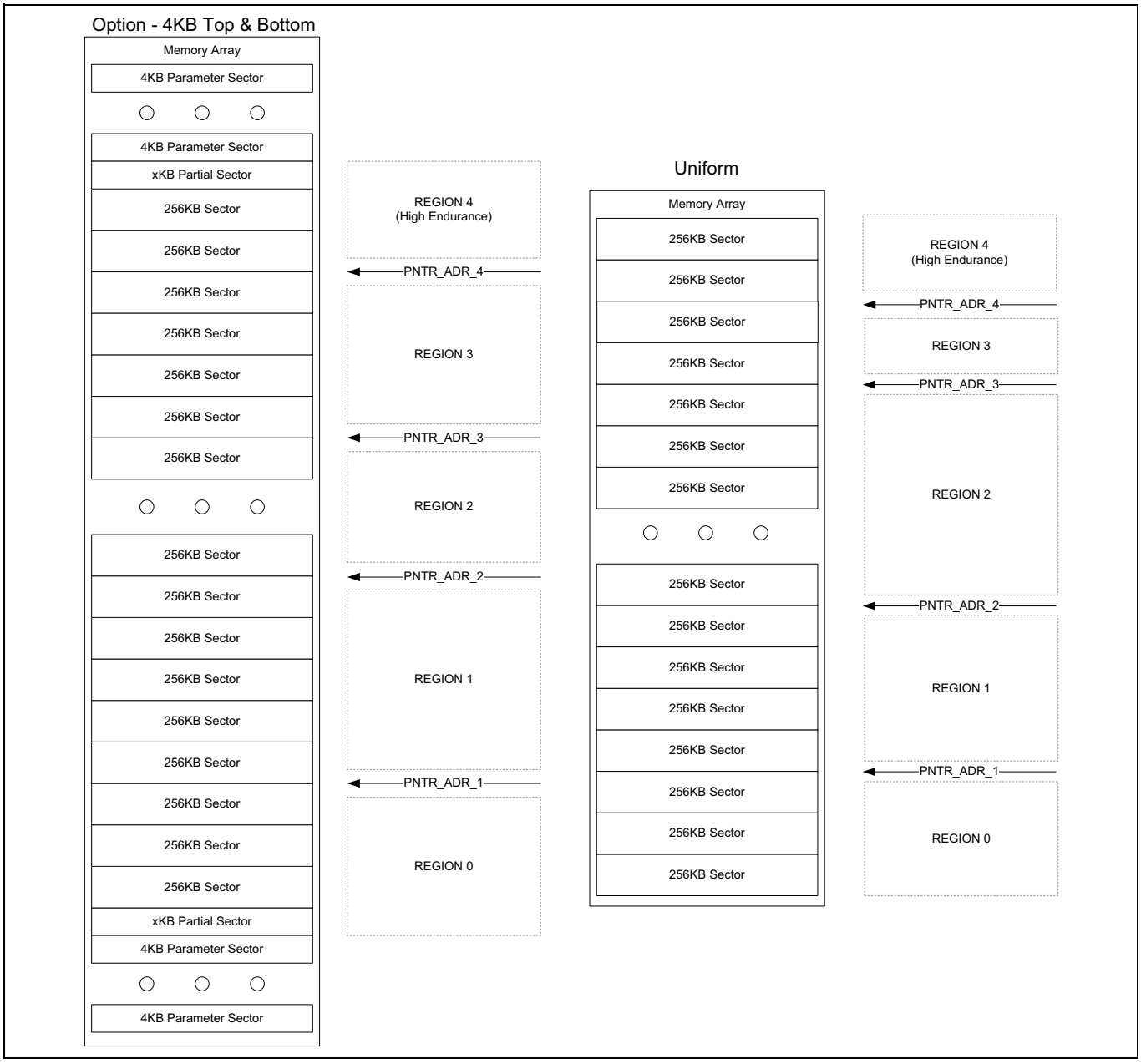


Figure 42 Infineon Endurance Flex architecture overview (Continued)

Table 11 Region definitions[12, 13, 14, 15]

Region	Lower limit	Upper limit
0	Sector 0	Address Pointer 1
1	Address Pointer 1	Address Pointer 2
2	Address Pointer 2	Address Pointer 3
3	Address Pointer 3	Address Pointer 4
4	Address Pointer 4	Highest Sector

Notes
12. The pointer addresses must obey the following rules:
    Pointer#4 address > Pointer#3 address
    Pointer#3 address > Pointer#2 address
    Pointer#2 address > Pointer#1 address
13. 4KB sectors are excluded.
14. It is required that the high data endurance and long data retention regions are configured at the time the device is first powered-up by the customer. Once configured, they can never be changed again.
15. The minimum size of any high endurance region is 20 sectors.

4.2.1 Configuration 1: Maximum endurance - Single high endurance region

Maximum endurance is achieved when all 256KB sectors are designated as high endurance. All sectors must be designated as high endurance using the Infineon Endurance Flex architecture pointer. Maximum endurance pointer configuration is shown in **Table 12**.

Table 12 Infineon Endurance Flex architecture pointer values for maximum endurance configuration[16]

Pointer #	Pointer address EPTADn[8:0]	Region type ERGNTn	Pointer enable# EPTEBn	Global region selection GBLSEL	Wear leveling enable WRLVEN
0	N/A	N/A	N/A	1’b1	1’b1
1	9’b111111111	1’b1	1’b1	N/A	N/A
2	9’b111111111				
3	9’b111111111				
4	9’b111111111				

Note
16. This is also the default configuration of the device.

4.2.2 Configuration 2: Two region selection - One long retention region and one high endurance region

Sectors for long retention or high endurance must be delineated using the Infineon Endurance Flex architecture pointer. Region 0 is defined as long retention and consists of 16 sectors. Region 1 is defined as high endurance and has 240 sectors. The pointer setup for two region configuration is shown in **Table 13**. The number of pointers defined is based on the number of regions configured.

Table 13 Infineon Endurance Flex architecture pointer values for two region configuration

Pointer #	Pointer address EPTADn[8:0]	Region type ERGNTn	Pointer enable# EPTEBn	Global region selection GBLSEL	Wear leveling enable WRLVEN
0	N/A	N/A	N/A	1’b0	1’b1
1	9’b000010000	1’b1	1'b0	N/A	N/A
2	9’b111111111	1’b1	1'b1		
3					
4					

4.2.3 Infineon Endurance Flex architecture related registers and transaction

Table 14 Infineon Endurance Flex architecture related registers and transactions

Related registers	Related SPI transactions (see Table 73)	Related quad SPI transactions (see Table 77)
Infineon Endurance Flex architecture Selection Registers (EFX4O, EFX3O, EFX2O, EFX1O, EFX0O) (see "Infineon Endurance Flex Architecture Selection Register (EFXx)" on page 95)	Read Any Register (RDARG_C_0)	Read Any Register (RDARG_C_0)
	Write Any Register (WRARG_C_1)	Write Any Register (WRARG_C_1)

4.3 Data integrity CRC

HL-T/HS-T family devices have a group of transactions to perform a hardware accelerated Cyclic Redundancy Check (CRC) calculation over a user defined address range in the memory array. The calculation is another type of embedded operation similar to programming or erase, in which the device is busy while the calculation is in progress. The CRC operation uses the following CRC32 polynomial to determine the CRC check-value.

CRC32 Polynomial: $X^{32} + X^{28} + X^{27} + X^{26} + X^{25} + X^{23} + X^{22} + X^{20} + X^{19} + X^{18} + X^{14} + X^{13} + X^{11} + X^{10} + X^{9} + X^{8} + X^{6} + 1$

The check-value generation sequence is started by entering the DICHK_4_1 transaction. The transaction includes loading the beginning address into the CRC Start Address Register identifying the beginning of the address range that will be covered by the CRC calculation. The transaction also includes loading the ending address into the CRC End Address Register. Bringing CS# HIGH starts the CRC calculation. The CRC process calculates the check-value on the data contained at the starting address through the ending address.

During the calculation period the device goes into the Busy state (STR1V[0] - RDYBSY = 1). Once the check-value calculation has completed the device returns to the Ready state (STR1V[0] - RDYBSY = 0) and the calculated check-value is available to be read. The check-value is stored in the Data Integrity CRC Register (DCRV[31:0]) and can be read using Read Any Register (RDARG_C_0) transaction.

The check-value calculation can only be initiated when the device is in Standby State; and once started it can be suspended with the CRC Suspend transaction (SPEPD_0_0) to read data from the memory array. During the Suspended state the CRC Suspend Status Bit in the Status Register 2 will be set (STR2V[4] - DICRCS = 1). Once suspended, the host can read the Status Register, read data from the array and can resume the CRC calculation by using the CRC Resume transaction (RSEPD_0_0).

The Ending Address (ENDADD) must be at least four addresses higher than the Starting Address (STRADD). If ENDADD < STRADD + 3 the check-value calculation will abort and the device will return to the Ready state (STR1V[0] - RDYBSY = 0). Data Integrity CRC abort status bit will be set (STR2V[3] - DICRCA = 1) to indicate the aborted condition. The DICRCA bit can be cleared, once set, by software reset or a valid subsequent CRC command execution. If ENDADD < STRADD + 3, the check-value will hold indeterminate data.

Note Any invalid transaction during CRC check-value calculation can corrupt the check-value data.

4.3.1 Data integrity check related registers and transactions

Table 15 Data integrity CRC related registers and transactions

Related registers	Related SPI transactions (see Table 73)	Related quad SPI transactions (see Table 77)
Status Register 1 (STR1N, STR1V) (see Table 41)	Data Integrity Check (DICHK_4_1)	Data Integrity Check (DICHK_4_1)
Status Register 2 (STR2V) (see Table 44)	Suspend Erase/Program/Data Integrity Check (SPEPD_0_0)	Suspend Erase/Program/Data Integrity Check (SPEPD_0_0)
Data Integrity CRC Check-Value Register (DCRV) (see Table 54)	Resume Erase/Program/ Data Integrity Check (RSEPD_0_0)	Resume Erase/Program/ Data Integrity Check (RSEPD_0_0)

4.4 Data protection schemes

Data protection is required to safeguard against unintended changes to stored data and device configuration. This includes inadvertent erasing or programming the memory array as well as writing to the configuration registers which can alter the functionality of the device. Three types of protection schemes are discussed which range from protecting either a single or a group of sectors to either a portion or the complete memory array. **Figure 43** shows an overview of different protection schemes along with applicable data regions.

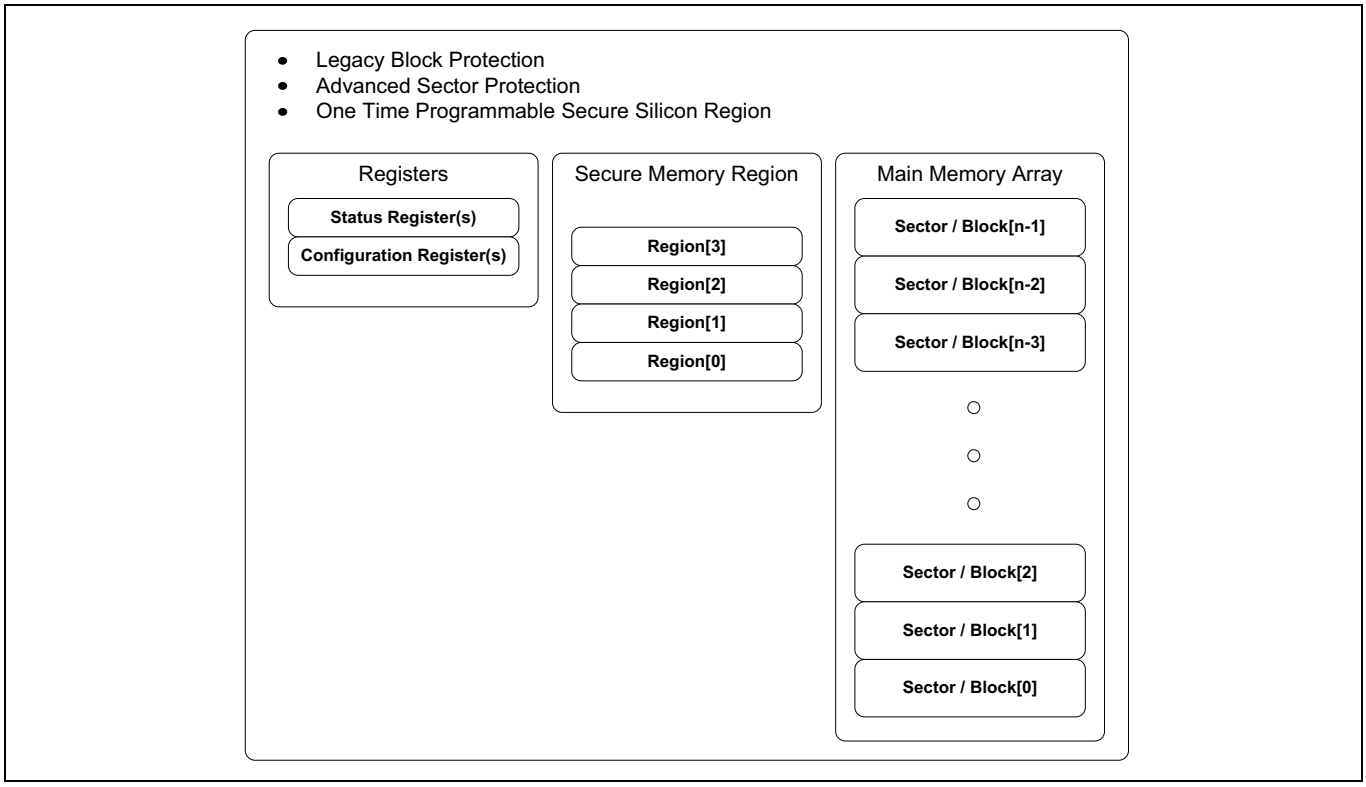


Figure 43 Data protection and security (write/program/erase) schemes

4.4.1 Legacy block protection (LBP)

The legacy block protection (LBP) is a block-based data protection scheme. LBP supports compatibility with legacy serial NOR Flash devices. LBP provides protection for data in the memory array and device configuration by protecting Status and Configuration registers.

4.4.1.1 Memory array protection

The protection for the memory array is with block size selection, which is achieved through a combination of bits present in the Status Register 1 (STR1N[4:2]/STR1V[4:2] - LBPROT[2:0]) and Configuration Register 1 (CFR1N[5]/CFR1V[5] - TBPROT).

Table 16 provides the LBP memory array block selection summary.

Table 16 Legacy block memory array protection selection

CFR1N[5]/CFR1V[5] TBPROT	STR1N[4]/STR1V[4] LBPROT[2]	STR1N[3]/STR1V[3] LBPROT[1]	STR1N[2]/STR1V[2] LBPROT[0]	Memory array block size	256Mb (KBs)	512Mb (KBs)	1Gb (KBs)
0	0	0	0	None	0	0	0
0	0	0	1	Upper 64th	512	1024	2048
0	0	1	0	Upper 32nd	1024	2048	4096
0	0	1	1	Upper 16th	2048	4096	8192
0	1	0	0	Upper 8th	4096	8192	16384
0	1	0	1	Upper 4th	8192	16384	32768
0	1	1	0	Upper Half	16384	32768	65536
0	1	1	1	All sectors	32768	65536	131072
1	0	0	0	None	0	0	0
1	0	0	1	Lower 64th	512	1024	2048
1	0	1	0	Lower 32nd	1024	2048	4096
1	0	1	1	Lower 16th	2048	4096	8192
1	1	0	0	Lower 8th	4096	8192	16384
1	1	0	1	Lower 4th	8192	16384	32768
1	1	1	0	Lower Half	16384	32768	65536
1	1	1	1	All sectors	32768	65536	131072

4.4.1.2 Configuration protection

LBP has selection bits in Configuration Register 1 (CFR1N[4,0]/CFR1V[4,0] - PLPROT, TLPROT) which either permanently or temporarily protect Status and Configuration registers, thereby again protecting the device's configuration. The temporary protection remains in effect until the next power down or hardware reset or JEDEC serial flash reset signaling protocol.

Table 17 Option 2 - Legacy block configuration protection selection[17]

CFR1N[4]/CFR1V[4] PLPROT	CFR1N[0]/CFR1V[0] TLPROT	Register protection status
0	0	Status and Configuration registers are unprotected
1	X	Status and Configuration registers are permanently protected (TBPROT, LBPROT[2:0], SP4KBS, TB4KBS)
0	1	Status and Configuration registers are Protected till next Power down (TBPROT, LBPROT[2:0], SP4KBS, TB4KBS)

Note
17. Protecting the configuration also protects the memory array blocks which have been selected for protection.

4.4.1.3 Write Protect signal

The Write Protect (DQ2_WP#) input in combination with the Status Register Write Disable bit (STR1x[7]) provide hardware input signal controlled protection. When WP# is LOW and STR1x[7] is set to "1" Status Register 1 (STR1N and STR1V) and Configuration Register-1 (CFR1N and CFR1V) are protected from alteration. This prevents disabling or changing the protection defined by the Block Protect bits.

4.4.1.4 Legacy block protection flowchart

The LBP protection scheme flowchart is shown in **Figure 44**.

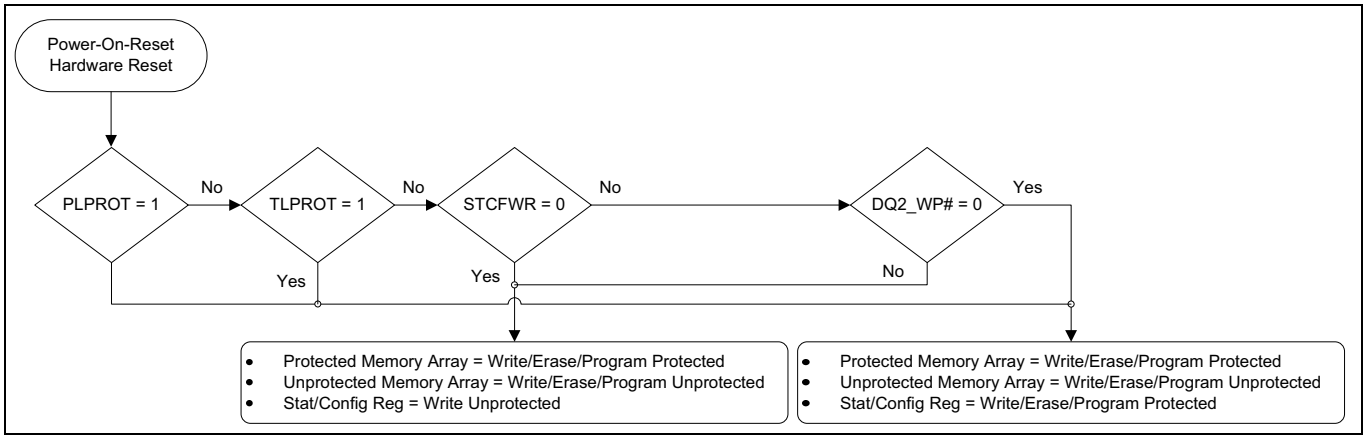


Figure 44 Legacy block protection flowchart

4.4.1.5 LBP related registers and transactions

Table 18 LBP related registers and transactions

Related registers	Related SPI transactions (see Table 73)	Related quad SPI transactions (see Table 77)
Status Register 1 (STR1N, STR1V) (see Table 41)	Read Any Register (RDARG_C_0)	Read Any Register (RDARG_C_0)
Configuration Register 1 (CFR1N, CFR1V) (see Table 45)	Write Any Register (WRARG_C_1)	Write Any Register (WRARG_C_1)
	Read Status Register 1 (RDSR1_0_0)	Read Status Register 1 (RDSR1_0_0)
	Write Enable (WRENB_0_0)	Write Enable (WRENB_0_0)

4.4.2 Advanced sector protection (ASP)

The advanced sector protection (ASP) scheme allows each memory array sector to be independently controlled for protection against erasing or programming, either by volatile or nonvolatile locking features. The nonvolatile locking configuration can also be locked, as well as password-protected.

The main memory array sectors are protected against erase and program by volatile (DYB) and nonvolatile (PPB) protection bit pairs. Each DYB/PPB bit pair can be individually set to '0' protecting the related sector or cleared to '1' unprotecting the related sector. DYB protection bits can be set and cleared as often as needed whereas PPB bits being nonvolatile must adhere to their respective technology based endurance requirements. **Figure 45** shows an overview of ASP.

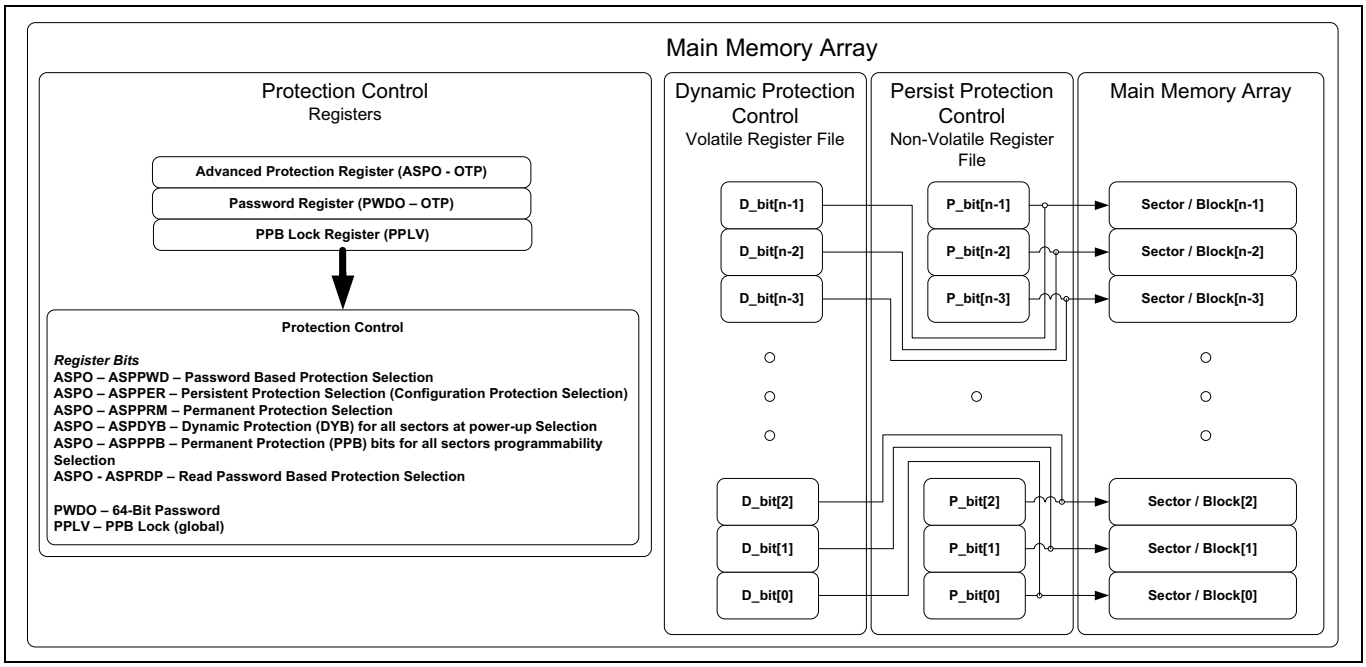


Figure 45 Advanced sector protection (Nonvolatile)

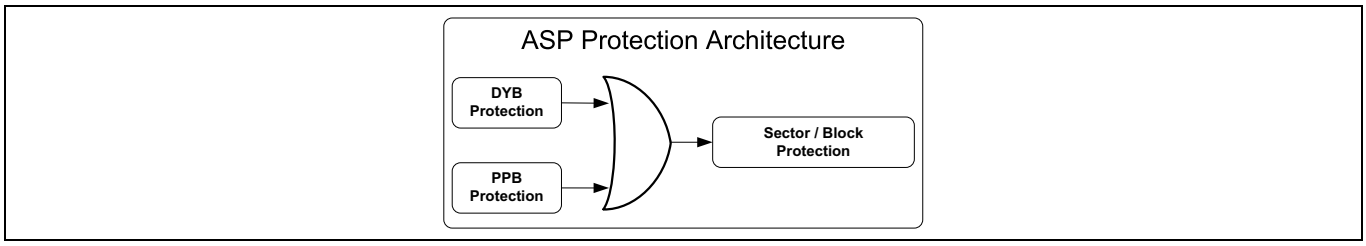


Figure 46 DYB and PPB protection control

ASP provides a rich set of configuration options producing multiple data protection schemes which can be employed based on design or system needs. These configuration options are discussed in **"Configuration protection"** on page 42 through **"ASP related registers and transactions"** on page 47.

4.4.2.1 Configuration protection

ASP provides provisions to protect device's configuration through Persistent Protection scheme. Selecting bit 1 in Advanced Sector Protection Register (ASPO[1] - ASPPER) selects the Persistent Protection scheme and protects the following registers or register bits from write or program:

- CFR1V[6, 5, 4, 2]/CFR1N[6, 5, 4, 2] - SP4KBS, TBPROT, PLPROT, TB4KBS
- CFR3N[3]/CFR3V[3] - UNHYSA
- ASPO[15:0]
- PWDO[63:0]

The persistent protection scheme flowchart is shown in **Figure 47**.

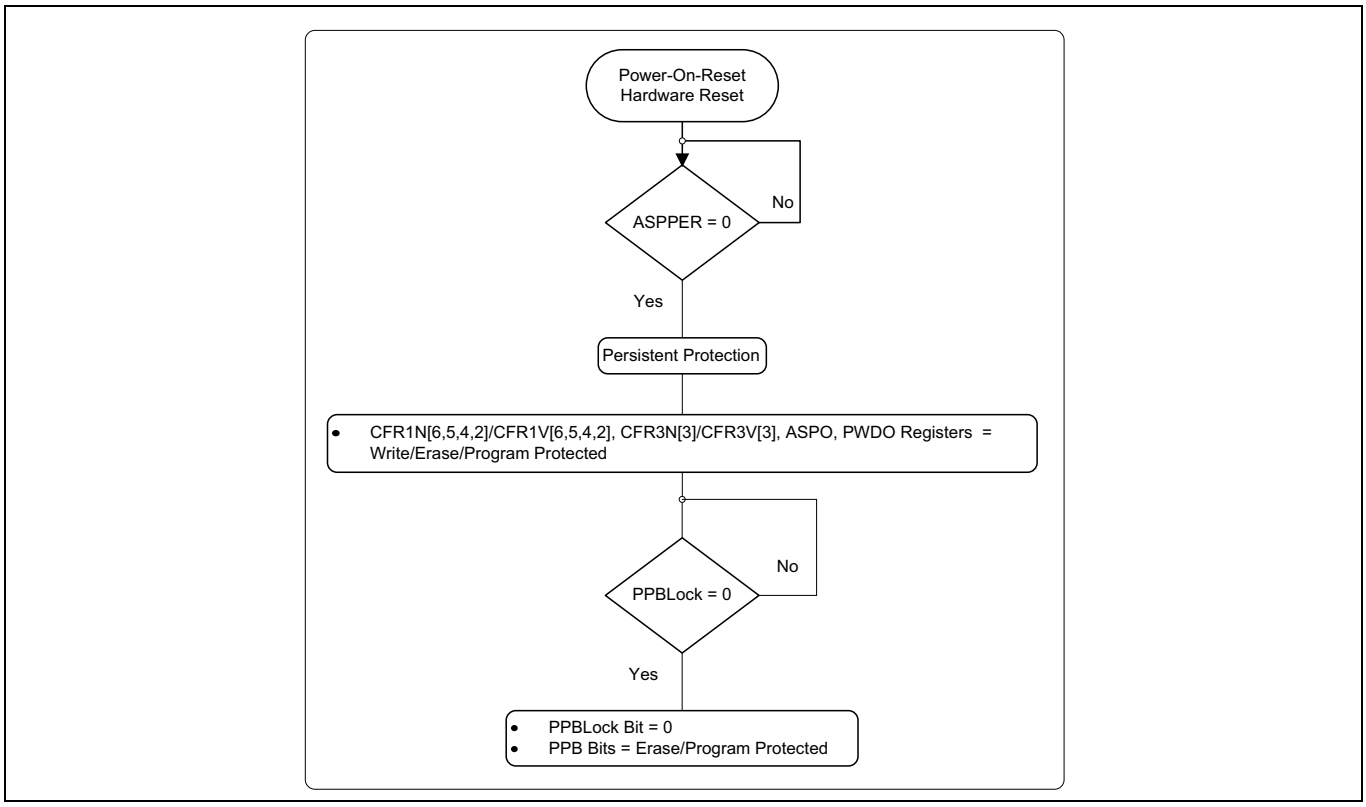


Figure 47 Persistent protection scheme flowchart

4.4.2.2 Dynamic DYB (volatile) sector protection

Dynamic Protection Bits (DYB) are volatile and unique for each sector and can be individually modified. DYBs only control protection for sectors that have their PPBs cleared. By issuing the DYB Write transaction, the DYB are set to '0' or cleared to '1', thus placing each sector in the protected or unprotected state respectively. This feature allows software to easily protect sectors against inadvertent changes, yet does not prevent the easy removal of protection when changes are needed. The DYB can be set to '0' or cleared to '1' as often as needed.

In Dynamic Sector Protection scheme, an option is provided to reset all DYB volatile protection bits to '0' upon power up (protected), essentially protecting all sectors from erase or program. Selecting bit 4 in the Advanced Sector Protection Register (ASPO[4] - ASPDYB) selects the Dynamic Protection (DYB) for all sectors at power-up protection scheme. These DYB bits can be individually set to '1', if desired. The Dynamic Sector Protection scheme flowchart showing power up protection is shown in **Figure 48**.

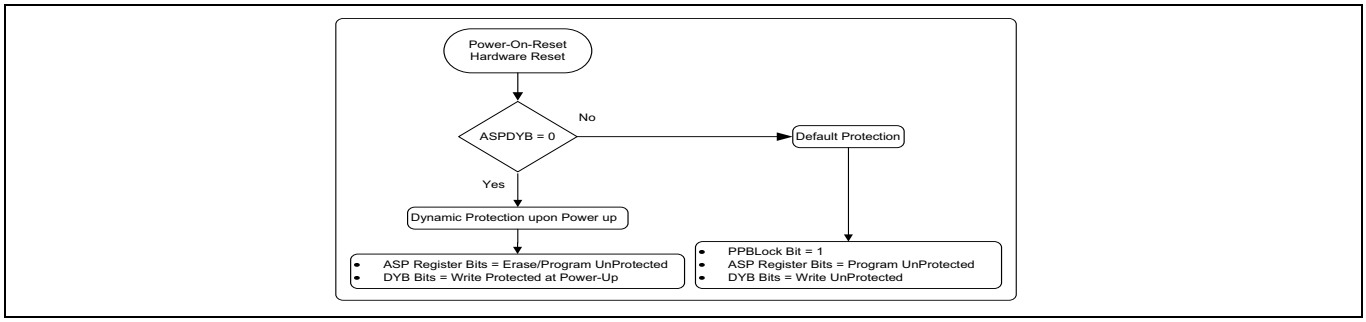


Figure 48 Dynamic sector protection scheme flowchart

4.4.2.3 Permanent/temporary PPB (nonvolatile) sector protection

Each nonvolatile bit (PPB) provides nonvolatile protection for an individual memory sector, which remains locked (protection enabled) until its corresponding bit is cleared to '1'. There are two options to control the PPB based nonvolatile selection in ASP, namely Permanent and Temporary.

4.4.2.4 Permanent PPB protection scheme

The PPB are located in a separate nonvolatile flash array. One of the PPB bits is assigned to each sector. When a PPB is programmed to 0 its related sector is protected from program and erase operations. The PPB are programmed individually but must be erased as a group, similar to the way individual words may be programmed in the main array but an entire PPB sector must be erased at the same time. Programming a PPB bit requires the typical word programming time. During a PPB bit programming operation or PPB bit erasing, the Status Register can be accessed to determine when the operation has completed. Erasing all the PPBs requires typical sector erase time.

Permanent PPB based protection scheme, as the name applies, is permanent and can never be altered. Once the PPB architecture is decided, selecting bit 0 in Advanced Sector Protection Register (ASPO[0]) enables the Permanent Protection for all PPB bits essentially disabling all PPB erase and program operations. ASPO is also protected from write or program.

The Permanent PPB Protection scheme flowchart is shown in **Figure 49**.

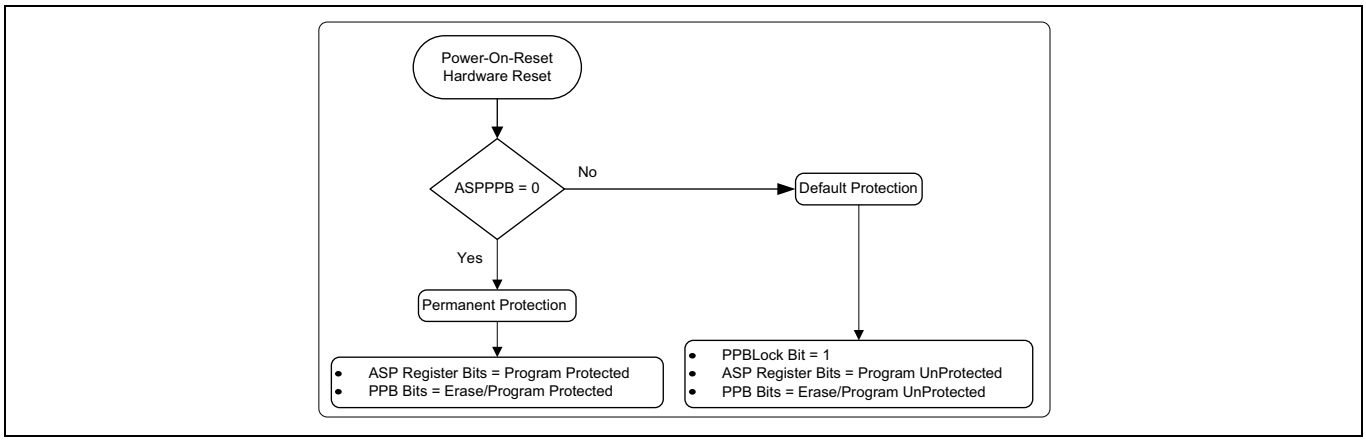


Figure 49 Permanent PPB sector protection flowchart

4.4.2.5 Temporary PPB protection scheme

PPB based nonvolatile protection architecture can be temporarily locked where erasing and programming of the individual PPB bits is inhibited. The Persistent Protection Lock Bit (PPBLock) is a volatile bit for protecting all PPB bits. When cleared to '0', it locks all PPBs and when set to '1', it allows the PPBs to be changed. There is only one PPB Lock Bit per device. The PPBLock transaction (WRPLB_0_0) is used to clear the bit to '0'. The PPB Lock Bit must be cleared to '0' only after all the PPBs are configured to the desired settings. The PPB Lock Bit is set to '1' during POR or a Hardware Reset. When cleared with the PPBLock transaction, no software command sequence can set PPBLock, only another Hardware Reset or Power-Up can set PPBLock.

Note Temporary PPB Protection does not require any ASP configuration.

4.4.2.6 Password protection scheme

Password Protection scheme allows an even higher level of security, by requiring a 64-bit password for setting PPBLock. In addition to this password requirement, after Power-Up or Hardware Reset, the PPB Lock Bit is cleared to 0 to ensure protection at Power-Up. Successful execution of the Password Unlock transaction by entering the entire password sets the PPB Lock Bit to '1', allowing for sector PPB modifications. Selecting bit 2 in Advanced Sector Protection Register (ASPO[2] - ASPPWD) selects the Password Protection scheme. Password Protection scheme also protects ASPO from write or program.

Note A password must be programmed before selecting the password protection scheme. The password unlock SPI transaction (PWDUL_0_1) is used to provide a password for comparison.

The Password Protection scheme flowchart is shown in **Figure 50**.

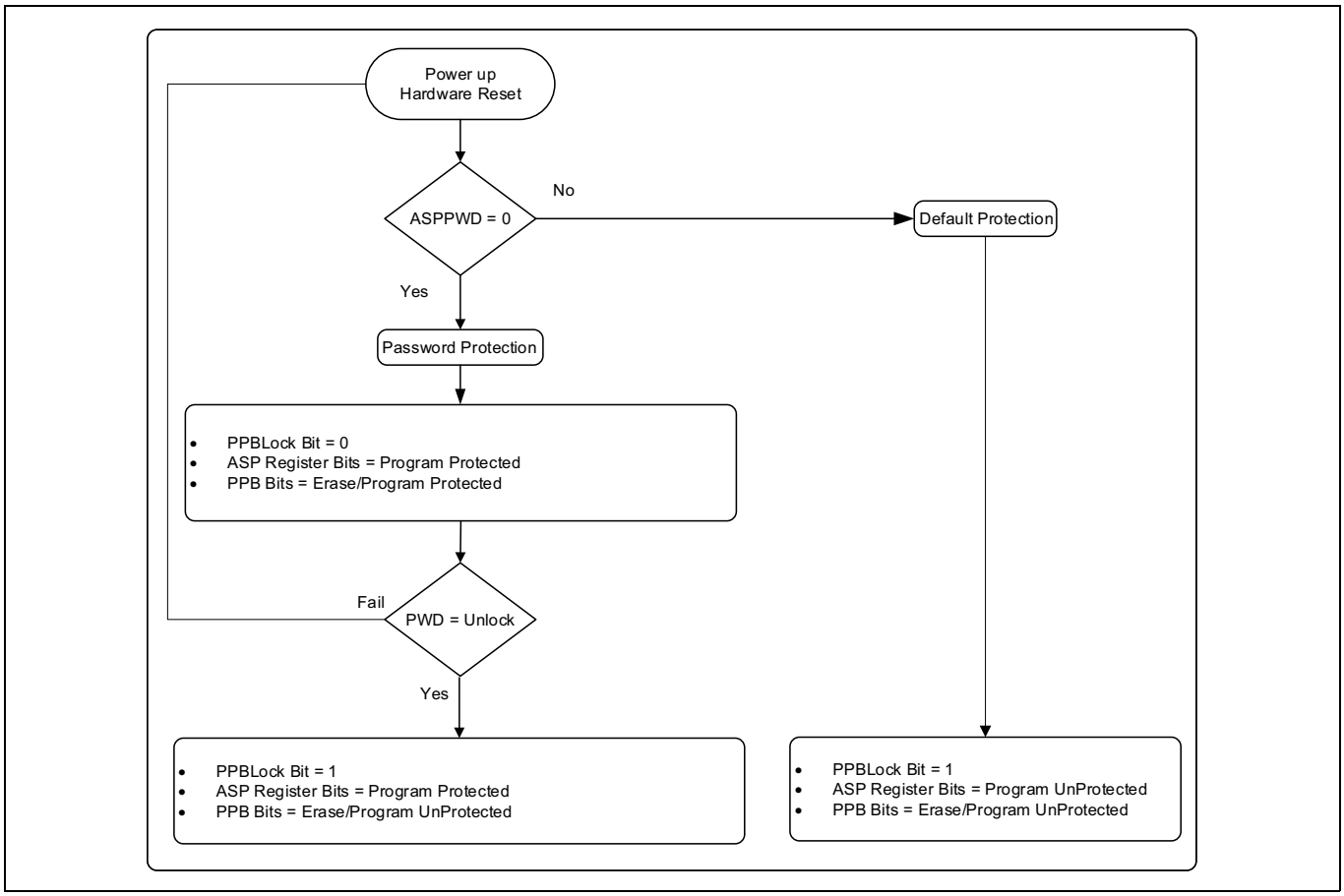


Figure 50 Password protection scheme flowchart

4.4.2.7 Read password protection scheme

The Read Password Protection scheme replaces the Password Protection scheme and provides the most data protection. The Read Password Protection scheme enables protecting the flash Memory Array from read, program, and erase. Only the lowest or highest (256 KB) sector address range, selected by bit 5 of Configuration Register 1 (CFR1x[5] - TBPROT), remains readable until a successful Password Unlock transaction is complete. A ‘0’ selects from the top most sector and a ‘1’ selects from the bottom most sector irrespective of the sector address supplied in the read transaction. Note that reads from the read-protected portion of the array will alias back to the readable sector.

Clear Program and Erase Failure Flags transaction, all memory array Read transactions, Password Unlock transaction, Read manufacturer and device ID transaction, Read SFDP transaction, Read Status Register-1 transaction, Read Status Register-2 transaction, Read ECC Status transaction, Clear ECC Status Register transaction, and Enter DPD Mode transaction are allowed during Password Read Mode before the Password is supplied.

Note A password must be programmed before selecting the Read Password Protection Scheme. The password unlock SPI transaction

(PWDUL_0_1) is used to provide a password for comparison.

The Read Password Protection scheme flowchart is shown in **Figure 51**.

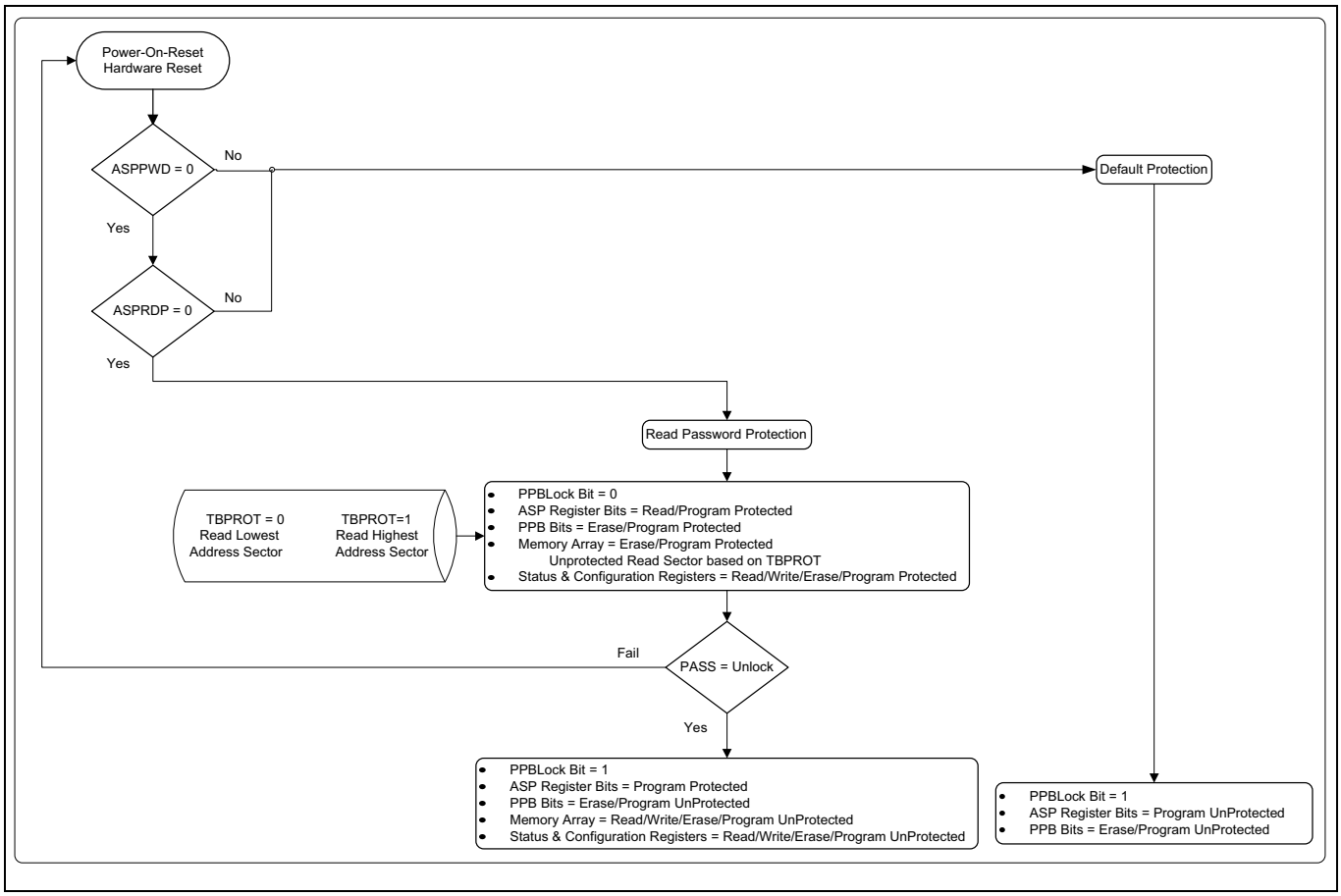


Figure 51 Read password protection scheme flowchart

4.4.2.8 PPB Bits - OTP selection

ASP provides a configuration option to permanently disable the PPB erase transaction (ERPPB_0_0). This makes all PPB bits OTP. With this option, once the PPB protection is selected, it can never be changed. Selecting bit 3 in Advanced Sector Protection Register (ASPO[3] - ASPPPB) makes PPB bits OTP.

4.4.2.9 General ASP guidelines

- Persistent protection (ASPPER) and Password protection (ASPPWD) are mutually exclusive - only one option can be programmed.
- Read Password protection (ASPRDP) if desired, must be programmed at the same time as Password protection (ASPPWD).
- Once the password is programmed and verified, the Password Protection scheme (ASPPWD) must be programmed (to 0) to prevent reading the password.
- When the Read Password scheme and Password Protection scheme are enabled (i.e. ASPO[5] - ASPRDP, ASPO[2] - ASPPWD are programmed to 0), then all addresses are redirected to the Boot Sector until the password unlocking sequence is properly entered with the correct password. At which time, the Read Password Mode is disabled and all addressing will select the proper location.
- Programming memory spaces or writing registers is not allowed when Read Password Protection Mode is active.

4.4.2.10 ASP related registers and transactions

Table 19 ASP related registers and transactions

Related registers	Related SPI transactions (see Table 73)	Related quad SPI transactions (see Table 77)
Advanced Sector Protection Register (ASPO) (see Table 58)	Read Dynamic Protection Bit (RDDYB_4_0, RDDYB_C_0)	Read Dynamic Protection Bit (RDDYB_4_0, RDDYB_C_0)
Configuration Register 1 (CFR1N, CFR1V) (see Table 45)	Write Dynamic Protection Bit (WRDYB_4_1, WRDYB_C_1)	Write Dynamic Protection Bit (WRDYB_4_1, WRDYB_C_1)
	Read Persistent Protection Bit (RDPPB_4_0, RDPPB_C_0)	Read Persistent Protection Bit (RDPPB_4_0, RDPPB_C_0)
	Program Persistent Protection Bit (PRPPB_4_0, PRPPB_C_0)	Program Persistent Protection Bit (PRPPB_4_0, PRPPB_C_0)
	Erase Persistent Protection Bit (ERPPB_0_0)	Erase Persistent Protection Bit (ERPPB_0_0)
	Write PPB Protection Lock Bit (WRPLB_0_0)	Write PPB Protection Lock Bit (WRPLB_0_0)
	Read Password Protection Mode Lock Bit (RDPLB_0_0)	Read Password Protection Mode Lock Bit (RDPLB_4_0)
	Password Unlock (PWDUL_0_1)	Password Unlock (PWDUL_4_1)
	Write Enable (WRENB_0_0)	Write Enable (WRENB_0_0)
	Read Any Register (RDARG_C_0)	Read Any Register (RDARG_C_0)
	Write Any Register (WRARG_C_1)	Write Any Register (WRARG_C_1)

4.4.3 Secure silicon region (SSR)

Secure silicon region (SSR) is a 1024 byte memory region (separate from the main memory array). The 1024 bytes are divided into 32, individually lockable 32-byte regions. **Figure 52** provides an overview of SSR.

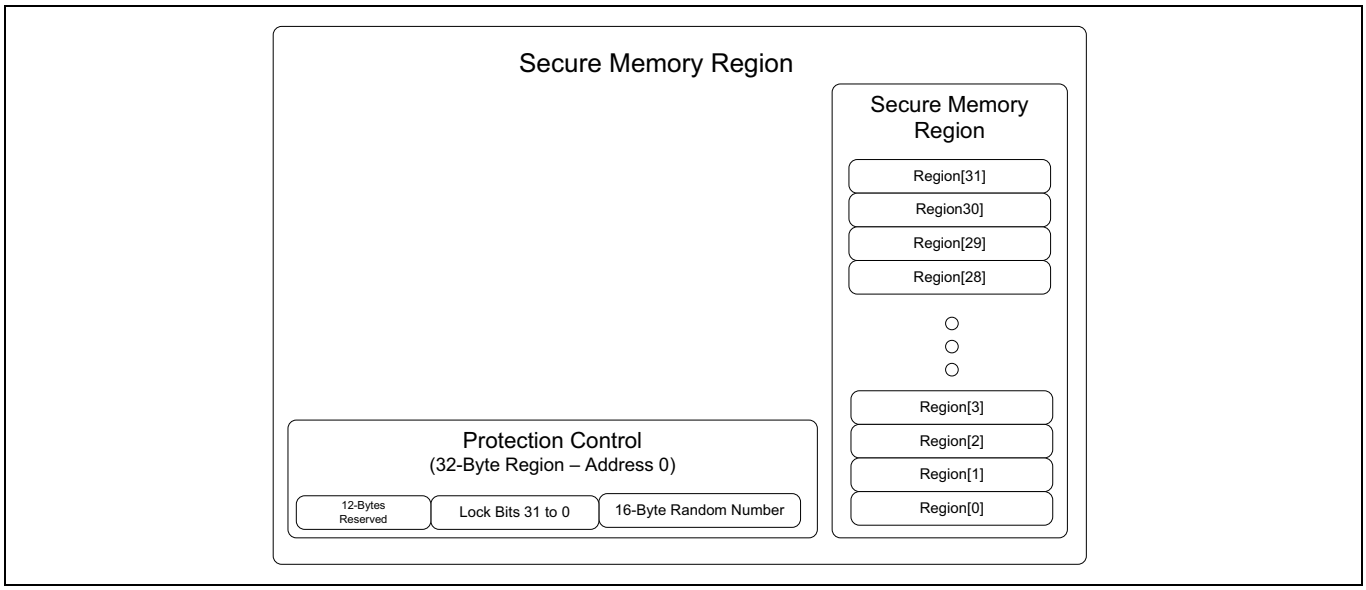


Figure 52 OTP protection (nonvolatile)

The first 32-byte region (starting at address 0) provides the protection mechanism for the other 32-byte regions. The sixteen lowest bytes of this region contain a 128-bit random number. The random number cannot be written to, erased or programmed. The next four bytes (32 bits in total) of this region provide protection from programming if set to '0' for the remaining 32-byte regions - one bit per 32-byte region. All other bytes are reserved.

Note Attempting to Erase or Program the 128-bit random number will result in ERSERR or PRGERR, respectively. A hardware Reset is required to bring the device back to Standby mode.

4.4.3.1 SSR related registers and transactions

Table 20 SSR related registers and transactions

Related registers	Related SPI transactions (see Table 73)	Related quad SPI transactions (see Table 77)
N/A	Program Secure Silicon Region (PRSSR_C_1)	Program Secure Silicon Region (PRSSR_C_1)
	Read Secure Silicon Region (RDSSR_C_0)	Read Secure Silicon Region (RDSSR_C_0)

4.5 SafeBoot

SEMPER™ Flash memory devices contain an embedded microcontroller which is used to initialized the device, manage embedded operations, and perform other advanced functionality. An initialization failure of this embedded microcontroller or corruption of the nonvolatile configuration registers can render the flash device unusable. Baring a catastrophic event, such as permanent corruption of the embedded microcontroller firmware, it is possible to recover the device.

The SafeBoot feature allows Status Register polling to detect an embedded microcontroller initialization failure or configuration register corruption through error signatures.

4.5.1 Microcontroller initialization failure detection

If the microcontroller embedded in the flash device fails to initialize, a hardware reset can recover the device, unless it is a catastrophic failure. This hardware reset must be initiated by the Host controller. Upon detecting a failed microcontroller initialization, the flash device automatically reverts to its Default Boot mode (1S-1S-1S) and provides a failure signature in its Status Register.

Table 21 shows the device's Status Register bits upon detecting an initialization failure.

Table 21 Status register 1 power-on detection signature

Bit	Field name	Function	Detection signature
STR1V[7]	STCFWR	Status Register and Configuration Registers Protection Selection against write (erase/program)	0
STR1V[6]	PRGERR	Programming Error Status Flag	1
STR1V[5]	ERSERR	Erasing Error Status Flag	1
STR1V[4]	LBPROT[2:0]	Legacy Block Protection based memory Array size selection **Note:** LBPROT[2:0] can be anything from 000 to 111 based on Block Protection configuration.	0
STR1V[3]			0
STR1V[2]			0
STR1V[1]	WRPGEN	Write/Program Enable Status Flag	0
STR1V[0]	RDYBSY	Device Ready/Busy Status Flag	1

Table 22 Interface configuration upon detecting power-on failure[18]

Interface	Transactions supported	Register type	Address (# of bytes)	Frequency of operation	Register read latency (# of clock cycles)	Output impedance
SPI (1S-1S-1S)	Read Status Register 1 (RDSR1_0_0) Read Any Register (RDARG_C_0)	Status Register (Volatile Only)	4	Maximum (allowed for RDSR1_0_0, RDARG_C_0)	2	45 Ω

Note
18. For reading the Status Register, providing the NonVolatile Status Register address to RDARG_C_0 will produce indeterminate results.

4.5.1.1 Host polling behavior

The host will need to go through a Status Register polling sequence to determine if an initialization failure has occurred in the device. The flowchart for the sequence is shown in **Figure 53**.

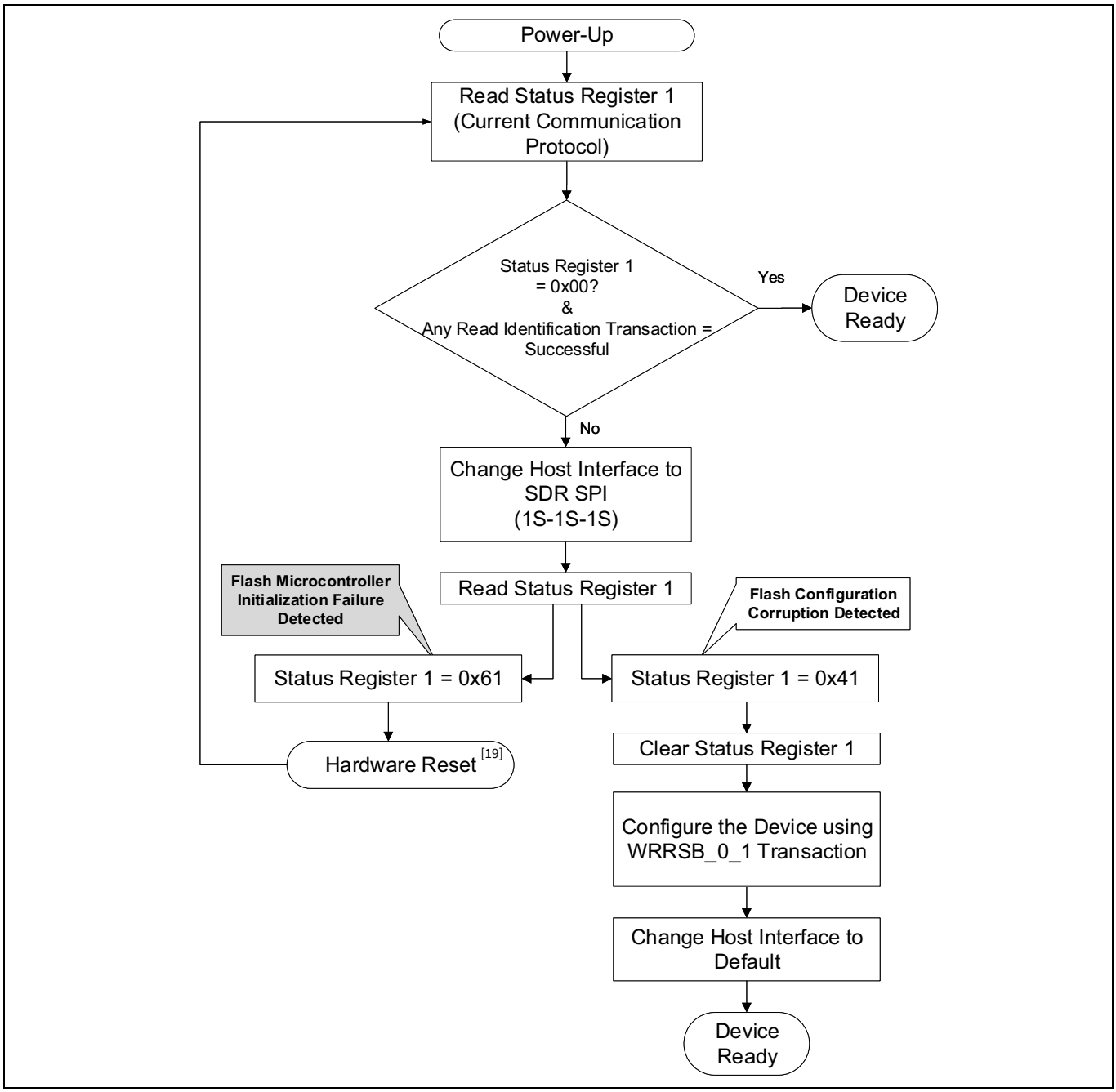


Figure 53 Host polling sequence for microcontroller initialization failure detection

Note The polling sequence must start from the higher I/O interface configuration to lower I/O interface configuration only. For example, 4S-4D-4D to 1S-1S-1S.

Note
19. If you have Vcc within specifications and a hardware reset does not resolve the issue, replace the flash device.

4.5.1.2 Microcontroller initialization failure detection related registers and transactions

Table 23 Microcontroller initialization failure related registers and transactions

Related registers	Related SPI transactions (see Table 73)	Related quad SPI transactions (see Table 77)
Status Register 1 Volatile (STR1V) (see Table 41)	Read Any Register (RDARG_C_0)	N/A
	Read Status Register-1 (RDSR1_0_0)	

4.5.2 Configuration corruption detection

If during device's configuration update, such as writing to a nonvolatile register, a power loss occurs or a hardware reset is initiated, the write register transaction will get interrupted. The device will return to Standby mode, but the nonvolatile register data is most likely corrupted since the embedded write operation was prematurely terminated. During the next power-up, the configuration corruption is detected and the device reverts to its Default Boot mode (1S-1S-1S) and allows rewriting the configuration again. The device will maintain the configured protection scheme.

Table 24 shows the device's Status Register bits upon detecting a configuration corruption.

Table 24 Status Register 1 configuration corruption detection signature

Bit	Field name	Function	Detection signature
STR1V[7]	STCFWR	Status Register and Configuration Registers Protection Selection against write (erase/program)	0
STR1V[6]	PRGERR	Programming Error Status Flag	1
STR1V[5]	ERSERR	Erasing Error Status Flag	0
STR1V[4]	LBPROT[2:0]	Legacy Block Protection based memory Array size selection **Note** LBPROT[2:0] can be anything from 000 to 111 based on Block Protection configuration.	0
STR1V[3]			0
STR1V[2]			0
STR1V[1]	WRPGEN	Write/Program Enable Status Flag	0
STR1V[0]	RDYBSY	Device Ready/Busy Status Flag	1

Table 25 Interface configuration upon detecting configuration corruption

Interface	Transactions supported	Address (# of bytes)	Frequency of operation	Register read latency (# of clock cycles)	Output impedance
SPI (1S-1S-1S)	All SPI (1S-1S-1S) transactions	4	Maximum	2	45 Ω

4.5.2.1 Host polling behavior

The host will need to go through a Status Register polling sequence to determine if a Configuration corruption has occurred in the device. The flowchart for the sequence is shown in **Figure 54**.

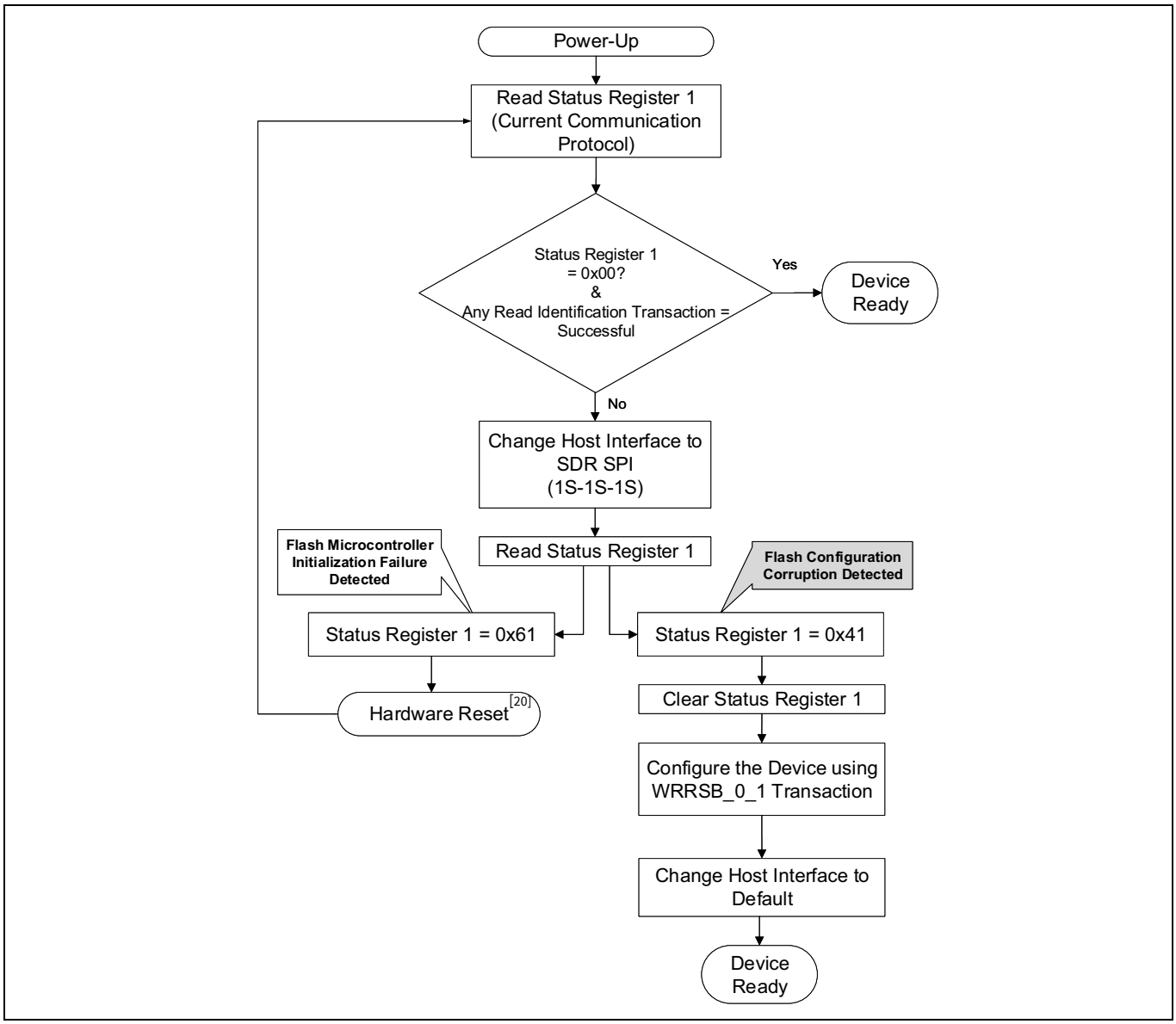


Figure 54 Host polling sequence for configuration corruption detection

Note The polling sequence must start from a higher I/O interface configuration to a lower I/O interface configuration. As an example, 4S-4D-4D to 1S-1S-1S. Not the other way around.

Note
20.If you have Vcc within specifications and a hardware reset does not resolve the issue, replace the flash device.

4.5.2.2 Configuration corruption detection related registers

Table 26 Configuration corruption detection related registers and transactions

Related registers	Related SPI transactions (see Table 73)	Related quad SPI transactions (see Table 77)
Status Register 1 Volatile (STR1V) (see Table 41)	All 1S-1S-1S transactions	N/A

4.6 AutoBoot

AutoBoot allows the host to read data from HL-T/HS-T family of devices after power up or after a hardware reset without having to send any read transactions (including the address). Based on the device configuration, data is output on the interface I/Os once CS# is brought LOW and CK is toggled.

The starting address for the read data is specified in the AutoBoot Register (ATBN[31:9] - STADR[22:0]). This starting address can be at any page boundary location in the memory (512 byte page boundary). Also identified in the AutoBoot Register is a starting delay which is represented as the number of clock cycles (ATBN[8:1] - STDLY[7:0]). This delay is instituted before the data is read out. The delay can be programmed to meet the host's requirements but a minimum amount is required to meet the memory access times based on the frequency for operation. It is highly recommended to check the Status Register 1 value after successful or unsuccessful AutoBoot execution to verify the configuration corruption (SafeBoot).

Note Wrap function must be disabled for AutoBoot.

Note AutoBoot is disabled when the Read Password feature is enabled, as part of the Advanced Sector Protection. It is recommended to disable AutoBoot (ATBN[0] - ATBTEN) when Read Password feature is enabled.

Note It is highly recommended to assign first AutoBoot address in the Long Retention region.

4.6.1 AutoBoot related registers and transactions

Table 27 AutoBoot related registers and transactions

Related registers	Related SPI transactions (see Table 73)	Related quad SPI transactions (see Table 77)
AutoBoot Register (ATBN) (see Table 66)	Read Any Register (RDARG_C_0)	Read Any Register (RDARG_C_0)
	Write Any Register (WRARG_C_1)	Write Any Register (WRARG_C_1)
	AutoBoot transaction (see Figure 15)	AutoBoot QPI transaction (see Figure 26)

4.7 Read

HL-T/HS-T supports different read transactions to access different memory maps, namely: Read Memory array, Read Device Identification, Read Register, Read Secure Silicon, Read Protection DYB and PPB bits.

These read transactions can use any protocol mentioned in the Transaction Protocols section and potentially can use the following features:

- The read transactions require latency cycles following the address to allow time to access the memory array (except RDAY1_4_0 and RDAY1_C_0 of 1S-1S-1S protocol) (see **Table 49**).
- The read transactions can use the Data Learning Pattern (DLP) driven by the memory, on all data outputs, in the latency cycles immediately before the start of data (see **"Data learning pattern (DLP)"** on page 57).
- The read transaction has the option of wrapped read length and alignment groups of 8-, 16-, 32-, or 64-bytes (see **Table 52** and **Table 53**).

4.7.1 Read Identification transactions

There are three unique identification transactions, each support Single and Quad SPI Protocols (see **Table 73**).

4.7.1.1 Read Device Identification transaction

The Read Device Identification (RDIDN_0_0) transaction provides read access to manufacturer identification and device identification. The transaction uses latency cycles set by (CFR3V[7:6]) to enable maximum clock frequency of 166MHz.

4.7.1.2 Read Quad Identification

The Read Quad Identification (RDQID_0) transaction provides read access to manufacturer identification, device identification information. This transaction is an alternate way of reading the same information provided by the RDIDN_0_0 transaction while in QPI mode. In all other respects the transaction behaves the same as the RDIDN_0_0 transaction.

The transaction is recognized only when the device is in Quad mode (CFR1V[1] = 1). The instruction is shifted in on DQ0-DQ3. After the last bit of the instruction is shifted into the device, then dummy cycles then, one byte of manufacturer identification and two bytes of device identification will be shifted sequentially out on DQ0–DQ3. Continued shifting of output beyond the end of the defined ID address space will provide undefined data. The maximum clock frequency for the transaction is 166 MHz.

4.7.1.3 Read SFDP transaction

The Read Serial Flash Discoverable Parameters (RSFDP_3_0) transaction provides access to the JEDEC Serial Flash Discovery Parameters (SFDP) (see **Table 73**). The transaction uses a 3-byte address scheme. If a non-zero address is set, the selected location in the SFDP space is the starting point of the data read. This enables random access to any parameter in the SFDP space. Continuous (sequential) read is supported with the RSFDP_3_0 transaction. Eight latency cycles are required. Read SFDP Transaction is not supported in Read Password mode before the password is provided. The maximum clock frequency for the Read SFDP transaction is 50MHz.

4.7.1.4 Read Unique Identification transaction

Read Unique Identification (RDUID_0_0) transaction is similar to Read Device Identification transaction, but accesses a different 64-bit number which is unique to each device. It is factory programmed.

4.7.1.5 Read Identification related register and transaction

Table 28 Read Identification related registers and transactions

Related registers	Related SPI transactions (see Table 73)	Related quad SPI transactions (see Table 77)
Configuration Register 3 (CFR3N, CFR3V) (see Table 50)	Read Identification (RDIDN_0_0)	Read Identification (RDIDN_0_0)
	Read Serial Flash Discoverable (RSFDP_3_0)	Read Serial Flash Discoverable (RSFDP_3_0)
	Read Unique Identification (RDUID_0_0)	Read Unique Identification (RDUID_0_0)
		Read Quad Manufacturer and Device Identification (RDQID_0_0)

4.7.2 Read Memory Array transactions

Memory array data can be read from the memory starting at any byte boundary. Data bytes are sequentially read from incrementally higher byte addresses until the host ends the data transfer by driving CS# input HIGH. If the byte address reaches the maximum address of the memory array, the read will continue at address zero of the array.

4.7.2.1 SPI Read and Read Fast transactions

The SPI Read SDR and Read Fast SDR transactions (1S-1S-1S) are supported for Host systems that require backward compatibility to legacy SPI. Read Fast SDR transaction is available with 3- or 4-byte address options. This protocol does not support the DLP for capture of data. The option of wrapped read length is available. The Read transaction is for maximum clock frequency of 50 MHz and requires no latency cycles. The Fast Read transaction uses latency cycles set by (CFR2V[3:0]) to enable maximum clock frequency of 166 MHz (see **Table 73**).

The Read Fast 4-Byte transaction has continuous read mode bits that follow the address so, a series of Read Fast 4-Byte transactions can eliminate the eight-bit command after the first Read Fast 4-Byte command sends a mode bit pattern of Axh that indicates the following transaction will also be a Read Fast 4-Byte command. The first Read Fast 4-Byte command in a series starts with the 8-bit command, followed by address, followed by eight cycles of mode bits, followed by an optional latency period. If the mode bit pattern is Axh the next transaction is assumed to be an additional Read Fast 4-Byte transaction that does not provide command bits. That transaction starts with address, followed by mode bits, followed by optional latency. Then the memory contents, at the address given, are shifted out on DQ1_SO.

4.7.2.2 Read SDR Dual I/O transaction

The Read SDR Dual I/O transaction provides high data throughput using Dual I/O SDR (1S-2S-2S) protocol. This protocol does not support DLP for capture of data. The option of wrapped read length is available. It supports 3- or 4-byte address options. It supports the mode bits and continuous read transactions. This transaction uses latency cycles set by (CFR2V[3:0]) to enable maximum 166MHz clock frequency (see **Table 73**).

4.7.2.3 Read SDR Quad Output transaction

The Read SDR Quad Output transaction uses the SDR Quad Output (1S-1S-4S) protocol. This protocol supports the DLP for capture of data. The option of wrapped read length is available. It supports 3- or 4-byte address options. This transaction uses latency cycles set by (CFR2V[3:0]) to enable maximum 166MHz clock frequency (see **Table 73**).

4.7.2.4 Read SDR and DDR Quad I/O transaction

The Read SDR Quad I/O transaction uses the SDR Quad I/O (1S-4S-4S) protocol and Read DDR Quad I/O transaction uses the DDR Quad I/O (1S-4D-4D) protocol. These protocols supports the DLP for capture of data. The option of wrapped read length is available. Both transactions also support the mode bits and continuous read transactions. In SDR Quad I/O transaction, the mode bit pattern is Axh and the next transaction is assumed to be an additional SDR Quad I/O transaction that does not provide command bits.

In DDR Quad I/O transaction, the mode bit pattern is A5h and the next transaction is assumed to be an additional DDR Quad I/O transaction that does not provide command bits. They support 3- or 4-byte address options. These transactions use latency cycles set by (CFR2V[3:0]) to enable maximum 166 MHz clock frequency (see **Table 73**).

4.7.2.5 Read QPI SDR and DDR transaction

The Read QPI SDR transaction uses the SDR QPI(4S-4S-4S) protocol and Read QPI DDR transaction uses the DDR QPI (4S-4D-4D) protocol. These protocols supports the DLP for capture of data. The option of wrapped read length is available. Both transactions also support the mode bits and continuous read transactions. In SDR QPI transaction, the mode bit pattern is Axh and the next transaction is assumed to be an additional SDR QPI transaction that does not provide command bits.

In DDR QPI transaction, the mode bit pattern is A5h and the next transaction is assumed to be an additional DDR QPI transaction that does not provide command bits. They support 3- or 4-byte address options. These transactions use latency cycles set by (CFR2V[3:0]) to enable maximum 166 MHz clock frequency (see **Table 73**).

4.7.2.6 Read memory array related registers and transactions

Table 29 Read memory array related registers and transactions

Related registers	Related SPI transactions (see Table 73)	Related dual I/O transactions (see Table 74)	Related quad SPI transactions (see Table 77)
Configuration Register 2 (CFR2N, CFR2V) (see Table 48)	Read SDR (RDAY1_4_0, RDAY1_C_0)	Read SDR Dual I/O (RDAY3_4_0, RDAY3_C_0)	Read SDR Quad Output (RDAY4_4_0, RDAY4_C_0)
Configuration Register 4 (CFR4N, CFR4V) (see Table 52)	Read Fast SDR (RDAY2_4_0, RDAY2_C_0)	Continuous Read SDR Dual I/O (RDAY6_4_0, RDAY6_C_0)	Read SDR Quad I/O (RDAY5_4_0, RDAY5_C_0)
Data Learning Pattern (DLPN, DLPV) (see Table 63)	–	–	Continuous Read SDR Quad I/O (RDAY6_4_0, RDAY6_C_0)
	–	–	Read DDR Quad I/O (RDAY7_4_0, RDAY7_C_0)
	–	–	Continuous Read DDR Quad I/O (RDAY8_4_0, RDAY8_C_0)
	–	–	Read QPI SDR (RDAY5_4_0, RDAY5_C_0)
	–	–	Continuous Read QPI SDR (RDAY6_4_0, RDAY6_C_0)
	–	–	Read QPI DDR (RDAY7_4_0, RDAY7_C_0)
	–	–	Continuous Read QPI DDR (RDAY8_4_0, RDAY8_C_0)

4.7.3 Read registers transactions

There are multiple registers for reporting embedded operation status or controlling device configuration options. Registers contain both volatile and nonvolatile bits. There are two ways to read the Registers. The Read Any Register transaction provides a way to read all device registers: nonvolatile and volatile by address selection. There are also dedicated Register Read transactions, which are defined per register and only read the contents of that register.

4.7.3.1 Read Any Register

The Read Any Register (RDARG_C_0) transaction is the best way to read all device registers, both nonvolatile and volatile. The transaction includes the address of the register to be read (see **Table 73**). This is followed by a number of latency cycles set by (CFR2V[3:0]) for reading nonvolatile registers and CFR3V[7:6] for reading volatile registers. See **Table 49** for NV Registers latency cycles and **Table 51** for Volatile Registers latency cycles. Then, the selected register contents are returned. If the read access is continued, the same addressed register contents are returned until the transaction is terminated; only one byte register location is read by each RDARG_C_0 transaction. For registers with more that one byte of data, the RDARG_C_0 transaction must again be used to read each byte of data.

The maximum clock frequency for the RDARG_C_0 transaction is 166 MHz.

The RDARG_C_0 transaction can be used during embedded operations to read Status Register 1 (STR1V). It is not used for reading registers such as ASP PPB Access Register (PPAV) and ASP Dynamic Block Access Register (DYAV). There are separate commands required to select and read the location in the array accessed. The RDARG_C_0 transaction will read invalid data from the PASS Register locations if the ASP Password protection mode is selected by programming ASPR[2:0]. Reading undefined locations provides undefined data.

4.7.3.2 Read Status Registers transaction

The Read Status Register (RDSR1_0_0, RDSR2_0_0) transactions allow the Status Registers' volatile contents to be read. The transaction uses latency cycles set by (CFR3V[7:6]) for reading volatile registers to enable maximum clock frequency of 166 MHz.

The volatile version of Status Registers contents can be read at any time, even while a program, erase, or write operation is in progress.

It is possible to read Status Register 1 continuously by providing multiples of eight clock cycles. The status is updated for each eight cycle read.

4.7.3.3 Read Configuration Register transaction

The Read Configuration Register (RDCR1_0_0) transaction allows the Configuration registers volatile contents be read. The transaction uses latency cycles set by (CFR3V[7:6]) for reading volatile registers to enable maximum clock frequency of 166 MHz.

The volatile version of Status Registers contents can be read at any time, even while a program, erase, or write operation is in progress.

It is possible to read Configuration Registers continuously by providing multiples of eight clock cycles. The status is updated for each eight cycle read.

4.7.3.4 Read Dynamic Protection Bit (DYB) access register transaction

The Read DYB Access Register (RDDYB_4_0,RDDYB_C_0) transaction reads the contents of the DYB Access Register. The transaction uses latency cycles set by (CFR3V[7:6]) for reading volatile registers to enable maximum clock frequency of 166 MHz. It is possible to read DYB Access register continuously, however the address of the DYB register does not increment, so the entire DYB array cannot be read in this fashion. Each location must be read with a separate Read DYB transaction.

4.7.3.5 Read Persistent Protection Bit (PPB) access register transaction

The Read PPB Access Register (RDPBB_4_0, RDPBB_C_0) transaction reads the contents of the PPB Access Register. The transaction uses latency cycles set by (CFR2V[3:0]) to enable maximum clock frequency of 166 MHz. It is possible to read PPB Access Register continuously, however the address of the PPB register does not increment, so the entire PPB array cannot be read in this fashion. Each location must be read with a separate Read PPB transaction.

4.7.3.6 Read PPB Lock Registers transaction

The Read PPB Lock Register (RDPLB_0_0) transactions allow the content of the nonvolatile registers to be read. The transaction uses latency cycles set by (CFR3V[7:6]) for reading volatile registers to enable maximum clock frequency of 166 MHz. It is possible to read PPB Lock Bit continuously.

4.7.3.7 Read ECC Data Unit status

The Read ECC Data Unit Status (RDECC_4_0, RDECC_C_0) transaction is used to determine the ECC status of the addressed unit data. In this transaction, the LSb of the address must be aligned to an ECC data unit. This transaction uses latency cycles set by (CFR3V[7:6]) for reading volatile registers to enable maximum clock frequency of 166 MHz.

The byte contents of the ECC Status for the selected ECC unit is then output. Any following data will be indeterminate. To read the next ECC unit status, another RDECC_4_0 or RDECC_C_0 transaction should be sent out to the next address, incremented by 16 [Data Unit size/8] bytes.

4.7.3.8 Read register related registers and transactions

Table 30 Read register related registers and transactions

Related registers	Related SPI transactions (see Table 73)	Related quad SPI transactions (see Table 77)
Configuration Register 2 (CFR2N, CFR2V) (see Table 48)	Read Any Register (RDARG_C_0)	Read Any Register (RDARG_C_0)
Configuration Register 3 (CFR3N, CFR3V) (see Table 50)	Read Status Register 1 (RDSR1_0_0)	Read Status Register 1 (RDSR1_0_0)
	Read Status Register 2 (RDSR2_0_0)	Read Status Register 2 (RDSR2_0_0)
	Read DYB (RDDYB_4_0, RDDYB_C_0)	Read DYB (RDDYB_4_0, RDDYB_C_0)
	Read PPB (RDPPB_4_0, RDPPB_C_0)	Read PPB (RDPPB_4_0, RDPPB_C_0)
	Read PPB Lock (RDPLB_0_0)	Read PPB Lock (RDPLB_0_0)
	Read ECC Status (RDECC_4_0, RDECC_C_0)	Read ECC Status (RDECC_4_0, RDECC_C_0)
	Read Configuration Register 1 (RDCR1_0_0)	Read Configuration Register 1 (RDCR1_0_0)

4.7.4 Data learning pattern (DLP)

The device supports data learning pattern (DLP) which allows the host controller to optimize the data capture window. The READ preamble training is only available in Quad Mode READs. The programmable training pattern is stored in a DLP Register. To enable training, a non-zero pattern must be stored in the DLP Register. The device outputs the pattern during the latency cycles. Bus Turnaround between the end of the address input by the host and the pattern output by the device is not a concern since the first three latency clock cycles are treated as dummy cycles. All IO signals transition the same data learning pattern bits.

The device outputs the learning pattern during latency cycles. The pattern driven on the IO signals depends on the number of latency cycles available for the READ transaction. If the latency is set to at least 9 clock cycles for SDR operation, the device will output the pattern on the IOs on the last 8 clock cycles before outputting the READ data. However, if the latency is set to less than 9 clock cycles, no data learning pattern is outputted. If the latency is set to at least 5 clock cycles for DDR operation, the device will output the pattern on the IOs on the last 4 clock cycles before outputting the READ data. However, if the latency is set to less than 4 clock cycles, no data learning pattern is outputted.

4.7.4.1 Data learning pattern related registers and transactions

Table 31 DLP related registers and transactions

Related registers	Related SPI transactions (see Table 73)	Related quad SPI transactions (see Table 77)
Data Learning Register (DLPN, DLPV) (see Table 48)	Program Data Learning Pattern (PRDLP_0_1)	Program Data Learning Pattern (PRDLP_0_1)
	Write Data Learning Pattern (WRDLP_0_1)	Write Data Learning Pattern (WRDLP_0_1)
	Read Data Learning Pattern Register (RDDLP_0_0)	Read Data Learning Pattern Register (RDDLP_0_0)

4.8 Write

There are write transactions for writing to the Registers. These write transactions can use the SPI and Quad SPI protocols as mentioned in the Transaction Protocols section:

4.8.1 Write Enable transaction

The Write Enable (WRENB_0_0) transaction sets the Write Program Enable Status (WRPGEN) bit of the Status Register 1 (STR1V[1]) to '1'. The WRPGEN bit must be set to '1' by issuing the Write Enable (WRENB_0_0) transaction to enable write, program, and erase transactions (see **Table 73**).

4.8.2 Write Enable for volatile registers

The volatile Status and Configuration registers, can be written by sending the WRENV_0_0 transaction followed by any write register transactions. This gives more flexibility to change the system configuration and memory protection schemes quickly without waiting for the typical nonvolatile bit write cycles or affecting the endurance of the status or configuration nonvolatile register bits. The WRENV_0_0 transaction is used only to direct the following write register transaction to change the volatile status and configuration register bit values.

4.8.3 Write Disable transaction

The Write Disable (WRDIS_0_0) transaction clears the Write Program Enable Status (WRPGEN) bit of the Status Register 1 (STR1V[1]) to '0'.

The WRPGEN bit can be cleared to 0 by issuing the Write Disable (WRDIS_0_0) transaction to disable commands that requires WRPGEN be set to '1' for execution. The WRDIS_0_0 transaction can be used by the user to protect memory areas against inadvertent write, program, or erase operations that can corrupt the contents of the memory. The WRDIS_0_0 transaction is ignored during an embedded operation while RDYBSY bit = 1 (STR1V[0]) (see **Table 73**).

4.8.4 Clear Program and Erase Failure Flags transaction

The Clear Program and Erase Failure Flags (CLPEF_0_0) transaction resets bit STR1V[5] (Erase Error Flag) and bit STR1V[6] (Program Error Flag) to '0'. This transaction will be accepted even when the device remains busy with RDYBSY set to '1', as the device does remain busy when either error bit is set. The WRPGEN bit will be unchanged after this transaction is executed (see **Table 73**).

4.8.5 Clear ECC Status Register transaction

The Clear ECC Status Register (CLECC_0_0) transaction resets bit ECSV[4] (2-bit ECC Detection), bit ECSV[3] (1-bit ECC Correction), INSV[1:0] ECC detection status bits, Address Trap Register EATV[31:0], and ECC Detection Counter ECTV[15:0]. It is not necessary to set the WRPGEN bit before this transaction is executed. The Clear ECC Status Register transaction will be accepted even when the device remains busy with WRPGEN set to '1', as the device does remain busy when either error bit is set. The WRPGEN bit will be unchanged after this command is executed (see **Table 73**).

4.8.6 Write Registers transactions

The Write Registers (WRREG_0_1) transaction allows new values to be written to both the Status and Configuration Registers. Before the Write Registers transaction can be accepted by the device, a Write Enable or Write Enable for Volatile Registers transaction must be received. After the Write Enable command has been decoded successfully, the device will set the WRPGEN in the Status Register to enable any write operations.

The Write Registers transaction is entered by shifting the instruction and the data bytes on DQ0_SI. The Status and Configuration Registers are one data byte in length.

The WRR operation first erases the register then programs the new value as a single operation. The Write Registers transaction will set the PRGERR or ERSERR bits if there is a failure in the WRREG_0_1 operation.

4.8.7 Write Any Register transaction

The Write Any Register (WRARG_C_1) transaction provides a way to write any device register, nonvolatile or volatile. The transaction includes the address of the register to be written, followed by one byte of data to write in the addressed register (see **Table 73**).

Before the WRARG_C_1 transaction can be accepted by the device, a Write Enable (WRENB_0_0) transaction must be issued and decoded, which sets the Write/Program Enable bit (WRPGEN) in the Status Register to enable any write operations. The RDYDSY bit in STR1V[0] can be checked to determine when the operation is completed. The PRGERR and ERSERR bits in STR1V[6:5] can be checked to determine if any error occurred during the operation.

Some registers have a mixture of bit types and individual rules controlling which bits can be modified. Some bits are read only, some are OTP, and some are designated Reserved (DNU).

Read only bits are never modified and the related bits in the WRARG_C_1 transaction data byte are ignored without setting a program or erase error indication (PRGERR or ERSERR in STR1V[6:5]). Hence, the value of these bits in the WRARG_C_1 data byte do not matter.

OTP bits can only be programmed to the level opposite of their default state. Writing of OTP bits back to their default state is ignored and no error is set.

Nonvolatile bits which are changed by the WRARG_C_1 data, require nonvolatile register write time (t_W) to be updated. The update process involves an erase and a program operation on the nonvolatile register bits. If either the erase or program portion of the update fails, the related error bit and RDYBSY bit in STR1V will be set to '1'.

Status Register 1 can be repeatedly read (polled) to monitor the RDYBSY bit (STR1V[0]) and the error bits (STR1V[6,5]) to determine when the register write is completed or failed. If there is a write failure, the CLPEF_0_0 transaction is used to clear the error status and enable the device to return to standby state.

The ASP PPB Lock Register (PPLV) register cannot be written by the WRARG_C_1 transaction. Only the Write PPB Lock Bit (WRPLB_0_0) transaction can write the PPLV Register.

The Data Integrity Check Register cannot be written by the WRARG_C_1 transaction. The Data Integrity Check Register is loaded by running the Data Integrity Check transaction (DICHK_4_1).

4.8.8 Write PPB Lock Bit

The Write PPB Lock Bit (WRPLB_0_0) transaction clears the PPB Lock Register PPLV[0] to zero. The PPBLCK bit is used to protect the PPB bits. When PPLV[0] = 0, the PPB Program/Erase transaction will be aborted. In Read Password Protection mode, PPBLCK bit is also used to control the high order bits of the address by forcing the address range to be limited to one sector where boot code is stored, until the read password is supplied (see **Table 73**).

Before the WRPLB_0_0 transaction can be accepted by the device, a Write Enable (WRENB_0_0) transaction must be issued and decoded by the device, which sets the Write/Program Enable (WRPGEN) in the Status Register 1 to enable any write operations.

While the operation is in progress, the Status Register can still be read to check the value of the RDYBSY bit. The WRPGEN bit is a '1' during the self-timed operation, and is a '0' when it is completed. When the Write PPB Lock transaction is completed, the RDYBSY bit is set to a '0' (see **Table 73**).

4.8.9 Enter 4 Byte Address Mode

The Enter 4 Byte Address Mode (EN4BA_0_0) transaction sets the volatile Address Length bit (CR2V[7]) to '1' to change most 3 byte address commands to require 4 bytes of address. The Read SFDP (RSFDP_3_0) transaction is not affected by the Address Length bit. RSFDP_3_0 is required by the JEDEC JESD216 standard to always have only 3 bytes of address.

A POR, hardware or software reset will set the address length per the non-volatile Address Length bit (CR2N[7]) definition.

4.8.10 Exit 4 Byte Address Mode

The Exit 4 Byte Address Mode (EX4BA_0_0) command sets the volatile Address Length bit (CR2V[7]) to '0' to change most 3 byte address commands to require 3 bytes of address. This command will not affect 4-byte only commands which will still continue to expect 4 bytes of address.

4.8.11 Write transactions related registers and transactions

Table 32 Write transactions related registers and transactions

Related registers	Related SPI transactions (see Table 73)	Related Quad SPI transactions (see Table 77)
Status Register 1 (STR1N, STR1V) (see Table 41)	Write Enable (WRENB_0_0)	Write Enable (WRENB_0_0)
	Write Registers (WRREG_0_1)	Write Registers (WRREG_0_1)
	Write Enable Volatile (WRENV_0_0)	Write Enable Volatile (WRENV_0_0)
	Write Disable (WRDIS_0_0)	Write Disable (WRDIS_0_0)
ECC Status Register (ECSV) (see Table 55)	Clear Program and Erase Failure Flags (CLPEF_0_0)	Clear Program and Erase Failure Flags (CLPEF_0_0)
	Clear ECC Status Register (CLECC_0_0)	Clear ECC Status Register (CLECC_0_0)
Address Trap Register (EATV) (see Table 56)	Write Any Register (WRARG_C_1)	Write Any Register (WRARG_C_1)
ECC Detection Counter (ECTV) (see Table 57)	Write PPB Lock Bit (WRPLB_0_0)	Write PPB Lock Bit (WRPLB_0_0)
Configuration Register 2 (CFR2V) (see Table 48)	Enter 4 Byte (EN4BA_0_0), Exit 4 Byte (EX4BA_0_0)	Enter 4 Byte (EN4BA_0_0), Exit 4 Byte (EX4BA_0_0)

4.9 Program

There are program transactions for programming data to the Memory Array, Secure Silicon Region and Persistent Protection Bits.

These program transactions can use SPI or Quad SPI protocols:

Before any program transaction can be accepted by the device, a Write Enable (WRENB_0_0) transaction must be issued and decoded by the device. Program transactions can only be executed by the device if the Write/Program Enable (WRPGEN) in the Status Register is set to '1' to enable program operations. When a program transaction is completed, the WRPGEN bit is reset to a '0'.

While the program transaction is in progress, the Status Register 1 may be read to check the value of the Device Ready/Busy (RDYBSY) bit. The RDYBSY bit is a '1' during the self-timed program transaction, and is a '0' when it is completed.

The PGMERR bit in STR1V[6] may be checked to determine if any error occurred during the program transaction.

A program transaction applied to a sector that has been Write Protected through any of the protection schemes, will not be executed and will set the PGMERR status fail bit.

The program transactions will be initiated when CS# is driven into the logic HIGH state.

4.9.1 Program granularity

The HS/L-T family supports multi-pass programming (bit walking) where programming a "0" over a "1" without performing the sector erase operation. Bit-walking is allowed for the non-AEC-Q100 industrial temperature range (–40°C to +85°C) of this device. It is required to perform only one programming operation (single-pass programming) on each ECC data unit between erase operations for the higher temperature range (–40°C to +105°C) and (–40°C to +125°C) devices and all AEC-Q100 devices.

Multi-pass programming without an erase operation will disable the device's ECC functionality for that data unit. Note that if 2-bit ECC is enabled, multi-pass Programming within the same sector will result in a Program Error.

4.9.2 Page programming

Page programming is done by loading a Page Buffer with data to be programmed and issuing a programming transaction to move data from the buffer to the memory array. This sets an upper limit on the amount of data that can be programmed with a single programming transaction. Page Programming allows up to a page size (either 256- or 512-bytes) to be programmed in one operation. The page size is determined by the Configuration Register 3 bit CFR3V[4]. The page is aligned on the page size address boundary. It is possible to program from one bit up to a page size in each Page Programming operation. It is recommended that a multiple of 16-byte length and aligned Program Blocks be written. This ensures that ECC is not disabled. For the very best Page Program throughput, programming should be done in full pages of 512 bytes aligned on 512-byte boundaries with each Page being programmed only once.

4.9.3 Program Page transaction

The Program Page (PRPGE_4_1, PRPGE_C_1) transaction programs data into the memory array. If data more than a page size (256B or 512B) is sent to the device, then the space between the starting address and the page aligned end boundary, the data loading sequence will wrap from the last byte in the page to the zero byte location of the same page and begin overwriting any data previously loaded in the page. If less than a page of data is sent to the device, then the sent data bytes will be programmed in sequence, starting at the provided address within the page, without having any effect on the other bytes of the same page. The programming process is managed by the device internal control logic. The PRGERR bit indicates if an error has occurred in the programming transaction that prevents successful completion of programming. This includes attempted programming of a protected area (see **Table 73**).

4.9.4 Program Secure Silicon Region transaction

The Program Secure Silicon (PRSSR_C_1) transaction programs data in the SSR, which is in a different address space from the main array data and is OTP. The SSR is 1024 bytes, so the address bits from A31 to A10 must be zero for this transaction (see **Table 73**). It is required to align start address to 32 bits while programming SSR space, which means the address bits A1 and A0 should be 0'b and host should deassert CS# to align with 32 bits.

The PRGERR bit in STR1V[6] may be checked to determine if any error occurred during the operation.

To program the OTP array in bit granularity, the rest of the bits within a data byte can be set to '1'.

Each SSR memory space can be programmed one or more times, provided that the region is not locked. Attempting to program zeros in a region that is locked will fail with the PRGERR bit in STR1V[6] set to '1'. Programming once, even in a protected area does not cause an error and does not set PRGERR bit. Subsequent programming can be performed only on the unprogrammed bits (that is, 1 data). Programming more than once within an ECC unit will disable ECC on that data unit.

4.9.5 Program Persistent Protect Bit (PPB)

The Program Persistent Protect Bit (PRPPB_4_0, PRPPB_C_0) transaction programs a bit in the PPB Register to protect the sector of the provided address from being programed or erased (see **Table 73**).

The PRGERR bit in STR1V[6] may be checked to determine if any error occurred during the operation. Program PPB bit transaction will abort when trying to program the PPB bits protected by ASPPPB (ASPO[3]), ASPPRM (ASPO[0]) and PPBLCK (PPLV[0]) bit.

4.9.6 Program related registers and transactions

Table 33 Program related registers and transactions

Related registers	Related SPI transactions (see Table 73)	Related quad SPI transactions (see Table 77)
Status Register 1 (STR1N, STR1V) (see **Table 41**)	Write Enable (WRENB_0_0)	Write Enable (WRENB_0_0)
	Program Page (PRPGE_4_1, PRPGE_C_1)	Program Page (PRPGE_4_1, PRPGE_C_1)
Advance Sector Protect Register (ASPO) (see **Table 58**)	Program Secure Silicon (PRSSR_C_1)	Program Secure Silicon (PRSSR_C_1)
ASP PPB Lock (PPLV) (see **Table 60**)	Program Persistent Protection Bit (PRPPB_4_0, PRPPB_C_0)	Program Persistent Protection Bit (PRPPB_4_0, PRPPB_C_0)
ECC Status Register (ECSV) (see **Table 55**)	Clear Program and Erase Failure Flags (CLPEF_0_0)	Clear Program and Erase Failure Flags (CLPEF_0_0)

4.10 Erase

There are erase transactions for erasing data bits to '1' (all bytes are FFh) for the Memory Array and Persistent Protection Bits.

Before any erase transaction can be accepted by the device, a Write Enable (WRENB_0_0) transaction must be issued and decoded by the device. Erase transactions can only be executed by the device if the Write/Program Enable bit (WRPGEN) in the Status Register is set to '1' to enable erase operations. When an erase transaction is completed, the WRPGEN bit is reset to a '0'.

While the erase transaction is in progress, the Status Register 1 may be read to check the value of the Device Ready/Busy (RDYBSY) bit. The RDYBSY bit is a '1' during the self-timed erase transaction, and is a '0' when it is completed.

The ERSERR bit in STR1V[5] can be checked to determine if any error occurred during the erase transaction.

An erase transaction applied to a sector that has been Write Protected through the Block Protection bits or ASP, will not be executed and will set the ERSERR status fail bit.

Erase transactions will be initiated when CS# is driven into the logic HIGH state.

When the device is shipped from the factory the default erase state is all bytes are FFh.

4.10.1 Erase 4KB Sector transaction

The Erase 4KB Sector (ER004_4_0, ER004_C_0) transaction sets all the bits of a 4KB sector to '1' (all bytes are FFh) (see **Table 73**).

This transaction is ignored when the device is configured for uniform sectors only (CFR3V[3] = 1). If the Erase 4KB sector transaction is issued to a non-4KB sector address, the device will abort the operation and will not set the ERSERR status fail bit.

4.10.2 Erase 256 KB Sector transaction

The Erase 256 KB Sector (ER256_4_0, ER256_C_0) transaction sets all bits in the addressed sector to '1' (all bytes are FFh) (see **Table 73**).

A device configuration option (CFR3V[3]) determines if the Hybrid Sector Architecture is in use. When CFR3V[3] = 0, 4 KB sectors overlay a portion of the highest or lowest address 128 KB or 64 KB of the device address space. If a sector erase transaction is applied to a 256 KB sector that is overlaid by 4 KB sectors, the overlaid 4 KB sectors are not affected by the erase. Only the visible (non-overlaid) portion of the 128 KB or 192 KB sector is erased. When CFR3V[3] = 1, there are no 4 KB sectors in the device address space and the Sector Erase transaction always operates on fully visible 256 KB sectors.

When BLKCHK is enabled an erase transaction first evaluates the erase status of the sector. If the sector is found to erased, the erase operation is aborted. The erase operation is only executed if programmed bits are found in the sector. Disabling BLKCHK executes an erase operation unconditionally.

4.10.3 Erase Chip transaction

The Erase Chip (ERCHP_0_0) transaction sets all bits to '1' (all bytes are FFh) inside the entire flash memory array (see **Table 73**).

An Erase Chip transaction can be executed only when the Block Protection (BP2, BP1, BP0) bits are set to 0's. If the BP bits are not zero, the transaction is not executed and ERSERR status fail bit is not set. The transaction will skip any sectors protected by the Advance Sector Protection DYB or PPB and the ERSERR status fail bit will not be set.

4.10.4 Erase Persistent Protection Bit (PPB) transaction

The Erase PPB transaction (ERPPB_0_0) sets all PPB bits to '1' (see **Table 73**). This transaction will abort if PPB bits are protected by ASPPPB (ASPO[3]), ASPPRM (ASPO[0]) and PPBLCK (PPLV[0]) bit.

4.10.5 Erase status and count

4.10.5.1 Evaluate Erase Status transaction

The Evaluate Erase Status (EVERS_C_0) transaction verifies that the last erase operation on the addressed sector was completed successfully. If the selected sector was successfully erased, then the erase status bit (STR2V[2]) is set to '1'. If the selected sector was not completely erased STR2V[2] is '0'. The Write/Program Enable transaction (to set the WRPGEN bit) is not required before this transaction. However, the RDYBSY bit is set by the device itself and cleared at the end of the operation, as visible in STR1V[0] when reading status (see **Table 73**).

The Evaluate Erase Status transaction can be used to detect when erase operations that have failed due to loss of power, reset, or failure during the erase operation. The transaction requires t_{EES} to complete and update the erase status in STR2V. The RDYBSY bit (STR1V[0]) can be read to determine when the Evaluate Erase Status transaction is completed. If a sector is found not erased with STR2V[2] = 0, the sector must be erased again to ensure reliable storage of data in the sector.

4.10.5.2 Sector Erase Count transaction

The Sector Erase Count (SEERC_C_0) transaction outputs the number of erase cycles for the addressed sector. The erase cycle count is stored in the Sector Erase Count (SECV[22:0]) Register, and can be read by using the Read Any Register transaction (RDARG_C_0). The RDYBSY bit is set by the device itself and cleared at the end of the operation, as visible in STR1V[0] when reading status (see **Table 73**).

The transaction requires t_{SEC} to complete and update the SECV[22:0] Register. The RDYBSY bit (STR1V[0]) may be read to determine when the Sector Erase Count Transaction finished. The SECV[23] bit is used to determine if the reported sector erase count is corrupted and was reset.

4.10.6 Erase related registers and transaction

Table 34 Erase related registers and transactions

Related registers	Related SPI transactions (see Table 73)	Related quad SPI transactions (see Table 77)
Status Register 1 (STR1N, STR1V) (see Table 41)	Write Enable (WRENB_0_0)	Write Enable (WRENB_0_0)
Status Register 2 (STR2V) (see Table 44)	Erase 4KB Sector (ER004_4_0, ER004_C_0)	Erase 4KB Sector (ER004_4_0, ER004_C_0)
	Erase 256KB Sector (ER256_4_0, ER256_C_0)	Erase 256KB Sector (ER256_4_0, ER256_C_0)
ASP PPB Lock (PPLV) (see Table 60)	Erase Chip (ERCHP_0_0)	Erase Chip (ERCHP_0_0)
ECC Status Register (ECSV) (see Table 55)	Evaluate Erase Status (EVERS_C_0)	Evaluate Erase Status (EVERS_C_0)
Sector Erase Count Register (SECV) (see Table 67)	Sector Erase Count (SEERC_C_0)	Sector Erase Count (SEERC_C_0)
	Erase Persistent Protection Bit (PPB) transaction (ERPPB_0_0)	Erase Persistent Protection Bit (PPB) transaction (ERPPB_0_0)

4.11 Suspend and resume embedded operation

HL-T/HS-T device can interrupt and suspend the running embedded operations such as Erase, Program, or Data Integrity Check. It can also resume the suspended operation once the host finishes the intermediate operation and sends the respective resume transaction to the device.

4.11.1 Erase, program, or data integrity check suspend

The Suspend transaction allows the system to interrupt a program, erase, or data integrity check operation and then read from any other non erase-suspended sector, non-program-suspended-page or the array. The Device Ready/Busy Status Flag (RDYBSY) in Status Register 1 (STR1V[0]) must be checked to know when the program, erase, or data integrity check operation has stopped.

4.11.1.1 Program suspend

- Program suspend is valid only during a programming operation.
- The Program Operation Suspend Status flag (PROGMS) in Status Register-2 (STR2V[0]) can be used to determine if a programming operation has been suspended or was completed at the time RDYBSY changes to ‘0’.
- A program operation can be suspended to allow a read operation.
- Reading at any address within a program-suspended page produces undetermined data.

4.11.1.2 Erase suspend

- Erase suspend is valid only during a sector erase operation.
- The erase operation Suspend status flag (ERASES) in Status Register-2 (STR2V[1]) can be used to determine if an erase operation has been suspended or was completed at the time RDYBSY changes to ‘0’.
- A Chip Erase operation cannot be suspended.
- An Erase operation can be suspended to allow a program operation or a read operation.
- During an erase suspend, the DYB array can be read to examine sector protection.
- A new erase operation is not allowed with an already suspended erase, program, or data integrity check operation. An erase transaction is ignored in this situation.
- Reading at any address within an erase-suspended sector produces undetermined data.

4.11.1.3 Data integrity check suspend

- Data integrity check suspend is valid only during a Data Integrity Check Calculation operation.
- The Memory Array Data Integrity Cyclic Redundancy Check Suspend Status Flag (DICRCS) in Status Register-2 (STR2V[4]) can be used to determine if a data integrity check operation has been suspended or was completed at the time RDYBSY changes to ‘0’.
- A data integrity check operation can be suspended to allow a read operation.

The Write Any Register or Erase Persistent Protection Bit transactions are not allowed during Erase, Program, or Data Integrity Check Suspend. It is therefore not possible to alter the Block Protection or PPB bits during Erase Suspend. If there are sectors that may need programming during Erase suspend, these sectors should be protected only by DYB bits that can be turned OFF during Erase Suspend.

The time required for the suspend operation to complete is t_{PEDS}.

After an erase-suspended program operation is complete, the device returns to the erase-suspend mode. The system can determine the status of the program operation by reading the RDYBSY bit in the Status Register 1, just as in the standard program operation.

Table 35 lists the transactions allowed during the suspend operation.

Table 35 Transactions allowed during suspend

Transaction name	Allowed during erase suspend	Allowed during program suspend	Allowed during data integrity check suspend
Write Disable (WRDIS_0_0)	Yes	No	No
Read Status Register 1 (RDSR1_0_0)		Yes	Yes
Write Enable (WRENB_0_0)		No	No
Write Enable Volatile (WRENV_0_0)			
Read Status Register 2 (RDSR2_0_0)		Yes	Yes
Read Configuration Register 1 (RDCR1_0_0)			
Program Page (PRPGE_4_1, PRPGE_C_1)		No	No
Read ECC Status (RDECC_4_0, RDECC_C_0)		Yes	Yes
Clear ECC Status Register (CLECC_0_0)			
Read PPB Lock Bit (RDPLB_0_0)			
Resume Program / Erase / Data Integrity Check (RSEPD_0_0)			
Resume Program / Erase (RSEPA_0_0)			
Program SSR (PRSSR_C_1)		No	No
Read SSR (RDSSR_C_0)		Yes	Yes
Read Unique ID (RDUID_0_0)		Yes	
Read SFDP (RSFDP_3_0)			
Read Quad Manufacturer and device Identification (RDQID_0_0)			
Read Any Register (RDARG_C_0)			
Software Reset Enable (SRSTE_0_0)			
Clear Program and Erase Failure Flags (CLPEF_0_0)			
Software Reset (SFRST_0_0)			
Legacy Software Reset (SFRSL_0_)			
Read Identification Register (RDIDIN_0_0) (manufacturer and device identification)			
Suspend Program / Erase / Data Integrity Check (SPEPD_0_0)		No	No
Suspend Program / Erase (SPEPA_0_0)			
Read DYB (RDDYB_4_0, RDDYB_C_0)		Yes	Yes
Read PPB (RDPPB_4_0, RDPPB_C_0)			
Read SDR (RDAY1_C_0, RDAY1_4_0)			
Read Fast SDR (RDAY2_C_0, RDAY2_4_0)			
Read SDR Dual I/O (RDAY3_C_0, RDAY3_4_0)			
Read SDR Quad Output (RDAY4_C_0, RDAY4_4_0)			
Read SDR Quad I/O (RDAY5_C_0, RDAY5_4_0)			
Read DDR Quad I/O (RDAY7_C_0, RDAY7_4_0)	Yes	Yes	Yes
Read Data Learning Pattern (RDDLP_0_0)			

4.11.2 Erase, Program, or Data Integrity Check Resume

An Erase, Program, or Data Integrity Check Resume transaction must be written to resume a suspended operation. After program or read operations are completed during a Program, Erase or Data Integrity Check suspend, the Resume transaction is sent to resume the suspended operation.

After an Erase, Program, or Data Integrity Check Resume transaction is issued, the RDYBSY bit in Status Register 1 will be set to a '1' and the programming operation will resume if one is suspended. If no program operation is suspended, the suspended erase operation will resume. If there is no suspended program, erase or data integrity check operation, the resume transaction is ignored.

Program, Erase, or Data Integrity Check operations may be interrupted as often as necessary. For example, a program suspend transaction could immediately follow a program resume transaction, but for a program or erase operation to progress to completion there must be some period of time between resume and the next suspend transaction greater than or equal to t_{PEDRS}.

Figure 55 shows the flow of suspend and resume operation.

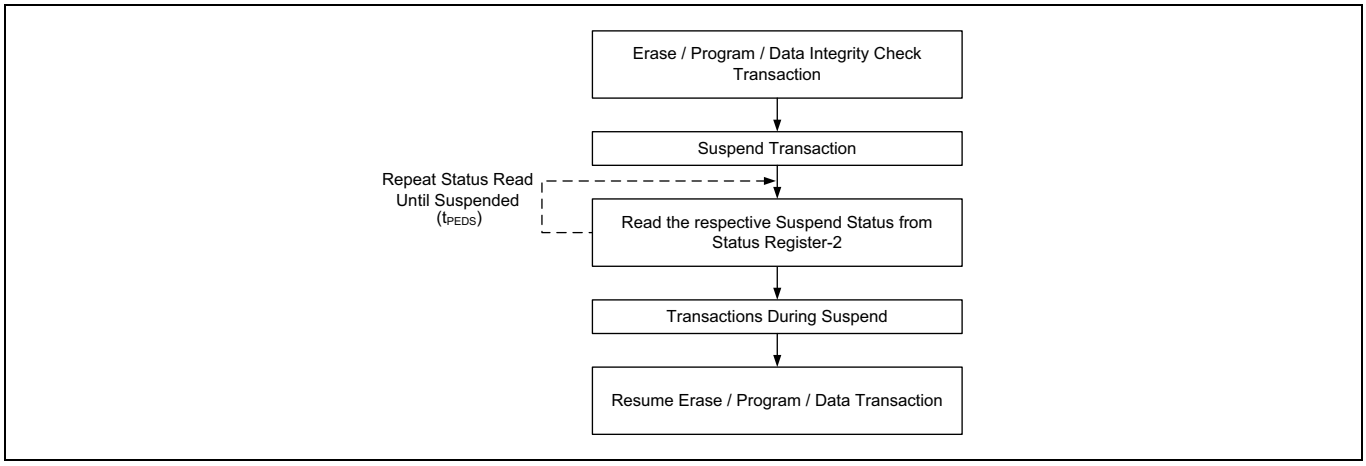


Figure 55 Suspend and resume sequence

4.11.3 Suspend and resume related registers and transactions

Table 36 Erase related registers and transactions

Related registers	Related SPI transactions (see Table 73)	Related quad SPI transactions (see Table 77)
Status Register 1 (STR1N, STR1V) (see Table 41)	Suspend Erase / Program / Data Integrity Check (SPEPD_0_0)	Suspend Erase / Program / Data Integrity Check (SPEPD_0_0)
Status Register 2 (STR2V) (see Table 44)	Resume Erase / Program / Data Integrity Check (RSEPD_0_0)	Resume Erase / Program / Data Integrity Check (RSEPD_0_0)
	Suspend Erase / Program (SPEPA_0_0)	Suspend Erase / Program (SPEPA_0_0)
	Resume Erase / Program (RSEPA_0_0)	Resume Erase / Program (RSEPA_0_0)
	Read Any Register (RDARG_C_0)	Read Any Register (RDARG_C_0)
	Read Status Register-1 (RDSR1_0_0)	Read Status Register-1 (RDSR1_4_0)
	Read Status Register-2 (RDSR2_0_0)	Read Status Register-2 (RDSR2_4_0)

4.12 Reset

HL-T/HS-T devices support four types of reset mechanisms.

- Hardware Reset (using RESET# input pin and DQ3_RESET# pin)
- Power-on reset (POR)
- JEDEC serial flash reset signaling protocol
- Software Reset

4.12.1 Hardware reset (using RESET# input pin and DQ3_RESET# pin)

The RESET# input initiates the reset operation with a transition from logic HIGH to logic LOW for > t_{RP}, and causes the device to perform the full reset process that is performed during POR. The hardware reset process requires a period of t_{RH} to complete. See **Table 84** for timing specifications.

The DQ3_RESET# input initiates the reset operation under the following when CS# is HIGH for more than t_{CS} time or when Quad or QPI mode is not enabled. The DQ3_RESET# input has an internal pull-up to V_{CC} and may be left unconnected if Quad or QPI mode is not used. The t_{CS} delay after CS# goes HIGH gives the memory or host system time to drive DQ3 HIGH after its use as a Quad or QPI mode I/O signal while CS# was LOW. The internal pull-up to V_{CC} will then hold DQ3_RESET# HIGH until the host system begins driving DQ3_RESET#. The DQ3_RESET# input is ignored while CS# remains HIGH during t_{CS}, to avoid an unintended Reset operation. If CS# is driven LOW to start a new transaction, DQ3_RESET# is used as DQ3.

When the device is not in Quad or QPI mode or, when CS# is HIGH, and DQ3_RESET# transitions from V_{IL} to V_{IH} for > t_{RP}, following t_{CS}, the device will reset register states in the same manner as POR. The hardware reset process requires a period of t_{RH} to complete. If the POR process did not complete correctly for any reason during power-up (t_{PU}), RESET# going LOW will initiate the full POR process instead of the hardware reset process and will require t_{PU} to complete the POR process.

Additional DQ3_RESET# notes

- If both RESET# and DQ3_RESET# input options are available use only one reset option in your system. DQ3_RESET# input reset operation can be disable by setting CFR2N[5] = 0 setting the DQ3_RESET to only operate as DQ3. The RESET# input can be disable by not connecting or tying the RESET# input to V_{IH}. RESET# and DQ3_RESET# must be HIGH for t_{RS} following t_{PU}, before going LOW again to initiate a hardware reset.
- When DQ3_RESET# is driven LOW for at least a minimum period of time (t_{RP}), following t_{CS}, the device terminates any operation in progress, makes all outputs high impedance, and ignores all read/write transactions for the duration of t_{RH}. The device resets the interface to standby state.
- If Quad or QPI mode and the DQ3_RESET# feature are enabled, the host system should not drive DQ3 LOW during t_{CS}, to avoid driver contention on DQ3. Immediately following transactions that transfer data to the host in Quad or QPI mode, for example: Quad I/O Read, the memory drives DQ3_RESET# HIGH during t_{CS}, to avoid an unintended Reset operation. Immediately following transactions that transfer data to the memory in Quad mode, for example: Page Program, the host system should drive DQ3_RESET# HIGH during t_{CS}, to avoid an unintended Reset operation.DQ3_RESET# LOW is ignored during t_{CS} if Quad mode is enabled.

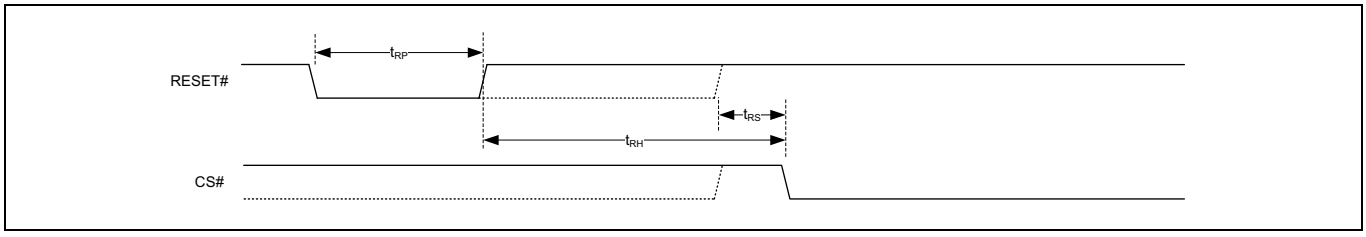


Figure 56 Hardware reset using RESET# input (reset pulse = t_{RP}(min))

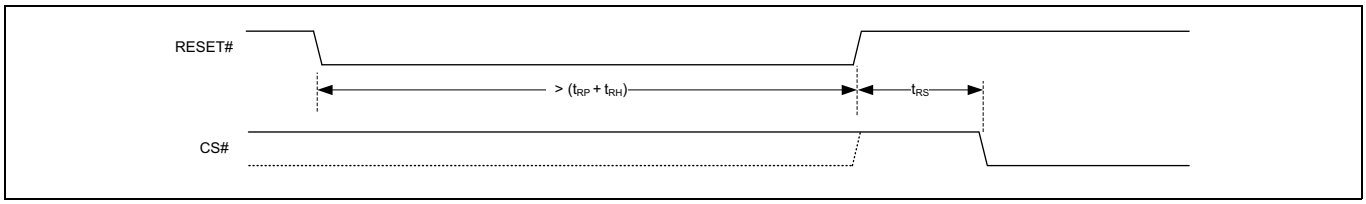


Figure 57 Hardware reset using RESET# input (reset pulse > (t_{RP} + t_{RH}))

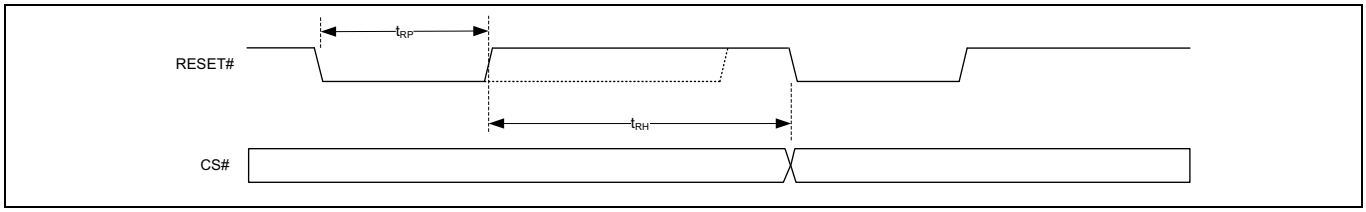


Figure 58 Hardware reset using RESET# input (back to back hardware reset)

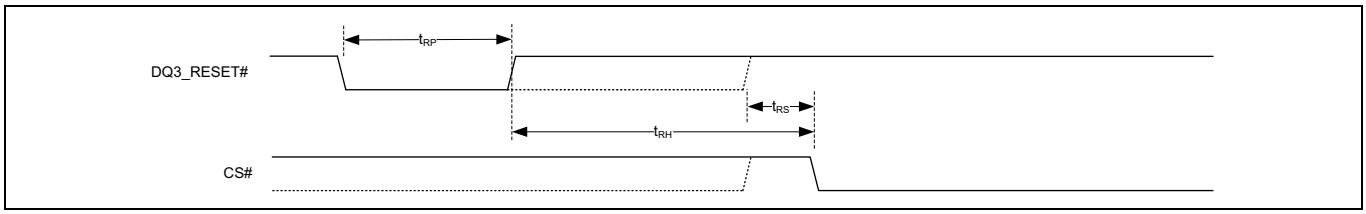


Figure 59 Hardware reset when quad or QPI mode is disabled and DQ3_RESET# is enabled

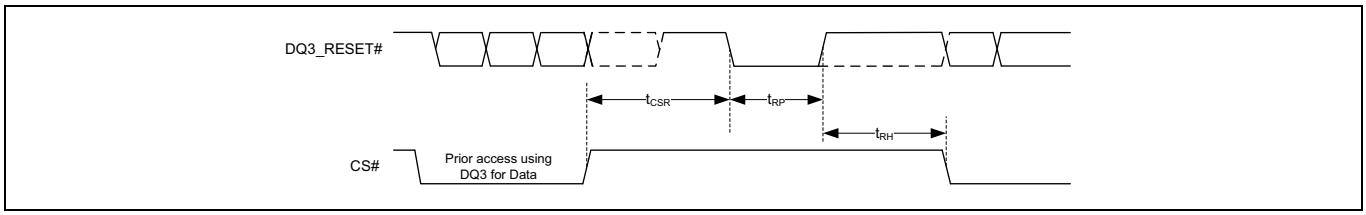


Figure 60 Hardware reset when quad or QPI mode and DQ3_RESET# are enabled

4.12.2 Power-on reset (POR)

The device executes a POR process until a time delay of t_{PU} has elapsed after the moment that V_{CC} rises above the minimum V_{CC} threshold (see **Figure 61** and **Figure 62**). The device must not be selected during power-up (t_{PU}). Therefore, CS# must rise with V_{CC}. No transactions may be sent to the device until the end of t_{PU}. See **Table 84** for timing specifications.

RESET# is ignored during POR. If RESET# is LOW during POR and remains LOW through and beyond the end of t_{PU}, CS# must remain HIGH until t_{RS} after RESET# returns HIGH.

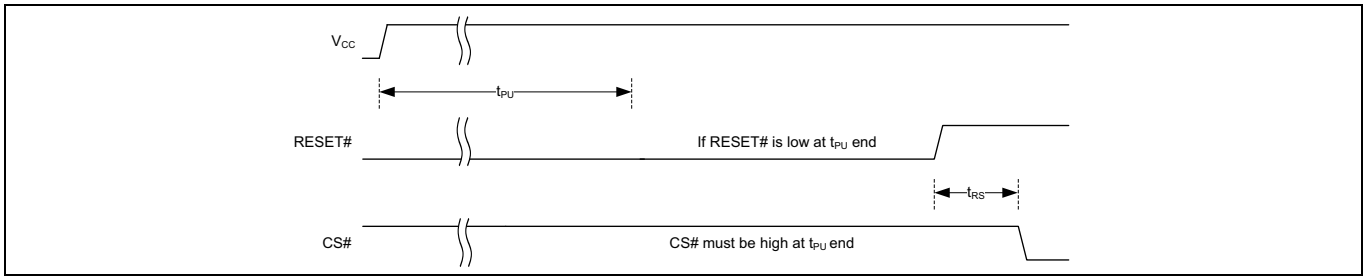


Figure 61 Reset LOW at the end of POR

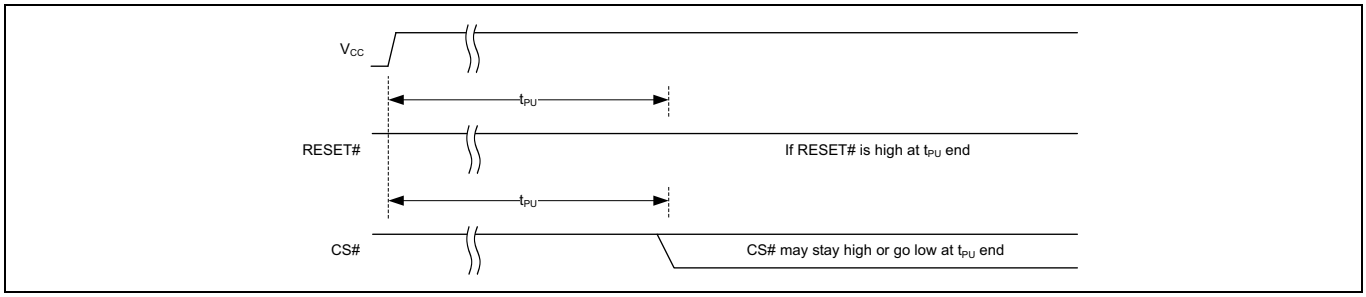


Figure 62 Reset HIGH at the end of POR

4.12.3 JEDEC serial flash reset signaling protocol

The JEDEC serial flash reset signaling protocol requires CS# and DQ0 signals. This reset method defines a signaling protocol, using existing signals, to initiate an SPI flash hardware reset, independent of the device operating mode or number of package pins.

The signaling protocol is shown in **Figure 63**. See **Table 84** for timing specifications. The JEDEC serial flash reset signaling protocol steps are as follows:

- CS# is driven active LOW.
- CK remains stable in either HIGH or LOW state.
- CS# and DQ0 are both driven LOW.
- CS# is driven HIGH (inactive).
- Repeat the above four steps, each time alternating the state of DQ0 for a total of four times.
- Reset occurs after the fourth CS# cycle completes and it goes HIGH (inactive).

After the fourth CS# pulse, the slave triggers its internal reset, the device terminates any operation in progress, makes all outputs high impedance, and ignores all read/write transactions for the duration of t_{RESET}. Then the device will be in standby state.

This reset sequence is not intended to be used at normal power on, but to be used only when the device is not responding to the system. This reset sequence will be operational from any state that the device may be in. Hence, JEDEC serial flash reset signaling protocol is useful for packages that don't support a RESET# pin to provide behavior identical to hardware reset.

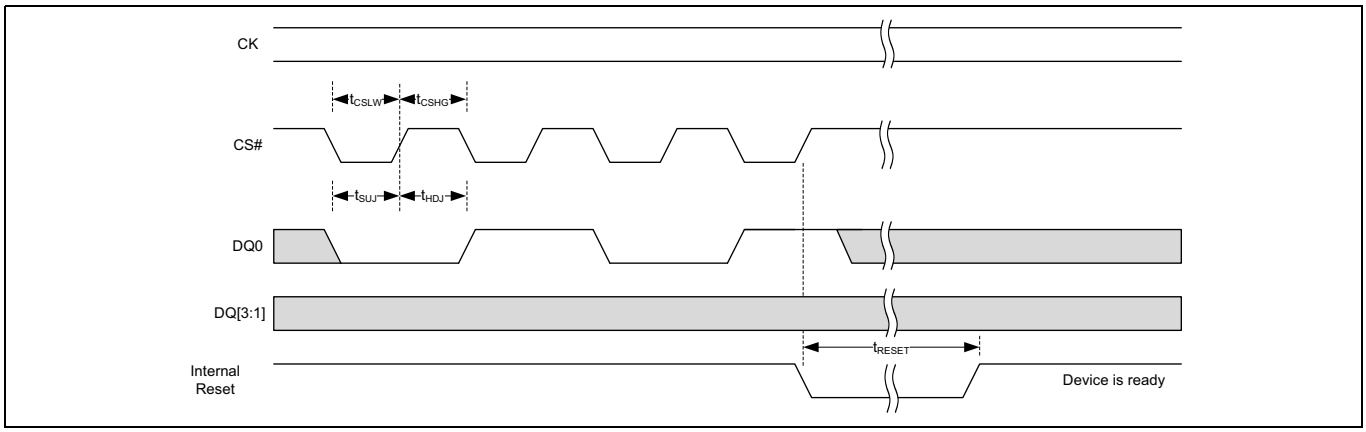


Figure 63 JEDEC serial flash reset signaling protocol

4.12.4 Software reset

Software controlled Reset transaction restores the device to its initial power up state, by reloading volatile registers from nonvolatile default values except the protection registers. It also terminates the embedded operations. A reset transaction (SFRST_0_0) is executed when CS# is brought HIGH at the end of the transaction and requires t_{SR} time to execute. See **Table 84** for timing specifications.

The Reset Enable (SRSTE_0_0) transaction is required immediately before a Reset transaction (SFRST_0_0) such that a software reset is a sequence of the two transactions. Any transaction other than SFRST_0_0 following the SRSTE_0_0 transaction will clear the reset enable condition and prevent a later SFRST_0_0 transaction from being recognized.

The Reset (SFRST_0_0) transaction immediately following a SRSTE_0_0 transaction, initiates the software reset process. During software reset, only RDSR1_0_0 and RDARG_C_0 of Status Register 1 are supported operations as long as the volatile and nonvolatile configuration states of the device are the same. If the configuration state is changing during software reset, reading Status Register 1 should only be done after the software reset time has elapsed.

The software reset is independent of the state of RESET#. If RESET# is HIGH or unconnected, and the software reset transactions are issued, the device will perform software reset.

The Legacy Software Reset (SFRSL_0_0) is a single transaction that initiates the software reset process. This command is disabled by default but can be enabled by programming CFR3V[0] = 1, for software compatibility with Infineon legacy devices.

4.12.4.1 Software reset related registers and transactions

Table 37 Erase related registers and transactions

Related registers	Related SPI transactions (see Table 73)	Related quad SPI transactions (see Table 77)
N/A	Software Reset Enable (SRSTE_0_0)	Software Reset Enable (SRSTE_0_0)
	Software Reset (SFRST_0_0)	Software Reset (SFRST_0_0)
	Legacy Software Reset (SFRSL_0_0)	Legacy Software Reset (SFRSL_0_0)

4.12.5 Reset behavior

Table 38 Reset behavior

Transaction / Register name	POR	Hardware reset and JEDEC serial flash reset signaling protocol	Software reset
Summary	• Device Reset • Status Bits Reset • All Volatile Registers Reset • Configuration Reload to Default • Volatile Protection Reset to Default • Nonvolatile Protection unchanged • Reset all Embedded operations	• Device Reset • Status Bits Reset • All Volatile Registers Reset • Configuration Reload to Default • Volatile Protection Reset to Default • Nonvolatile Protection unchanged • Reset all Embedded operations	• Device Reset • Status Bits Reset • Configuration Reload to Default • Volatile Protection Reset to Default • Nonvolatile Protection unchanged • Reset all Embedded operations
Interface Requirements	• All Inputs - Ignored • All Outputs - Tristated	• All Inputs - Ignored • All Outputs - Tristated	Transactions (SRSTE_0_0, SFRST_0_0)
Status Registers	Load from Nonvolatile Registers	Load from Nonvolatile Registers	Load from Nonvolatile Registers
Configuration Registers	Load from Nonvolatile Registers	Load from Nonvolatile Registers	Load from Nonvolatile Registers
Protection Registers	PPB Lock Register - Load based on ASPO[2:1]	PPB Lock Register - Load based on ASPO[2:1]	PPB Lock Register - No Change
	DYB Access Register - Load based on ASPO[4]	DYB Access Register - Load based on ASPO[4]	DYB Access Register - No Change
	Password Register - Load based on ASPO[2] and ASPO[0]	Password Register - Load based on ASPO[2] and ASPO[0]	Password Register - No Change
ECC Status Register	Load 0x00	Load 0x00	Load 0x00
Data Learning Pattern Register	Load from Nonvolatile Registers	Load from Nonvolatile Registers	No Change
AutoBoot Register	Load from Nonvolatile Registers	Load from Nonvolatile Registers	No Change
Data Integrity Check Register	Load 0x00	Load 0x00	Load 0x00
ECC Error Count Register	Load 0x00	Load 0x00	Load 0x00
Address Trap Register	Load 0x00	Load 0x00	Load 0x00
Infineon Endurance Flex architecture Register	Load from Nonvolatile Registers	Load from Nonvolatile Registers	No Change
I/O Mode	Load from Nonvolatile Registers	Load from Nonvolatile Registers	No Change
Memory/Register Erase in Progress	Not Applicable	Abort Erase	Abort Erase
Memory/Register Program in Progress	Not Applicable	Abort Program	Abort Program
Memory/Register Read in Progress	Not Applicable	Abort Read	Not Applicable

4.13 Power modes

4.13.1 Active power and standby power modes

The device is enabled and in the Active Power mode when Chip Select (CS#) is LOW. When CS# is HIGH, the device is disabled, but may still be in an Active Power mode until all program, erase, and write operations have completed. The device then goes into the Standby Power mode, and power consumption drops to I_{SB}. See **Table 82** for parameter specifications.

4.13.2 Deep power down (DPD) mode

Although the standby current during normal operation is relatively low, standby current can be further reduced with the DPD mode. The lower power consumption makes the DPD mode especially useful for battery powered applications.

4.13.2.1 Enter DPD

The device can enter DPD mode in two ways:

1. Enter DPD Mode using Transaction
2. Enter DPD Mode upon Power-up or Reset

Enter DPD Mode using the Enter Deep Power Down Mode transaction

The DPD mode is enabled by sending the Enter Deep Power Down Mode Transaction (ENDPD_0_0) then waiting for a delay of $t_{ENTDPD.}$ The CS# pin must be driven HIGH after the command byte has been latched. If this is not done, then the DPD transaction will not be executed. After CS# is driven HIGH, the power-down state will be entered within the time duration of t_{ENTDPD} (see **Table 84** for timing specifications) and power consumption drops to I_{DPD} (see **Table 82** for parameter specifications).

DPD can only be entered from an idle state. The DPD transaction is accepted only while the device is not performing an embedded algorithm as indicated by the Status Register 1 volatile, Device Ready/Busy Status Flag (RDYBSY) bit being cleared to zero (STR1V[0] = RDYBSY = 0). It is not allowed to send any transaction to device during t_{ENTDPD} time.

Enter DPD Mode upon Power-up or Reset

If the DPDPOR configuration bit is enabled (CFR4NV[2] = 1), the device will be in DPD mode after the completion of power-up, hardware reset or JEDEC serial flash reset signaling protocol. During POR or reset the CS# should follow the voltage applied on VCC to enter DPD mode as shown in **Figure 64**. It is not allowed to send any transaction to device during t_{ENTDPD} time.

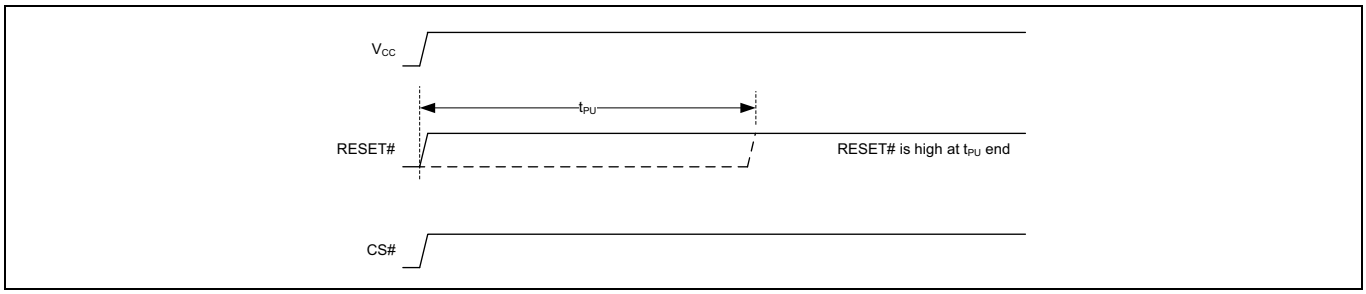


Figure 64 Enter DPD mode upon power-up or reset

4.13.2.2 Exit DPD

Device leaves DPD mode in one of the following ways:

Exit DPD Mode upon Hardware Reset

When the device is in DPD and CFR4NV[2] = 0, a Hardware reset will return the device to Standby mode.

Exit DPD Mode upon CS# Pulse

Device exits DPD upon receipt of CS# pulse of width t_{CSDPD}. The CS# should be driven HIGH after the pulse. HIGH to LOW transition on CS# is required to start a transaction cycle after the DPD exit. It takes t_{EXTDPD} to come out of DPD mode. The device will not respond until after t_{EXTDPD}.

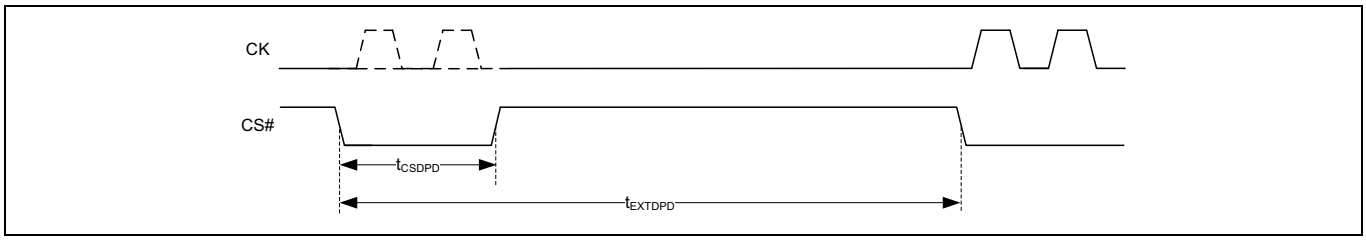


Figure 65 Exit DPD mode

The device maintains its configuration during DPD, meaning the device exits DPD in the same state as it entered. Registers such as the ECC Status, ECC Error Detection Counter, Address Trap, and Interrupt Status Registers will be cleared.

4.13.2.3 DPD related registers and transactions

Table 39 Erase related registers and transactions

Related registers	Related SPI transactions (see Table 73)	Related quad SPI transactions (see Table 77)
Configuration Register 4 (CFR4N, CFR4V) (see Table 52)	Enter Deep Power Down Mode (ENDPD_0_0)	Enter Deep Power Down Mode (ENDPD_0_0)

4.14 Power up and power down

The device must not be selected at power up or power down until V_{CC} reaches the correct value as follows:

- V_{CC} (min) at power up, and then for a further delay of t_{PU}
- V_{SS} at power down

4.14.1 Power up

The device ignores all transactions until a time delay of t_{PU} has elapsed after the moment that V_{CC} rises above the minimum V_{CC} threshold (see **Figure 66**). However, correct operation of the device is not guaranteed if V_{CC} returns below V_{CC} (min) during t_{PU}. No transaction should be sent to the device until the end of t_{PU}.

The device draws I_{POR} current during t_{PU}. After power up (t_{PU}), the WRPGEN bit is reset and there is the option to be in the DPD mode or Standby mode. The DPDPOR bit in Configuration Register 4 (CFR4N[2]) controls if the device will be in DPD or Standby mode after the completion of POR (see **Table 52**). If the DPDPOR bit is enabled (CFR4N[2] = 1) the device is in DPD mode after power up. A Hardware reset (RESET# and DQ3_RESET#) required to return the device to Standby mode after POR.

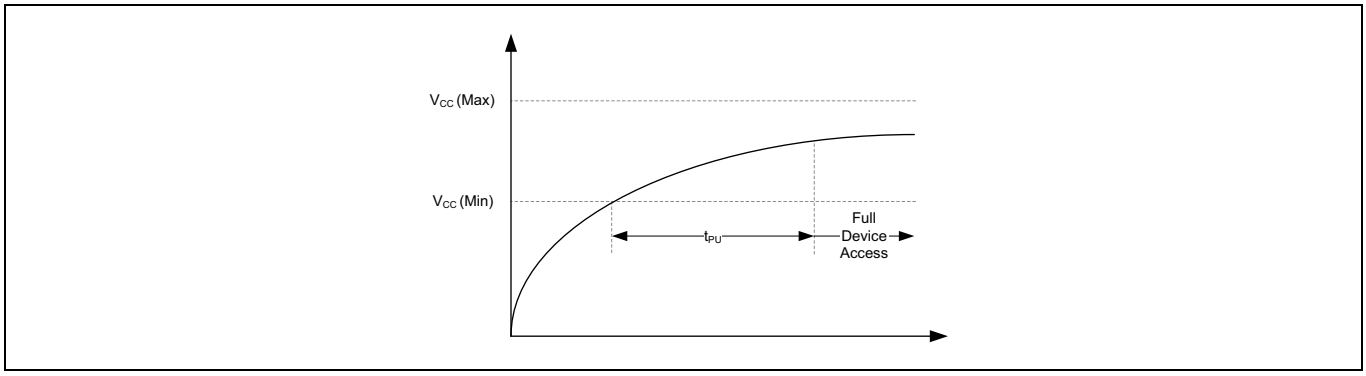


Figure 66 Power up

4.14.2 Power down

During power down or voltage drops below V_{CC}(cut-off), the voltage must drop below V_{CC}(LOW) for a period of t_{PD} for the part to initialize correctly on power up (see **Figure 67**). If during a voltage drop the V_{CC} stays above V_{CC}(cut-off) the part will stay initialized and will work correctly when V_{CC} is again above V_{CC}(min). In the event POR did not complete correctly after power up, the assertion of the RESET# signal will restart the POR process.

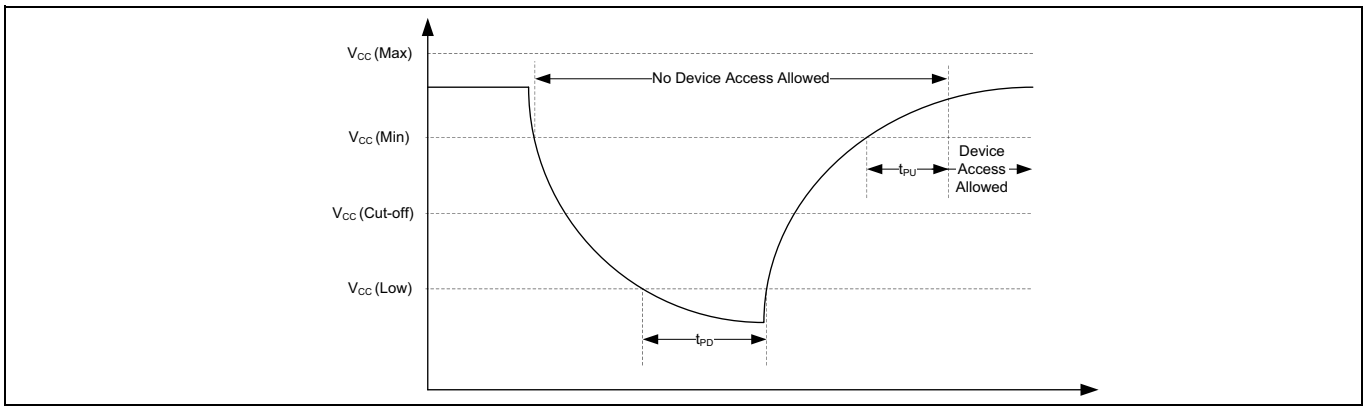


Figure 67 Power down and voltage drop

5 Registers

Registers are small groups of storage cells used to configure as well as report the status of the device operations. HL-T/HS-T family of devices use separate nonvolatile and volatile storage groups to implement the different register bit types for legacy compatibility as well as new functionality. Each register is organized as a group of volatile bits with associated nonvolatile bits (if permanence is required). During power-up, hardware reset or software reset, the data in the nonvolatile bits of the register is transferred to the volatile bits to provide the default state of the volatile bits. When writing new data to nonvolatile bits of the register, the volatile bits are also updated with the new data. However, when writing new data to the volatile register bits the nonvolatile bits retain the old data. The register structure is shown in **Figure 68**.

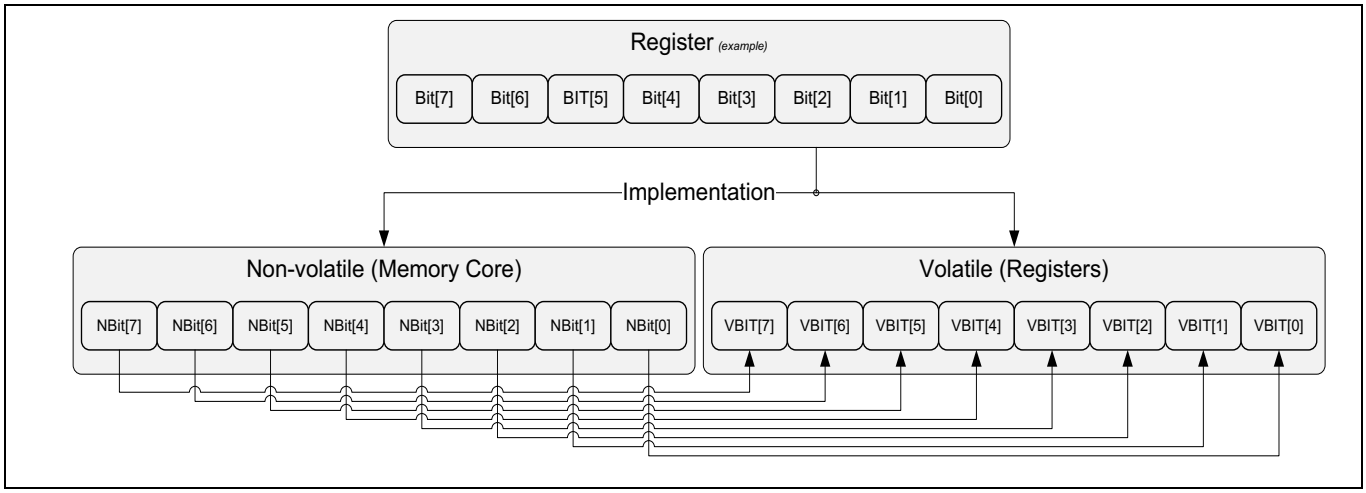


Figure 68 Register structure

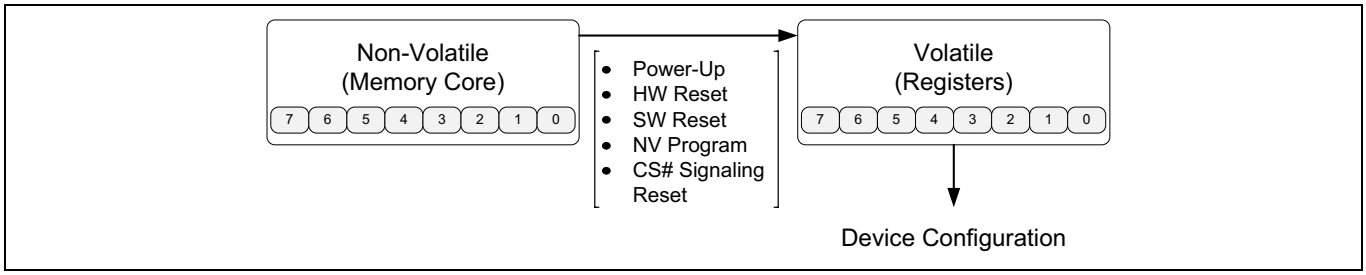


Figure 69 Data movement within register components

5.1 Register naming convention

Table 40 Register bit description convention

Bit number	Name	Function	Read/Write	Factory default (binary)	Description
REGNAME#T[x] T = N, V, O Descending Order	–	–	Possible options: N/A - Not Applicable R - Readable Only R/W - Readable and Writable R/1 - Readable and One Time Programmable	Possible options: 0 1	Format: Description of the Configuration bit 0 = Option '0' selection of the Bit 1 = Option '1' selection of the Bit Dependency: Is this Bit part of a function which requires multiple bits for implementation?

5.2 Status Register 1 (STR1x)

Status Register 1 contains both status and control bits. The functionality of supported Status Register 1 type is described in **Table 41**.

Table 41 Status Register 1[21]

Bit number	Name	Function	Read/Write N = Nonvolatile V = Volatile	Factory default (binary)	Description
STR1N[7] STR1V[7]	STCFWR	Status Register 1 and Configuration Register 1, 2, 3, 4 Protection Selection against write (erase/program)	N->R/W V->R/W	0	Description: The STCFWR bit selects enabling and disabling writes (erase/program) to Status Register 1 and configuration registers 1, 2, 3, 4 based on WP# (Write Protect Pin) in Single SPI mode. When STCFWR bit is enabled with WP# LOW, any transaction that can change status or configuration registers is ignored, effectively locking the state of the device. If WP#/DQ[2] is HIGH (irrespective of STCFWR), Status and Configuration Registers can be changed. Selection options: 1 = WP# based protection is enabled 0 = WP# based protection is disabled Dependency: N/A
STR1V[6]	PRGERR	Programming Error Status Flag	V -> R	0	Description: The PRGERR bit indicates program operation success or failure. When the PRGERR bit is set to a '1', it indicates that there was an error in the last programming operation. PRGERR bit is also set when a program operation is attempted within a protected memory region. When PRGERR is set, it can only be cleared with the Clear Program and Erase Failure Flags transaction or a hardware/software reset (see **Table 42**). **Note** The device will only go to standby mode once the PRGERR flag is cleared. Selection options: 0 = Last programming operation was successful 1 = Last programming operation was unsuccessful Dependency: N/A
STR1V[5]	ERSERR	Erasing Error Status Flag	V -> R	0	Description: The ERSERR bit indicates erase operation success or failure. When the ERSERR bit is set to a '1', it indicates that there was an error in the last erasing operation. ERSERR bit is also set when a erase operation is attempted within a protected memory sector. When ERSERR is set, it can only be cleared with the Clear Program and Erase Failure Flags transaction or a hardware/software reset (see **Table 43**). **Note** The device will only go to standby mode once the ERSERR flag is cleared. Selection options: 0 = Last erase operation was successful 1 = Last erase operation was unsuccessful Dependency: N/A
STR1N[4:2] STR1V[4:2]	LBPROT[2:0]	Legacy Block Protection based Memory Array size selection	If PLPROT = 0 N -> R/W V -> R/W If PLPROT = 1 N -> R V -> R	000	Description: The LBPROT[2:0] bits define the memory array size to be protected against program and erase transactions. Based on the LBPROT[2:0] configuration, either top 1/64, 1/4, 1/2, etc. or bottom 1/64, 1/4, 1/2, etc., or up to the entire array is protected. **Note** If PLPROT bit - Permanent Locking selection of Legacy Block Protection and 4KB Sector Architecture (CFR1x[4]) is set to a '1', the LBPROT[2:0] bits cannot be erased or programmed. Selection options: 000 = Protection is disabled 001 = 1/64th of the (top/bottom) array protection is enabled 010 = 1/32nd of the (top/bottom) array protection is enabled ….. 111 = All sectors are protected Dependency: TBPROT (CFR1x[5])

Note
21. STR1x value during POR, hardware reset, software reset, DPD exit, and JEDEC serial flash reset signaling protocol is not valid.

Table 41 Status Register 1[21] *(continued)*

Bit number	Name	Function	Read/Write N = Nonvolatile V = Volatile	Factory default (binary)	Description
STR1V[1]	WRPGEN	Write/Program Enable Status Flag	V -> R	0	Description: The WRPGEN bit must be set to '1' to enable all program, erase or register write operations - it provides protection against inadvertent changes to memory or register values. The Write Enable and Write Enable Volatile transactions set the WRPGEN bit to '1' to allow program, erase or write transactions to execute. The Write Disable (WRDIS_0_0) transaction resets WRPGEN to a '0' to prevent all program, erase, and write transactions from execution. The WRPGEN bit is cleared to '0' at the end of any successful program, erase or register write operation. After a power down / power up sequence or a hardware/software reset, the Deep Power Down WRPGEN bit is cleared to '0'. Selection options: 0 = Program, erase or register write is disabled 1 = Program, erase or register write is enabled Dependency: N/A
STR1V[0]	RDYBSY	Device Ready/Busy Status Flag	V -> R	0	Description: The RDYBSY bit indicates whether the device is performing an embedded operation or is in standby mode ready to receive new transactions. **Note** The PRGERR and ERSERR status bits are updated while RDYBSY is set. If PRGERR or ERSERR are set, the RDYBSY bit will remain set indicating the device is busy and unable to receive new transactions. A Clear Program and Erase Failure Flags transaction must be executed to return the device to standby mode. Selection options: 0 = Device is in standby mode ready to receive new operation transactions 1 = Device is busy and unable to receive new operation transactions Dependency: N/A

Note
21. STR1x value during POR, hardware reset, software reset, DPD exit, and JEDEC serial flash reset signaling protocol is not valid.

Table 42 PRGERR summary

Error flag	Symbol	Conditions
Program Error	PRGERR	Bits cannot be programmed '1' to '0'
		Trying to program in a protected region
		If ASP0[2] or ASP0[1] is 0, any nonvolatile register write attempting to change the value of CFR1N[6:2]/CFR1V[6:2]
		After the Password Protection Mode is selected and ASP Password Register update transaction executed
		SafeBoot Failure
		Configuration Failure

Table 43 ERSERR summary

Error flag	Symbol	Conditions
Erase Error	ERSERR	Sector Device Erase - All bits cannot be erased to '1's
		Trying to erase a protected region
		Register Erase - All bits cannot be erased to '1's during Erase portion of Register Write
		SafeBoot Failure

5.3 Status Register 2 (STR2x)

Status Register 2 provides device status on operations. The functionality of supported Status Register 2 type is described in **Table 44**.

Table 44 Status Register 2[22]

Bit number	Name	Function	Read/Write N = Nonvolatile V = Volatile	Factory default (binary)	Description
STR2V[7:5]	RESRVD	Reserved for future use	V -> R	0	This bit is Reserved for future use. This bit must always be written/loaded to its default state.
STR2V[4]	DICRCS	Memory Array Data Integrity Cyclic Redundancy Check Suspend Status Flag	V -> R	0	Description: The DICRCS bit is used to determine when the device is in Memory Array Data Integrity Cyclic Redundancy Check suspend mode. Selection options: 0 = Memory Array Data Integrity Cyclic Redundancy Check is not in suspend mode 1 = Memory Array Data Integrity Cyclic Redundancy Check is in suspend mode Dependency: N/A
STR2V[3]	DICRCA	Memory Array Data Integrity Cyclic Redundancy Check Abort Status Flag	V -> R	0	Description: The DICRCA bit indicates that the Memory Array Data Integrity Cyclic Redundancy Check calculation operation was aborted. The abort condition is based on ending address (ENDADD) and starting address (STRADD) relationship. If ENDADD < STRADD + 3, then DICRCA will be set and the device will return to the Standby state. DICRCA flag gets cleared at the next Data Integrity Cyclic Redundancy Check calculation operation when ENDADD ≥ STRADD + 3. Selection options: 0 = Memory Array Data Integrity Cyclic Redundancy Check calculation Is not aborted 1 = Memory Array Data Integrity Cyclic Redundancy Check calculation is aborted Dependency: N/A
STR2V[2]	SESTAT	Sector Erase Success/Failure Status Flag	V -> R	0	Description: The SESTAT bit indicates whether the erase operation on the sector completed successfully. Evaluate Erase Status transaction must be executed prior to reading SESTAT bit which specifies the sector address. Selection options: 1 = Addressed sector was erased successfully 0 = Addressed sector was not erased successfully Dependency: N/A
STR2V[1]	ERASES	Erase operation Suspend Status Flag	V -> R	0	Description: The ERASES bit is used to indicate if the Erase operation is suspended. Selection options: 0 = Erase operation is not in suspend mode 1 = Erase operation is in suspend mode Dependency: N/A
STR2V[0]	PROGMS	Program operation Suspend Status Flag	V -> R	0	Description: The PROGMS bit is used to indicate if the Program operation is suspended. Selection options: 0 = Program operation is not in suspend mode 1 = Program operation is in suspend mode Dependency: N/A

Note
22. STR2x value during POR, hardware reset, software reset, DPD exit, and JEDEC serial flash reset signaling protocol is not valid. STR2x bits are valid only when STR1V[0] / RDYBSY = 0.

5.4 Configuration Register 1 (CFR1x)

Configuration Register 1 controls interface and data protection functions.

Table 45 Configuration Register 1

Bit number	Name	Function	Read/Write N = Nonvolatile V = Volatile	Factory default (binary)	Description
CFR1N[7] CFR1V[7]	RESRVD	Reserved for future use	N -> R/W V -> R/W	0	This bit is Reserved for future use. This bit must always be written/loaded to its default state.
CFR1N[6] CFR1V[6]	SP4KBS	Split 4KB Sectors selection between top and bottom address space	If PLPROT = 0 N -> R/W V -> R If PLPROT = 1 N -> R V -> R	0	Description: The SP4KBS bit selects whether the 4KB sectors are grouped together or evenly split between High and LOW address ranges (see **Table 46**). Selection options: 0 = 4KB Sectors are grouped together 1 = 4KB Sectors are split between High and Low Addresses Dependency: TB4KBS(CFR1N[2])
CFR1N[5] CFR1V[5]	TBPROT	Top or Bottom Protection selection for Legacy Protection Mode	If PLPROT = 0 N -> R/W V -> R If PLPROT = 1 N -> R V -> R	0	Description: The TBPROT bit selects the reference point of the Legacy Block Protection bits (LBPROT[2:0]) in the Status Register on whether the protection starts from the top or starts from the bottom of the address range. The bit also selects a memory address range (lowest or highest) to remain readable is available for reading during Read Password Protection mode even before a successful Password entry is completed (see **Table 47**). Selection options: 0 = Legacy Protection is applicable in the top half of the address range 1 = Legacy Protection is applicable in the bottom half of the address range Dependency: LBPROT[2:0] (STR1x[3:1])
CFR1N[4] CFR1V[4]	PLPROT	Permanent Locking selection of Legacy Block Protection and 4KB Sector Architecture	N -> R/1 V -> R	0	Description: The PLPROT bit permanently protects the Legacy Block Protection and 4KB Sector location. It thereby permanently protects the memory array protection scheme and sector architecture (see **Table 47**). **Note** PLPROT protects LBPROT[2:0], SP4KBS, TBPROT, and TB4KBS bits from program and erase. It is recommended to configure these bits before configuring the PLPROT bit. Selection options: 0 = Legacy Block Protection and 4KB Sector Location are not protected 1 = Legacy Block Protection and 4KB Sector Location are protected Dependency: N/A
CFR1N[3] CFR1V[3]	RESRVD	Reserved for future use	N -> R/W V -> R/W	0	This bit is Reserved for future use. This bit must always be written/loaded to its default state.
CFR1N[2] CFR1V[2]	TB4KBS	Top or Bottom Address Range selection for 4KB Sector Block	If PLPROT = 0 N -> R/W V -> R If PLPROT = 1 N -> R V -> R	0	Description: The TB4KBS bit defines the logical address location of the 4KB sector block. The 4KB sector block replaces the fitting portion of the highest or lowest address sector (see **Table 46**). Selection options: 0 = 4KB Sector Block is in the bottom of the memory address space 1 = 4KB Sector Block is in the top of the memory address space Dependency: SP4KBS (CFR1x[6])

Table 45 Configuration Register 1 *(continued)*

Bit number	Name	Function	Read/Write N = Nonvolatile V = Volatile	Factory default (binary)	Description
CFR1N[1] CFR1V[1]	QUADIT	Quad SPI Interface Selection - I/O width set to 4 bits (1-1-4, 1-4-4)	N -> R/W V -> R/W	0	Description: The QUADIT bit selects the I/O width of the device. When configured to 4-bits (QUAD), WP# becomes DQ2 and DQ3_RESET# becomes DQ3. The QUADIT transactions require Opcode sent on a single I/O, Address either on a single or all four I/Os and Data always sent on all four I/Os. Selection options: 0 = Data Width set to 1 or 2 bits wide (1x - Single, 2x - Dual) 1 = Data Width set to 4 wide (4x - Quad) Dependency: N/A
CFR1N[0] CFR1V[0]	TLPROT	Temporary Locking selection of Legacy Block Protection and Sector Architecture	N -> R V -> R/W	0	Description: The TLPROT bit temporarily protects the Legacy Block Protection and 4KB Sector location. Upon power-up or a hardware reset, TLPROT is set to its default state. When selected, it protects the memory array protection scheme and sector architecture from any changes. **Note** TLPROT protects LBPROT[2:0], SP4KBS, TBPROT, and TB4KBS bits from program and erase. Selection options: 0 = Legacy Block Protection and 4KB Sector Location are not protected 1 = Legacy Block Protection and 4KB Sector Location are temporarily protected Dependency: N/A

Table 46 4KB parameter sector location selection

SP4KBS	TB4KBS	4KB location
0	0	4KB physical sectors at bottom (Low address)
0	1	4KB physical sectors at top, (High address)
1	X	4KB Parameter sectors are split between top (High Address) and bottom (Low Address)

Table 47 PLPROT and TLPROT protection

PLPROT	TLPROT	Array protection and 4K sector
0	0	Unprotected (Unlocked)
1	x	TBPROT, LBPROTx, SP4KBS, TB4KBS - Permanently Protected (Locked)
0	1	TBPROT, LBPROTx, SP4KBS, TB4KBS, Protected (Locked) till next Power-down

5.5 Configuration Register 2 (CFR2x)

Configuration Register 2 controls interface, memory read latency and address byte length selection.

Table 48 Configuration Register 2

Bit number	Name	Function	Read/Write N = Nonvolatile V = Volatile	Factory default (binary)	Description
CFR2N[7] CFR2V[7]	ADRBYT	Address Byte Length selection between 3 or 4 bytes for Instructions	N -> R/W V -> R/W	0	Description: The ADRBYT bit controls the expected address length for all instructions that require address and is selectable between 3 Bytes or 4 Bytes. Selection options: 0 = Instructions will use 3 Bytes for address 1 = Instructions will use 4 Bytes for address Dependency: N/A
CFR2N[6] CFR2V[6]	QPI-IT	QPI Interface & Protocol Selection - I/O width set to 4 bits (4-4-4)	N -> R/W V -> R/W	0	Description: The QPI-IT bit selects the I/O width of the device to be 4-bits wide. When configured to 4-bits (QPI-IT, QUADIT), WP# becomes DQ2 and DQ3_RESET# becomes DQ3. The QPI-IT transactions require Opcode, Address and Data always sent on all four I/Os. Selection options: 0 = Data Width set to 1 or 2 bits wide (1x - Single, 2x - Dual) - Legacy Protocol 1 = Data Width set to 4 wide (4x - Quad) - QPI Protocol Dependency: N/A
CFR2N[5] CFR2V[5]	DQ3RST	DQ3 and RESET Selection for DQ3 - Multiplexed operation on I/O #3	N -> R/W V -> R/W	0	Description: The DQ3RST bit controls the RESET# behavior on DQ3 signal. When enabled, a LOW on DQ3 will perform a hardware reset while CS# is HIGH. This multiplexed functionality on DQ3 is only available when QUADIT or QPI-IT interface modes are enabled. Disabling QUADIT or QPI-IT modes makes DQ3 a dedicated RESET# pin. Selection options: 0 = DQ3 has no multiplexed RESET# function 1 = DQ3 performs a hardware reset when LOW provided CS# is HIGH Dependency: N/A
CFR2N[4] CFR2V[4]	RESRVD	Reserved for future use	N -> R/W V -> R/W	0	These bits are Reserved for future use. This bit must always be written/loaded to its default state.
CFR2N[3:0] CFR2V[3:0]	MEMLAT[3:0]	Memory Array Read Latency selection - Dummy cycles required for initial data access	N -> R/W V -> R/W	1000	Description: The MEMLAT[3:0] bits control the read latency (dummy cycles) delay in all variable latency memory array and nonvolatile register read transactions. MEMLAT selection allows the user to adjust the read latency during normal operation based on different operating frequencies (see **Table 49**). Selection options: 0000 = 0 Latency Cycle Selection based on transaction opcodes ….. 1111 = 15 Latency Cycles Selection based on transaction opcodes Dependency: N/A

Table 49 Latency code (cycles) versus frequency[23, 24, 25, 27]

Latency code / cycles	Read transaction maximum frequency (MHz)					
	RDAY2_C_0 (1-1-1) **RDSSR_C_0 (1-1-1)** **RDECC_C_0 (1-1-1)** **RDECC_4_0 (1-1-1)** **RDARG_C_0 (1-1-1)**[26] **RDAY4_C_0 (1-1-4)** **RDAY4_4_0 (1-1-4)** **RDPPB_C_0 (1-1-1)** **RDPPB_4_0 (1-1-1)**	**RDAY2_4_0 (1-1-1)**	**RDAY3_C_0 (1-2-2)** **RDAY3_4_0 (1-2-2)**	**RDAY2_4_0 (4-4-4)** **RDAY5_4_0 (4-4-4)** **RDAY5_C_0 (4-4-4)** **RDAY5_C_0 (1-4-4)** **RDAY5_4_0 (1-4-4)** **RDPPB_C_0 (4-4-4)** **RDPPB_4_0 (4-4-4)**	**RDSSR_C_0 (4-4-4)**[28] **RDARG_C_0 (4-4-4)**[26] **RDECC_C_0 (4-4-4)** **RDECC_4_0 (4-4-4)**	**RDAY7_C_0 (1-4-4)** **RDAY7_4_0 (1-4-4)** **RDAY7_C_0 (4-4-4)** **RDAY7_4_0 (4-4-4)**
	Mode Cycle = 0	**Mode Cycle = 8**	**Mode Cycle = 4**	**Mode Cycle = 2**	**Mode Cycle = 0**	**Mode Cycle = 1**
0	50	156	81	43	18	N/A
1	68	166	93	56	31	N/A
2	81	166	106	68	43	43
3	93	166	118	81	56	56
4	106	166	131	93	68	68
5	118	166	143	106	81	81
6	131	166	156	118	93	93
7	143	166	166	131	106	102
8 (Default)	156	166	166	143	118	102
9	166	166	166	156	131	102
10	166	166	166	166	143	102
11	166	166	166	166	156	102
12	166	166	166	166	166	102
13	166	166	166	166	166	102
14	166	166	166	166	166	102
15	166	166	166	166	166	102

Notes
23. When using the ECC error reporting mechanisms, the read output data must be at least 2 bytes for correct ECC reporting.
24. CK frequency > 166 MHz SDR, or > 102 MHz DDR is not supported by this family of devices.
25. The Fast Read 4-byte address, QPI, Dual I/O, Quad I/O, QPI, DDR Quad I/O, and DDR QPI, protocols include Continuous Read Mode bits following the address. The clock cycles for these bits are not counted as part of the latency cycles shown in the table. For example, the legacy Quad I/O transaction has two Continuous Read mode cycles following the address. Therefore, the legacy Quad I/O transaction without additional read latency is supported only up to the frequency shown in the table for a read latency of 0 cycles. By increasing the variable read latency, the frequency of the Quad I/O transaction can be increased to allow operation up to the maximum supported 166MHz frequency.
26. Read Any Register transaction uses these latency cycles for reading nonvolatile registers.
27. Read SFDP transaction always have a dummy cycle of 8 and the maximum frequencies for different interfaces related to eight dummy cycles. Read Unique ID has 32 cycles of latency.
28. Secure Silicon Read (4-4-4) latency cycle > 0.

5.6 Configuration Register 3 (CFR3x)

Configuration register 3 controls transaction behavior.

Table 50 Configuration Register 3

Bit number	Name	Function	Read/Write N = Nonvolatile V = Volatile	Factory default (binary)	Description
CFR3N[7:6] CFR3V[7:6]	VRGLAT[1:0]	Volatile Register Read Latency selection - Dummy cycles required for initial data access	N -> R/W V -> R/W	00	Description: The VRGLAT[1:0] bits control the read latency (dummy cycles) delay in all variable latency register read transactions. VRGLAT[1:0] selection allows the user to adjust the read latency during normal operation based on different operating frequencies (see **Table 51**). Selection options: 00, 01, 10, 11 Latency Cycles Selection based on transaction opcodes Dependency: N/A
CFR3N[5] CFR3V[5]	BLKCHK	Blank Check selection during Erase operation for better endurance	N -> R/W V -> R/W	0	Description: When this feature is enabled an erase transaction first evaluates the erase status of the sector. If the sector is found to erased, the erase operation is aborted. In other words, the erase operation is only executed if programmed bits are found in the sector. Disabling BLKCHK executes an erase operation unconditionally. Selection options: 0 = Blank Check is disabled before executing an erase operation 1 = Blank Check evaluation is enabled before executing an erase operation Dependency: N/A
CFR3N[4] CFR3V[4]	PGMBUF	Program Buffer Size selection	N -> R/W V -> R/W	0	Description: The PGMBUF bit selects the Programming Buffer size which is used for page programming. Program buffer size affects the device programming time. **Note** If programming data exceeds the program buffer size, data gets wrapped. Selection options: 0 = 256 Byte Write Buffer Size 1 = 512 Byte Write Buffer Size Dependency: N/A
CFR3N[3] CFR3V[3]	UNHYSA	Uniform or Hybrid Sector Architecture selection	N -> R/W V -> R	0	Description: The UNHYSA bit selects between uniform (all 256 KB sectors) or hybrid (4 KB sectors and 256 KB sectors) sector architecture. If hybrid sector architecture is selected, 4 KB sector block is made part of the main flash array address map. The 4 KB sector block can overlay at either the highest or the lowest address range of the device. If uniform sector architecture is selected, 4 KB sector block is removed from the address map and all sectors are of uniform size. **Note** Hybrid sector architecture also enables 4 KB Sector Erase transaction (20h). Otherwise, 4 KB Sector Erase transaction, if issued, is ignored by the device. Selection options: 0 = Hybrid Sector Architecture (combination of 4 KB sectors and 256 KB sectors) 1 = Uniform Sector Architecture (all 256 KB sectors) Dependency: SP4KBS(CFR1N[6]), TB4KBS(CFR1N[2])
CFR3N[2] CFR3V[2]	CLSRSM	Clear Status or Resume transaction 30h selection	N -> R/W V -> R/W	0	Description: The CLSRSM bit selects how the 30h transaction is used in the device. CLRRSM controls whether 30h transaction is used as clear status transaction or as an alternate Program / Erase / Data Integrity Check resume transaction. Selection options: 0 = Clear Status Register transaction 1 = Program / Erase / Data Integrity Check Resume transaction Dependency: N/A
CFR3N[1] CFR3V[1]	RESRVD	Reserved for future use	N -> R/W V -> R/W	0	This bit is Reserved for future use. This bit must always be written/loaded to its default state.
CFR3N[0] CFR3V[0]	LSFRST	Legacy Software Reset transaction F0h selection	N -> R/W V -> R/W	0	Description: The LSFRST bit selects the software reset transaction. It allows the legacy F0h single transaction for software reset. Selection options: 0 = Legacy Software Reset is disabled 1 = Legacy Software Reset is enabled Dependency: N/A

Table 51 Register latency code (cycles) versus frequency[29, 31]

Latency code	Frequency	Fast read registers (No address) **RDSR1_0_0 (1-1-1)** **RDSR1_0_0 (4-4-4)** **RDSR2_0_0 (1-1-1)** **RDCR1_0_0 (1-1-1)** **RDDLP_0_0 (1-1-1)** **RDIDN_0_0 (1-1-1)** **RDIDN_0_0 (4-4-4)** **RDPLB_0_0 (1-1-1)** **RDQID_0_0 (1-4-4, 4-4-4)**	Regular read registers (No address) **RDSR2_0_0 (4-4-4)** **RDCR1_0_0 (4-4-4)** **RDDLP_0_0 (4-4-4)** **RDPLB_0_0 (4-4-4)**	Regular read registers (With address) **RDDYB_C_0 (1-1-1) (4-4-4)** **RDDYB_4_0 (1-1-1) (4-4-4)** **RDARG_C_0**[30] **(1-1-1) (4-4-4)**
00 (Default)	50MHz	0	0	0
01	133MHz	0	1	1
10	133MHz	1	1	1
11	166MHz	2	2	2

Notes
29. CK frequency > 166 MHz SDR, or 102 MHz DDR is not supported by this family of devices.
30. Read Any Register transaction uses these latency cycles for reading volatile registers.
31. Read SFDP transaction always have a dummy cycle of 8 and the maximum frequencies for different interfaces related to eight dummy cycles. Read Unique ID has 32 cycles of latency.

5.7 Configuration Register 4 (CFR4x)

Configuration Register 4 controls the main flash array read transactions burst wrap behavior and output driver impedance.

Table 52 Configuration Register 4

Bit number	Name	Function	Read/Write N = Nonvolatile V = Volatile	Factory default (binary)	Description
CFR4N[7:5] CFR4V[7:5]	IOIMPD[2:0]	I/O Driver Output Impedance selection	N -> R/W V -> R/W	000	Description: The IOIMPD[2:0] bits select the IO driver output impedance (drive strength). The output impedance configuration bits adjust the drive strength during normal device operation to meet system signal integrity requirements. Selection options: 000 = 45 Ω (Factory Default) 001 = 120 Ω 010 = 90 Ω 011 = 60 Ω 100 = 45 Ω 101 = 30 Ω 110 = 20 Ω 111 = 15 Ω Dependency: N/A
CFR4N[4] CFR4V[4]	RBSTWP	Read Burst Wrap Enable selection	N -> R/W V -> R/W	0	Description: The RBSTWP bit selects the read burst wrap feature. It allows the device to enter and exit burst wrapped read mode during normal operation. The wrap length is selected by RBSTWL[1:0] bits. Selection options: 0 = Read Wrapped Burst disabled 1 = Read Wrapped Burst enabled Dependency: RBSTWL[1:0] (CFR4x[1:0])
CFR4N[3] CFR4V[3]	ECC12S	Error Correction Code (ECC) 1-bit or 1-bit/2-bit error correction selection	N -> R/W V -> R/W	1	Description: The ECC12S bit selects between 1-bit ECC error detection/correction or both 1-bit ECC error detection and correction and 2-bit ECC error detection. This configuration option affects Address Trap Register and ECC Counter Register functionalities as well. The host needs to erase and reprogram the data in the SEMPER™ Flash memory upon ECC configuration change (1-bit correction to 1-bit correction and 2-bit detection or vice versa). Selection options: 0 = 1-bit ECC Error Detection/Correction 1 = 1-bit ECC Error Detection/Correction and 2-bit ECC error detection Dependency: N/A
CFR4N[2] CFR4V[2]	DPDPOR	Deep Power Down power saving mode entry selection upon POR	N -> R/W V -> R	0	Description: The DPDPOR bit selects if the device will be in either Deep Power Down (DPD) mode or the Standby mode after the completion of POR. If enabled, DPDPOR configures the device to start in DPD mode to reduce current consumption until the device is needed. If the device is in DPD, a pulse on CS# or a Hardware reset will return the device to Standby mode. Selection options: 0 = Standby mode is entered upon the completion of POR 1 = Deep Power Down Power mode is entered upon the completion of POR Dependency: N/A
CFR4N[1:0] CFR4V[1:0]	RBSTWL[1:0]	Read Burst Wrap Length selection	N -> R/W V -> R/W	00	Description: The RBSTWL[1:0] bits select the read burst wrap length and alignment during normal operation. It selects the fixed length/aligned group of 8-, 16-, 32-, or 64-bytes (see **Table 53**). Selection options: 00 = 8 Bytes Wrap length 01 = 16 Bytes Wrap length 10 = 32 Bytes Wrap length 11 = 64 Bytes Wrap length Dependency: RBSTWP (CFR4x[4])

Table 53 Output data wrap sequence

Wrap boundary (Bytes)	Start address (Hex)	Address sequence (Hex)
Sequential	XXXXXX03	03, 04, 05, 06, 07, 08, 09, 0A, 0B, 0C, 0D, 0E, 0F, 10, 11, 12, 13, 14, 15, 16, 17, 18.
8	XXXXXX00	00, 01, 02, 03, 04, 05, 06, 07, 00, 01, 02.
8	XXXXXX07	07, 00, 01, 02, 03, 04, 05, 06, 07, 00, 01.
16	XXXXXX02	02, 03, 04, 05, 06, 07, 08, 09, 0A, 0B, 0C, 0D, 0E, 0F, 00, 01, 02, 03.
16	XXXXXX0C	0C, 0D, 0E, 0F, 00, 01, 02, 03, 04, 05, 06, 07, 08, 09, 0A, 0B, 0C, 0D, 0E.
32	XXXXXX0A	0A, 0B, 0C, 0D, 0E, 0F, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 1A, 1B, 1C, 1D, 1E, 1F, 00, 01, 02, 03, 04, 05, 06, 07, 08, 09, 0A, 0B, 0C, 0D, 0E, 0F.
32	XXXXXX1E	1E, 1F, 00, 01, 02, 03, 04, 05, 06, 07, 08, 09, 0A, 0B, 0C, 0D, 0E, 0F, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 1A, 1B, 1C, 1D, 1E, 1F, 00.
64	XXXXXX03	03, 04, 05, 06, 07, 08, 09, 0A, 0B, 0C, 0D, 0E, 0F, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 1A, 1B, 1C, 1D, 1E, 1F, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 2A, 2B, 2C, 2D, 2E, 2F, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 3A, 3B, 3C, 3D, 3E, 3F 00, 01, 02.
64	XXXXXX2E	2E, 2F, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 3A, 3B, 3C, 3D, 3E, 3F, 00, 01, 02, 03, 04, 05, 06, 07, 08, 09, 0A, 0B, 0C, 0D, 0E, 0F, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 1A, 1B, 1C, 1D, 1E, 1F, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 2A, 2B, 2C, 2D.

5.8 Memory Array Data Integrity Check CRC Register (DCRV)

The Memory Array Data Integrity Check CRC Register (DCRV) stores the results of the CRC calculation on the data contained between the specified starting and ending addresses.

Table 54 Memory Array Data Integrity Check CRC Register

Bit number	Name	Function	Read/Write N = Nonvolatile V = Volatile	Factory default (hex)	Description
DCRV[31:0]	DTCRCV[31:0]	Memory Array Data CRC Checksum Value	V -> R	0x00000000	Description: The DTCRCV[31:0 bits store the checksum value of the CRC process on the memory array data contained within the starting address and the ending address. Selection options: Checksum Value Dependency: N/A

5.9 ECC Status Register (ECSV)

The ECC Status Register (ECSV) contains the ECC status of any error correction action performed on the unit data whose byte was addressed during last read.

Note Unit data is defined as the number of bytes over which the ECC is calculated. HL-T/HS-T family devices have a 16 bytes (128 bits) unit data.

Table 55 ECC Status Register

Bit number	Name	Function	Read/Write N = Nonvolatile V = Volatile	Factory default (binary)	Description
ECSV[7:5]	RESRVD	Reserved for future use	V -> R	000	This bit is Reserved for future use. This bit must always be written/loaded to its default state.
ECSV[4]	ECC2BT	ECC Error 2-bit Error Detection Flag	V -> R	0	Description: The ECC2BT bit indicates that a 2-bit ECC Error was detected in the data unit (16 bytes). A Clear ECC Status Register transaction (CLECC_0_0) will reset ECC2BT. **Note** ECC2BT is updated every time any memory address is read and is sticky, i.e. once it is set, it remains set. The ECC2BT status is maintained until a Clear ECC Status Register transaction (CLECC_0_0) is executed. **Note** ECC1BT is not valid if ECC2BT status flag is set. Selection options: 0 = No 2-bit ECC Error was detected in the data unit (16 bytes) 1 = 2-bit ECC Error was detected in the data unit (16 bytes) Dependency: CFR4x[3]
ECSV[3]	ECC1BT	ECC Error 1-bit Error Detection and Correction Flag	V -> R	0	Description: The ECC1BT bit indicates that a 1-bit ECC Error was detected and corrected in the data unit (16 bytes). A Clear ECC Status Register transaction (CLECC_0_0) will reset ECC1BT. **Note** ECC1BT is updated every time any memory address is read and is sticky, i.e. once it is set, it remains set. The ECC1BT status is maintained until a Clear ECC Status Register transaction (CLECC_0_0) is executed. Selection options: 0 = No 1-bit ECC Error was detected in the data unit (16 bytes) 1 = 1-bit ECC Error was detected in the data unit (16 bytes) Dependency: N/A
ECSV[2:0]	RESRVD	Reserved for future use	V -> R	000	This bit is Reserved for future use. This bit must always be written/loaded to its default state.

5.10 ECC Address Trap Register (EATV)

The ECC Address Trap Register (EATV) stores the address of the ECC unit data where either a 1-Bit/2-Bit error or only a 1-Bit error occurred during a read operation. It stores the ECC unit address of the first ECC error captured during a memory read operation since the last Clear ECC transaction.

Table 56 ECC Address Trap Register

Bit number	Name	Function	Read/Write N = Nonvolatile V = Volatile	Factory default (hex)	Description
EATV[31:0]	ECCATP[31:0]	ECC 1-bit and 2-bit Error Address Trap Register	V -> R	0x00000000	Description: The Address Trap Register (ECCATP[31:0]) stores the ECC unit data address where a 1-Bit/2-Bit error occurred during a read operation. ECCATP[31:0] stores the ECC unit address of the first ECC error captured during a memory read operation since the last Clear ECC Status Register transaction (CLECC_0_0). **Note** ECCATP[31:0] is only updated during Read Instruction. **Note** Mask non-valid upper ECCATP address bits from ECC unit address. **Note** Clear ECC Status Register transaction (CLECC_0_0), POR or Hardware/Software reset clears the EATV[31:0] to 0x00000000. Selection options: ECC Error Data Unit Address Dependency: N/A

5.11 ECC Error Detection Counter Register (ECTV)

The ECC Error Detection Counter Register (ECTV) stores the number of either 1-Bit/2-Bit or only 1-Bit ECC errors have occurred during read operations since the last POR or hardware/software reset.

Table 57 ECC Count Register

Bit number	Name	Function	Read/Write N = Nonvolatile V = Volatile	Factory default (hex)	Description
ECTV[15:0]	ECCCNT[15:0]	ECC 1-bit and 2-bit Error Count Register	V -> R	0x0000	Description: The ECCCNT[15:0] stores the number of 1-bit/2-bit ECC errors occurred during read operations since the last POR or hardware/software reset. **Note** ECCCNT[15:0] is only updated during Read Instruction. **Note** Only one ECC error is counted for each data unit. If multiple read transactions access the same unit data containing an ECC error, the ECCCNT[15:0] will increment each time the unit data is read. **Note** Once the count reaches 0xFFFF, the ECCCNT[15:0] will stop incrementing **Note** POR or Hardware/Software reset clears the ECCNT[15:0] to 0x0000. Selection options: ECC Error Count Dependency: N/A

5.12 Advanced Sector Protection Register (ASPO)

The ASP Register (ASPO) configures the behavior of Advanced Sector Protection scheme.

Table 58 Advanced Sector Protection Register

Bit number	Name	Function	Read/Write N = Nonvolatile V = Volatile	Factory default (binary)	Description
ASPO[15:6]	RESRVD	Reserved for future use	N -> R/1	1111111111	This bit is Reserved for future use. This bit must always be written/loaded to its default state.
ASPO[5]	ASPRDP	Read Password based Protection selection	N -> R/1	1	Description: The ASPRDP bit selects the Read Password Mode Protection mode. Read Password Protection mode works in conjunction with Password Protection mode to protect all sectors from Read/Erase/Program. Based on TBPROT configuration bit (CFR1x[5]), either the top or bottom sector is available for reading. Selection options: 0 = Read Password Protection Mode is enabled 1 = Read Password Protection Mode is disabled Dependency: TBPROT (CFR1x[5])
ASPO[4]	ASPDYB	Dynamic Protection (DYB) for all sectors at power-up selection	N -> R/1	1	Description: The ASPDYB bit selects whether all DYB bits (sectors) are in the protected state following power-up or hardware reset. DYB bits will individually need to be reset to change sector protections. Selection options: 0 = DYB based sector protection enabled at power-up or hardware reset 1 = DYB based sector protection disabled at power-up or hardware reset Dependency: N/A
ASPO[3]	ASPPPB	Permanent Protection (PPB) bits for all sectors programmability selection	N -> R/1	1	Description: The ASPPPB bit selects whether all PPB bits are OTP making PPB sector protection permanent. **Note** ASPPPB disables PPB erase transaction (ERPPB_0_0). Selection options: 0 = PPB bits are OTP 1 = PPB bits can be erased and programmed as desired Dependency: N/A

Table 58 Advanced Sector Protection Register *(continued)*

Bit number	Name	Function	Read/Write N = Nonvolatile V = Volatile	Factory default (binary)	Description
ASPO[2]	ASPPWD	Password Based Protection selection	N -> R/1	1	Description: The ASPPWD bit selects the Password Protection Mode. Password Protection mode protects all PPB bits till the correct password is entered. The ASPPWD can also be used in combination with the ASPRDP to protect all registers and all memory from erase/program and to protect sectors from being read as well till the correct password is provided - except for top or bottom sector which is available for reading based on TBPROT configuration bit (CFR1x[5]). **Note** When ASPPWD is selected, ASPO[15:0], CFR1N[7:2] and PWDO[63:0] are protected against Write operations. Selection options: 0 = Password Protection Mode is enabled 1 = Password Protection Mode is disabled Dependency: N/A
ASPO[1]	ASPPER	Persistent Protection selection (Register Protection selection)	N -> R/1	1	Description: The ASPPER bit selects the Persistent Protection Mode. The Persistent Protection mode (ASPPER) protects the ASPO[15:0], CFR1x[6, 5, 4, 2] and CFR3x[3] registers from erase or program. Selection options: 0 = Persistent Protection Mode is enabled 1 = Persistent Protection Mode is disabled Dependency: N/A
ASPO[0]	ASPPRM	Permanent Protection selection	N -> R/1	1	Description: The ASPPRM bit selects the Permanent Protection Mode. The Permanent Protection mode (ASPPRM) permanently protects the PPB bits from erase or program. ASPPRM bit should be programmed once all the PPB based sector protections are finalized. **Note** Permanent protection is independent of the PPBLOCK bit. Selection options: 0 = Permanent Protection Mode is enabled 1 = Permanent Protection Mode is disabled Dependency: N/A

5.13 ASP Password Register (PWDO)

The ASP Password Register (PWDO) is used to permanently define a password.

Table 59 Password Register

Bit number	Name	Function	Read/Write N = Nonvolatile V = Volatile	Factory default (hex)	Description
PWDO[63:0]	PASWRD[63:0]	Password Register	N -> R/1	0xFFFFFFFFFFFFFFFF	Description: The PASWRD[63:0] permanently stores a password used in password protected modes of operation. When the Password Protection Mode is enabled, this register will output the undefined data upon read password request. Selection options: Password Dependency: N/A

5.14 ASP PPB Lock Register (PPLV)

The PPBLCK bit in the ASP PPB Lock Register (PPLV) is used to protect the PPB bits.

Table 60 ASP PPB Lock Register

Bit number	Name	Function	Read/Write N = Nonvolatile V = Volatile	Factory default (binary)	Description
PPLV[7:1]	RESVRD	Reserved for future use	V -> R	0000000	This bit is Reserved for future use. This bit must always be written/loaded to its default state.
PPLV[0]	PPBLCK	PPB Temporary Protection selection	V -> R/W	1, ASPO[2:1]	Description: The PPBLCK bit is used to temporarily protect all the PPB bits. Selection options: 1 = PPB Bits can be erased or programmed 0 = PPB bits are protected against erase or program till the next POR or hardware reset Dependency: N/A

5.15 ASP PPB Access Register (PPAV)

The ASP PPB Access Register (PPAV) is used to provide the state of each sector's PPB protection bit.

Table 61 ASP PPB Access Register

Bit number	Name	Function	Read/Write N = Nonvolatile V = Volatile	Factory default (binary)	Description
PPAV[7:0]	PPBACS[7:0]	Sector Based PPB Protection status	N -> R/W	11111111	Description: The PPBACS[7:0] bits are used to provide the state of the individual sector's PPB bit. Selection options: FF = PPB for the sector addressed by the Read PPB transaction (RDPPB_4_0) is 1, not protecting that sector from program or erase operations 00 = PPB for the sector addressed by the Read PPB transaction (RDPPB_4_0) is 0, protecting that sector from program or erase operations Dependency: N/A

5.16 ASP Dynamic Block Access Register (DYAV)

The ASP DYB Access Register (DYAV) is used to provide the state of each sector's DYB protection bit.

Table 62 ASP DYB Access Register

Bit number	Name	Function	Read/Write N = Nonvolatile V = Volatile	Factory default (binary)	Description
DYAV[7:0]	DYBACS[7:0]	Sector Based DYB Protection status	V -> R/W	11111111	Description: The DYBACS[7:0] bits are used to provide the state of the individual sector's DYB bit. Selection options: FF = DYB for the sector addressed by the Read DYB transaction (RDDYB_4_0) is 1, not protecting that sector from program or erase operations 00 = DYB for the sector addressed by the Read DYB transaction (RDDYB_4_0) is 0, protecting that sector from program or erase operations Dependency: N/A

5.17 Data Learning Register (DLPx)

The Data Learning Pattern Register (DLPx) contains the 8-bit Data Learning pattern.

Table 63 Data Learning Register

Bit number	Name	Function	Read/Write N = Nonvolatile V = Volatile	Factory default (hex)	Description
DLPN[7:0] DLPV[7:0]	DTLRPT[7:0]	Data Learning Pattern selection	N -> R/W V -> R/W	0x00	Description: The DTLRPT[7:0] bits provide the data pattern which is output during Read Latency cycles. This pattern is transferred to the host during SDR/DDR read transaction latency cycles to provide a training pattern to help the host more accurately center the data capture point in the received data bits. Selection options: Pattern Dependency: N/A

Table 64 DLR feature summary

Interface type	SDR	DDR
1-1-1	N/A	N/A
1-2-2		
1-1-4	Yes	
1-4-4		Yes
4-4-4		
AutoBoot	N/A	N/A
Register Access		

Table 65 Data learning pattern behavior

Interface data type	Latency type 1	Latency type 2
SDR	Greater than or equal to 9; DLP on last 8 Clock Cycles	Less than 9; DLP is truncated
DDR	Greater than or equal to 5; DLP on last 4 Clock Cycles	Less than 5; DLP is truncated

5.18 AutoBoot Register (ATBN)

The AutoBoot Register (ATBN) provides a means to automatically read boot code as part of the power-on reset, or hardware reset process.

Table 66 AutoBoot Register

Bit number	Name	Function	Read/Write N = Nonvolatile V = Volatile	Factory default (binary)	Description
ATBN[31:9]	STADR[22:0]	Starting Address Selection where AutoBoot will start reading data from	N -> R/W	00000000000000000000000	Description: The STADR[22:0] bits set the starting address from which the device will output the read data. Selection options: Address Bits Dependency: N/A
ATBN[8:1]	STDLY[7:0]	AutoBoot Read Starting Delay Selection	N -> R/W	00000000	Description: The STDLY[7:0] bits specify the initial delay (clock cycles) needed by the host before it can accept data. **Note** STDLY[7:0] = 0x00 is valid up to 50 MHz. STDLY[7:0] > 0x00 or higher is valid up to 166 MHz. Selection options: Address Bits Dependency: N/A
ATBN[0]	ATBTEN	AutoBoot Feature Selection	N -> R/W	0	Description: The ATBTEN bit enables or disables the AutoBoot feature. Selection options: 0 = AutoBoot feature disabled 1 = AutoBoot feature enabled Dependency: N/A

5.19 Sector Erase Count Register (SECV)

The Sector Erase Count Register (SECV) contains the number of times the addressed sector has been erased.

Table 67 Sector Erase Count Register

Bit number	Name	Function	Read/Write N = Nonvolatile V = Volatile	Factory default (hex)	Description
SECV[23]	SECCPT	Sector Erase Count Corruption Status Flag	V -> R	0x0	Description: The SECCPT bit is used to determine if the reported sector erase count is corrupted and was reset. **Note** If SECCPT is set due to count corruption, it will reset to '0' on the next successful erase operation on the selected sector. Selection options: 0 = Sector Erase Count is not corrupted and is valid 1 = Sector Erase Count is corrupted and is not valid Dependency: N/A
SECV[22:0]	SECVAL[22:0]	Sector Erase Count Value	V -> R	0x000000	Description: The SECVAL[22:0] bits store the number of times a sector has been erased. Selection options: Value Dependency: N/A

5.20 Infineon Endurance Flex Architecture Selection Register (EFXx)

The Infineon Endurance Flex Architecture Selection Registers (EFXx) define the long retention / high endurance regions based on a four pointer based architecture.

Table 68 Infineon Endurance Flex Architecture Selection Register (Pointer 4)

Bit number	Name	Function	Read/Write N = Nonvolatile V = Volatile	Factory default (binary)	Description
EFX4O[10:2]	EPTAD4[8:0]	Infineon Endurance Flex architecture Pointer 4 Address Selection	N -> R/1	111111111	Description: The EPTAD4[8:0] bits define the 9-bit address of the beginning sector from where the long retention / high endurance region is defined. Selection options: Pointer Address Dependency: N/A
EFX4O[1]	ERGNT4	Infineon Endurance Flex architecture Pointer 4 based Region Type Selection	N -> R/1	1	Description: The ERGNT4 bit defines whether the region is long retention or high endurance. Selection options: 0 = Long Retention Sectors 1 = High Endurance Sectors Dependency: N/A
EFX4O[0]	EPTEB4	Infineon Endurance Flex architecture Pointer 4 Enable# Selection	N -> R/1	1	Description: The EPTEN4 bit define whether the wear leveling pointer is enabled/disabled. Selection options: 0 = Pointer Address Enabled 1 = Pointer Address Disabled Dependency: N/A

Table 69 Infineon Endurance Flex Architecture Selection Register (Pointer 3)

Bit number	Name	Function	Read/Write N = Nonvolatile V = Volatile	Factory default (binary)	Description
EFX3O[10:2]	EPTAD3[8:0]	Infineon Endurance Flex architecture Pointer 3 Address Selection	N -> R/1	111111111	Description: The EPTAD3[8:0] bits define the 9-bit address of the beginning sector from where the long retention / high endurance region is defined. Selection options: Pointer Address Dependency: N/A
EFX3O[1]	ERGNT3	Infineon Endurance Flex architecture Pointer 3 based Region Type Selection	N -> R/1	1	Description: The ERGNT3 bit defines whether the region is long retention or high endurance. Selection options: 0 = Long Retention Sectors 1 = High Endurance Sectors Dependency: N/A
EFX3O[0]	EPTEB3	Infineon Endurance Flex architecture Pointer 3 Enable# Selection	N -> R/1	1	Description: The EPTEN3 bit define whether the wear leveling pointer is enabled/disabled. Selection options: 0 = Pointer Address Enabled 1 = Pointer Address Disabled Dependency: N/A

Table 70 Infineon Endurance Flex Architecture Selection Register (Pointer 2)

Bit number	Name	Function	Read/Write N = Nonvolatile V = Volatile	Factory default (binary)	Description
EFX2O[10:2]	EPTAD2[8:0]	Infineon Endurance Flex architecture Pointer 2 Address Selection	N -> R/1	111111111	Description: The EPTAD2[8:0] bits define the 9-bit address of the beginning sector from where the long retention / high endurance region is defined. Selection options: Pointer Address Dependency: N/A
EFX2O[1]	ERGNT2	Infineon Endurance Flex architecture Pointer 2 based Region Type Selection	N -> R/1	1	Description: The ERGNT2 bit defines whether the region is long retention or high endurance. Selection options: 0 = Long Retention Sectors 1 = High Endurance Sectors Dependency: N/A
EFX2O[0]	EPTEB2	Infineon Endurance Flex architecture Pointer 2 Enable# Selection	N -> R/1	1	Description: EPTEN2 bit define whether the wear leveling pointer is enabled/disabled. Selection options: 0 = Pointer Address Enabled 1 = Pointer Address Disabled Dependency: N/A

Table 71 Infineon Endurance Flex Architecture Selection Register (Pointer 1)

Bit number	Name	Function	Read/Write N = Nonvolatile V = Volatile	Factory default (binary)	Description
EFX1O[10:2]	EPTAD1[8:0]	Infineon Endurance Flex architecture Pointer 1 Address Selection	N -> R/1	111111111	Description: The EPTAD1[8:0] bits define the 9-bit address of the beginning sector from where the long retention / high endurance region is defined. Selection options: Pointer Address Dependency: N/A
EFX1O[1]	ERGNT1	Infineon Endurance Flex architecture Pointer 1 based Region Type Selection	N -> R/1	1	Description: The ERGNT1 bit defines whether the region is long retention or high endurance. Selection options: 0 = Long Retention Sectors 1 = High Endurance Sectors Dependency: N/A
EFX1O[0]	EPTEB1	Infineon Endurance Flex architecture Pointer 1 Enable# Selection	N -> R/1	1	Description: The EPTEN1 bit define whether the wear leveling pointer is enabled/disabled. Selection options: 0 = Pointer Address Enabled 1 = Pointer Address Disabled Dependency: N/A

Table 72 Infineon Endurance Flex Architecture Selection Register (Pointer 0)

Bit number	Name	Function	Read/Write N = Nonvolatile V = Volatile	Factory default (binary)	Description
EFX0O[1]	GBLSEL	All Sectors based Region type Selection	N -> R/1	1	Description: The GBLSEL bit defines whether all sectors are defined as long retention region or high endurance region. **Note** If all other pointer registers are disabled, this bit defines the behavior of the entire memory space and is hardwired to start at Sector 0. Selection options: 0 = Long Retention Sectors 1 = High Endurance Sectors Dependency: N/A
EFX0O[0]	WRLVEN	Wear Leveling Enable Selection	N -> R/1	1	Description: The WRLVEN bit enables/disables the wear leveling feature. Selection options: 0 = Wear Leveling Disabled 1 = Wear Leveling Enabled Dependency: N/A

6 Transaction table

6.1 1-1-1 transaction table

Table 73 1-1-1 transaction table

Function	Transaction name	Description	Prerequisite transaction	Byte 1 (Hex)	Byte 2 (Hex)	Byte 3 (Hex)	Byte 4 (Hex)	Byte 5 (Hex)	Byte 6 (Hex)	Byte 7 (Hex)	Byte 8 (Hex)	Byte 9 (Hex)	Transaction format	Max freq. (MHz)	Address length
Read device ID	RDIDN_0_0	**Read manufacturer and device identification** transaction provides read access to manufacturer and device identification.	–	9F (CMD)	–	–	–	–	–	–	–	–	Figure 12	166	N/A
	RSFDP_3_0	**Read JEDEC Serial Flash Discoverable Parameters** transaction sequentially accesses the Serial Flash Discovery Parameters (SFDP).	–	5A (CMD)	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	–	–	–	–	–	Figure 13	50	3
	RDUID_0_0	**Read Unique ID** accesses a factory programmed 64-bit number which is unique to each device.	–	4C (CMD)	–	–	–	–	–	–	–	–	Figure 12	166	N/A
Register access	RDSR1_0_0	**Read Status Register 1** transaction allows the Status Register 1 contents to be read from DQ1/SO.	–	05 (CMD)	–	–	–	–	–	–	–	–			
	RDSR2_0_0	**Read Status Register-2** transaction allows the Status Register-2 contents to be read from DQ1/SO.	–	07 (CMD)	–	–	–	–	–	–	–	–			
	RDCR1_0_0	**Read Configuration Register-1** transaction allows the Configuration Register-1 contents to be read from DQ1/SO.	–	35 (CMD)	–	–	–	–	–	–	–	–			
	RDARG_C_0	**Read Any Register** transaction provides a way to read all addressed nonvolatile and volatile device registers.	–	65 (CMD)	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	–	–	–	–	–	Figure 13		3
			–		ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	–	–	–	–			4
	WRENB_0_0	**Write Enable** sets the Write Enable Latch bit of the Status Register 1 to 1 to enable write, program, and erase transactions.	–	06 (CMD)	–	–	–	–	–	–	–	–	Figure 7		N/A
	WRENV_0_0	**Write Enable Volatile** enable write of volatile Registers.	–	50 (CMD)	–	–	–	–	–	–	–	–			

Table 73 1-1-1 transaction table *(continued)*

Function	Transaction name	Description	Prerequisite transaction	Byte 1 (Hex)	Byte 2 (Hex)	Byte 3 (Hex)	Byte 4 (Hex)	Byte 5 (Hex)	Byte 6 (Hex)	Byte 7 (Hex)	Byte 8 (Hex)	Byte 9 (Hex)	Transaction format	Max freq. (MHz)	Address length
Register access	WRDIS_0_0	**Write Disable** sets the Write Enable Latch bit of the Status Register 1 to 0 to disable write, program, and erase transactions executaion.	–	04 (CMD)	–	–	–	–	–	–	–	–	Figure 11	166	N/A
	WRREG_0_1	**Write Register** transaction provides a way to write Status Register 1 and Configuration Registers 1 - 4	WRENB_0_0	01 (CMD)	Input STR1 data [7:0]	Input CFR1 data [7:0]	Input CFR2 data [7:0]	Input CFR3 data [7:0]	Input CFR4 data [7:0]	–	–	–			
	WRRSB_0_1	**SafeBoot Write Register** transaction to recover the device from configuration corruption.	WRENB_0_0	01 (CMD)	Input STR1 data [7:0]	Input CFR1 data [7:0]	Input CFR2 data [7:0]	Input CFR3 data [7:0]	Input CFR4 data [7:0]	Input 0x00	–	–			
	WRARG_C_1	**Write Any Register** transaction provides a way to write all addressed nonvolatile and volatile device registers.	WRENB_0_0	71 (CMD)	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	Input Data [7:0]	–	–	–	–	Figure 10		3
					ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	Input Data [7:0]	–	–	–			4
	CLPEF_0_0	**Clear Program and Erase Failure Flags** transaction resets STR1V[5] (Erase failure flag) and STR1V[6] (Program failure flag) **Note** This command may be disabled and the instruction value instead used for a program / erase resume command. See **"Configuration Register 3 (CFR3x)"** on page 85.	–	30 (CMD)	–	–	–	–	–	–	–	–	Figure 7		N/A
			–	82 (CMD)	–	–	–	–	–	–	–	–			
	EN4BA_0_0	**Enter 4 Byte Address Mode** transaction sets the Address Legth bit CFR2V[7] to 1	–	B7 (CMD)	–	–	–	–	–	–	–	–			
	EX4BA_0_0	**Exit 4 Byte Address Mode** transaction sets the Address Length bit CFR2V[7] to 0	–	B8 (CMD)	–	–	–	–	–	–	–	–			
	RDDLP_0_0	**Read Data Learning Pattern Register** transaction reads the DLP pattern.	–	41 (CMD)	–	–	–	–	–	–	–	–	Figure 12		
Register access	PRDLP_0_1	**Program Data Learning Pattern** transaction programs DLP pattern into the Nonvolatile registers	WRENB_0_0	43 (CMD)	Input DLP data [7:0]	–	–	–	–	–	–	–	Figure 11		
	WRDLP_0_1	**Write Data Learning Pattern** transaction writes DLP pattern into the Volatile register.	WRENB_0_0	4A (CMD)	Input DLP data [7:0]	–	–	–	–	–	–	–			

Table 73 1-1-1 transaction table *(continued)*

Function	Transaction name	Description	Prerequisite transaction	Byte 1 (Hex)	Byte 2 (Hex)	Byte 3 (Hex)	Byte 4 (Hex)	Byte 5 (Hex)	Byte 6 (Hex)	Byte 7 (Hex)	Byte 8 (Hex)	Byte 9 (Hex)	Transaction format	Max freq. (MHz)	Address length
Register access	WRAUB_0_1	**AutoBoot Register Write** transaction writes AutoBoot pattern into the register.	WRENB_0_0	15 (CMD)	Input Data 1 [7:0]	Input Data 2 [7:0]	(Continue)	–	–	–	–	–	Figure 11	166	N/A
ECC	RDECC_C_0	**Read ECC Status** is used to determine the ECC status of the addressed data unit.	–	19 (CMD)	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	–	–	–	–	–	Figure 13		3
			–		ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	–	–	–	–			4
	RDECC_4_0		–	18 (CMD)	ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	–	–	–	–			4
	CLECC_0_0	**Clear ECC Status Register** transaction resets ECC Status Register bit[4] (2-bit ECC Detection), ECC Status Register bit[3] (1-bit ECC Correction), Address Trap Register and ECC Detection Counter.	–	1B (CMD)	–	–	–	–	–	–	–	–	Figure 7		N/A
CRC	DICHK_4_1	**Data Integrity Check** transaction causes the device to perform a Data Integrity Check over a user defined address range.	–	5B (CMD)	Start ADDR [31:24]	Start ADDR [23:16]	Start ADDR [15:8]	Start ADDR [7:0]	End ADDR [31:24]	End ADDR [23:16]	End ADDR [15:8]	End ADDR [7:0]	Figure 9		4
Read flash array	RDAY1_C_0	**Read SDR** transaction reads out the memory contents starting at the given address.	–	03 (CMD)	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	–	–	–	–	–	Figure 14	50	3
			–		ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	–	–	–	–			4
	RDAY1_4_0		–	13 (CMD)	ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	–	–	–	–			4
	RDAY2_C_0	**Read Fast SDR** transaction reads out the memory contents starting at the given address.	–	0B (CMD)	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	–	–	–	–	–	Figure 13	166	3
			–		ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	–	–	–	–			4
	RDAY2_4_0		–	0C (CMD)	ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	Mode [7:0]	–	–	–			4
Program flash array	PRPGE_C_1	**Program Page** programs 256B or 512B data to the memory array in one transaction.	WRENB_0_0	02 (CMD)	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	Input Data 1 [7:0]	Input Data 2 [7:0]	(Continue)	–	–	Figure 10		3
					ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	Input Data 1 [7:0]	Input Data 2 [7:0]	(Continue)	–			4

Table 73 1-1-1 transaction table *(continued)*

Function	Transaction name	Description	Prerequisite transaction	Byte 1 (Hex)	Byte 2 (Hex)	Byte 3 (Hex)	Byte 4 (Hex)	Byte 5 (Hex)	Byte 6 (Hex)	Byte 7 (Hex)	Byte 8 (Hex)	Byte 9 (Hex)	Transaction format	Max freq. (MHz)	Address length
Program flash array	PRPGE_4_1	**Program Page** programs 256B or 512B data to the memory array in one transaction.	WRENB_0_0	12 (CMD)	ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	Input Data 1 [7:0]	Input Data 2 [7:0]	(Continue)	–	Figure 10	166	4
Erase flash array	ER004_C_0	**Erase 4KB Sector** transaction sets all the bits of a 4KB sector to 1 (all bytes are FFh).	WRENB_0_0	20 (CMD)	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	–	–	–	–	–	Figure 8		3
					ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	–	–	–	–			4
	ER004_4_0		WRENB_0_0	21 (CMD)	ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	–	–	–	–			
Erase flash array	ER256_C_0	**Erase 256KB Sector** transaction sets all the bits of a 256KB sector to 1 (all bytes are FFh).	WRENB_0_0	D8 (CMD)	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	–	–	–	–	–			3
					ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	–	–	–	–			4
	ER256_4_0		WRENB_0_0	DC (CMD)	ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	–	–	–	–			
Erase flash array	ERCHP_0_0	**Erase Chip** transaction sets all bits to 1 (all bytes are FFh) inside the entire flash memory array.	WRENB_0_0	60 or C7 (CMD)	–	–	–	–	–	–	–	–	Figure 7		N/A
	EVERS_C_0	**Evaluate Erase Status** transaction verifies that the last erase operation on the addressed sector was completed successfully.	–	D0 (CMD)	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	–	–	–	–	–	Figure 8		3
			–		ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	–	–	–	–			4
	SEERC_C_0	**Sector Erase Count** transaction outputs the number of erase cycles for the sector of the inputed address from the Sector Erase Count Register.	–	5D (CMD)	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	–	–	–	–	–			3
			–		ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	–	–	–	–			4
Suspend / resume	SPEPD_0_0	**Suspend Erase / Program / Data Integrity Check** transaction allows the system to interrupt a programming, erase or data integrity check operation	–	75 (CMD	–	–	–	–	–	–	–	–	Figure 7	166	N/A
	SPEPA_0_0	**Suspend Erase / Program** alternate transaction allows the system to interrupt a programming or erase.	–	85 (CMD)	–	–	–	–	–	–	–	–			
			–	B0 (CMD)	–	–	–	–	–	–	–	–			
	RSEPD_0_0	**Resume Erase / Program / Data Integrity Check** transaction allows the system to resume a programming, erase or data integrity check operation	–	7A (CMD)	–	–	–	–	–	–	–	–			

Table 73 1-1-1 transaction table *(continued)*

Function	Transaction name	Description	Prerequisite transaction	Byte 1 (Hex)	Byte 2 (Hex)	Byte 3 (Hex)	Byte 4 (Hex)	Byte 5 (Hex)	Byte 6 (Hex)	Byte 7 (Hex)	Byte 8 (Hex)	Byte 9 (Hex)	Transaction format	Max freq. (MHz)	Address length
Suspend / resume	RSEPA_0_0	**Resume Erase / Program** alternate transaction allows the system to resume a programming, erase or data integrity check operation	–	8A (CMD)	–	–	–	–	–	–	–	–	Figure 7	166	N/A
			–	30 (CMD)	–	–	–	–	–	–	–	–			
Secure silicon region array	PRSSR_C_1	**Program Secure Silicon Region** transaction programs data in 1024 bytes of Secure Silicon Region	WRENB_0_0	42 (CMD)	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	Input Data 1 [7:0]	Input Data 2 [7:0]	(Continue)	–	–	Figure 10		3
					ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	Input Data 1 [7:0]	Input Data 2 [7:0]	(Continue)	–			4
	RDSSR_C_0	**Read Secure Silicon Region** transaction reads data from the SSR.	–	4B (CMD)	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	–	–	–	–	–	Figure 13		3
			–		ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	–	–	–	–			4
Advanced sector protection	PRASP_0_1	ASP Register Write	WRENB_0_0	2F (CMD)	ASP Low Byte [7:0]	ASP High Byte [7:0]	–	–	–	–	–	–	Figure 11		N/A
	RDDYB_C_0	**Read Dynamic Protection Bit** transaction reads the contents of the DYB Access register.	–	FA (CMD)	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	–	–	–	–	–	Figure 13		3
			–		ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	–	–	–	–			4
	RDDYB_4_0		–	E0 (CMD)	ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	–	–	–	–			
	WRDYB_C_1	**Write Dynamic Protection Bit** transaction writes to the DYB Access register	WRENB_0_0	FB (CMD)	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	Input Data [7:0]	–	–	–	–	Figure 10		3
					ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	Input Data [7:0]	–	–	–			4
	WRDYB_4_1		WRENB_0_0	E1 (CMD)	ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	Input Data [7:0]	–	–	–			
Advanced sector protection	RDPPB_C_0	**Read Persistent Protection Bit** transaction reads the contents of the PPB Access register	–	FC (CMD)	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	–	–	–	–	–	Figure 13	166	3
			–		ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	–	–	–	–			4
	RDPPB_4_0		–	E2 (CMD)	ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	–	–	–	–			

Table 73 1-1-1 transaction table *(continued)*

Function	Transaction name	Description	Prerequisite transaction	Byte 1 (Hex)	Byte 2 (Hex)	Byte 3 (Hex)	Byte 4 (Hex)	Byte 5 (Hex)	Byte 6 (Hex)	Byte 7 (Hex)	Byte 8 (Hex)	Byte 9 (Hex)	Transaction format	Max freq. (MHz)	Address length
Advanced sector protection	PRPPB_C_0	**Program Persistent Protection Bit** transaction programs / writes the PPB register to enable the sector protection.	WRENB_0_0	FD (CMD)	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	–	–	–	–	–	Figure 8		3
					ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	–	–	–	–			4
	PRPPB_4_0		WRENB_0_0	E3 (CMD)	ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	–	–	–	–			
	ERPPB_0_0	**Erase Persistent Protection Bit** transaction sets all persistent protection bits to 1.	WRENB_0_0	E4 (CMD)	–	–	–	–	–	–	–	–	Figure 7		N/A
	WRPLB_0_0	**Write PPB Protection Lock Bit** transaction clears the PPB Lock to 0.	WRENB_0_0	A6 (CMD)	–	–	–	–	–	–	–	–			
	RDPLB_0_0	**Read Program Persistent Protection Lock Bit** transaction shifts out the 8-bit PPB Lock register contents with MSb first	–	A7 (CMD)	–	–	–	–	–	–	–	–	Figure 12		
	PGPWD_0_1	**Program Password** transaction programs the 64-bit password to flash device.	WRENB_0_0	E8 (CMD)	Password [7:0]	Password [15:8]	Password [23:16]	Password [31:24]	Password [39:32]	Password [47:40]	Password [55:48]	Password [63:56]	Figure 11		
	PWDUL_0_1	**Password Unlock** transaction sends the 64-bit password to flash device. If the supplied password does not match the hidden password in the Password Register, the device is locked and only a hardware reset or POR will return the device to standby state, ready for new transactions such as a retry of the PWDUL_0_1. If the password does match, the PPB Lock bit is set to 1.	–	E9 (CMD)	Password [7:0]	Password [15:8]	Password [23:16]	Password [31:24]	Password [39:32]	Password [47:40]	Password [55:48]	Password [63:56]			
Reset	SRSTE_0_0	**Software Reset Enable** command is required immediately before a SFRST_0_0 transaction	–	66 (CMD)	–	–	–	–	–	–	–	–	Figure 7		
	SFRST_0_0	**Software Reset** transaction restores the device to its initial power up state, by reloading volatile registers from nonvolatile default values	SRSTE_0_0	99 (CMD)	–	–	–	–	–	–	–	–			

Table 73 1-1-1 transaction table *(continued)*

Function	Transaction name	Description	Prerequisite transaction	Byte 1 (Hex)	Byte 2 (Hex)	Byte 3 (Hex)	Byte 4 (Hex)	Byte 5 (Hex)	Byte 6 (Hex)	Byte 7 (Hex)	Byte 8 (Hex)	Byte 9 (Hex)	Transaction format	Max freq. (MHz)	Address length
Reset	SFRSL_0_0	**Legacy Software Reset** transaction restores the device to its initial power up state, by reloading volatile registers from nonvolatile default values	–	F0 (CMD)	–	–	–	–	–	–	–	–	Figure 7	166	N/A
Deep power down	ENDPD_0_0	**Enter Deep Power Down Mode** transaction shifts device in the lowest power consumption mode	–	B9 (CMD)	–	–	–	–	–	–	–	–			

6.2 1-2-2 transaction table

Table 74 1-2-2 transaction table

Function	Transaction name	Description	Prerequisite transaction	Byte 1 (Hex)	Byte 2 (Hex)	Byte 3 (Hex)	Byte 4 (Hex)	Byte 5 (Hex)	Byte 6 (Hex)	Byte 7 (Hex)	Byte 8 (Hex)	Byte 9 (Hex)	Transaction format	Max freq. (MHz)	Address length
Read flash array	RDAY3_C_0	**Read SDR Dual I/O** transaction reads out the memory contents starting at the given address.	–	BB (CMD)	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	Mode [7:0]	–	–	–	–	Figure 16	166	3
			–		ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	Mode [7:0]	–	–	–			4
	RDAY3_4_0		–	BC (CMD)	ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	Mode [7:0]	–	–	–			
	RDAY6_C_0	**Continuous Read SDR Dual I/O** transaction reads out the memory contents starting at the given address.	RDAY3_C_0	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	Mode [7:0]	–	–	–	–	–	Figure 17		3
				ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	Mode [7:0]	–	–	–	–			4
	RDAY6_4_0		RDAY3_4_0	ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	Mode [7:0]	–	–	–	–			

6.3 1-1-4 transaction table

Table 75 1-1-4 transaction table

Function	Transaction name	Description	Prerequisite transaction	Byte 1 (Hex)	Byte 2 (Hex)	Byte 3 (Hex)	Byte 4 (Hex)	Byte 5 (Hex)	Byte 6 (Hex)	Byte 7 (Hex)	Byte 8 (Hex)	Byte 9 (Hex)	Transaction format	Max freq. (MHz)	Address length
Read flash array	RDAY4_C_0	**Read SDR Quad Output** transaction reads out the memory contents starting at the given address.	–	6B (CMD)	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	–	–	–	–	–	**Figure 18**	166	3
			–		ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	–	–	–	–			4
	RDAY4_4_0		–	6C (CMD)	ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	–	–	–	–			

6.4 1-4-4 transaction table

Table 76 1-4-4 transaction table

Function	Transaction name	Description	Prerequisite transaction	Byte 1 (Hex)	Byte 2 (Hex)	Byte 3 (Hex)	Byte 4 (Hex)	Byte 5 (Hex)	Byte 6 (Hex)	Byte 7 (Hex)	Byte 8 (Hex)	Byte 9 (Hex)	Transaction format	Max freq. (MHz)	Address length
Read manufacturer and device ID	RDQID_0_0	**Read Quad manufacturer and device identification** transaction provides read access to manufacturer and device identification.	–	AF (CMD)	–	–	–	–	–	–	–	–	Figure 23		N/A
Read flash array	RDAY5_C_0	**Read SDR Quad I/O** transaction reads out the memory contents starting at the given address.	–	EB (CMD)	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	Mode [7:0]	–	–	–	–	Figure 19	166	3
			–		ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	Mode [7:0]	–	–	–			4
	RDAY5_4_0		–	EC (CMD)	ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	Mode [7:0]	–	–	–			4
	RDAY6_C_0	Continuous Read SDR Quad I/O transaction reads out the memory contents starting at the given address.	RDAY5_C_0	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	Mode [7:0]	–	–	–	–	–	Figure 20		3
					ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	Mode [7:0]	–	–	–			4
	RDAY6_4_0		RDAY5_4_0	ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	Mode [7:0]	–	–	–	–			4
	RDAY7_C_0	**Read DDR Quad I/O** transaction reads out the memory contents starting at the given address.	–	ED (CMD)	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	Mode [7:0]	–	–	–	–	Figure 21	102	3
			–		ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	Mode [7:0]	–	–	–			4
	RDAY7_4_0		–	EE (CMD)	ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	Mode [7:0]	–	–	–			4
	RDAY8_C_0	Continuous Read DDR Quad I/O transaction reads out the memory contents starting at the given address.	RDAY7_C_0	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	Mode [7:0]	–	–	–	–	–	Figure 22		3
					ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	Mode [7:0]	–	–	–			4
	RDAY8_4_0		RDAY7_4_0	ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	Mode [7:0]	–	–	–	–			4

6.5 4-4-4 transaction table

Table 77 4-4-4 transaction table

Function	Transaction name	Description	Prerequisite transaction	Byte 1 (Hex)	Byte 2 (Hex)	Byte 3 (Hex)	Byte 4 (Hex)	Byte 5 (Hex)	Byte 6 (Hex)	Byte 7 (Hex)	Byte 8 (Hex)	Byte 9 (Hex)	Transaction format	Max freq. (MHz)	Address length
Read device ID	RDIDN_0_0	**Read manufacturer and device identification** transaction provides read access to manufacturer and device identification.	–	9F (CMD)	–	–	–	–	–	–	–	–	Figure 27	166	N/A
	RSFDP_3_0	**Read JEDEC Serial Flash Discoverable Parameters** transaction sequentially accesses the Serial Flash Discovery Parameters (SFDP).	–	5A (CMD)	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	–	–	–	–	–	Figure 31	50	3
	RDQID_0_0	**Read Quad manufacturer and device identification** transaction provides read access to manufacturer and device identification.	–	AF (CMD)	–	–	–	–	–	–	–	–	Figure 27	166	N/A
	RDUID_0_0	**Read Unique ID** accesses a factory programmed 64-bit number which is unique to each device.	–	4C (CMD)	–	–	–	–	–	–	–	–			
Register access	RDSR1_0_0	**Read Status Register 1** transaction allows the Status Register 1 contents to be read from DQ1/SO.	–	05 (CMD)	–	–	–	–	–	–	–	–			
	RDSR2_0_0	**Read Status Register-2** transaction allows the Status Register-2 contents to be read from DQ1/SO.	–	07 (CMD)	–	–	–	–	–	–	–	–			
	RDCR1_0_0	**Read Configuration Register-1** transaction allows the Configuration Register-1 contents to be read from DQ1/SO.	–	35 (CMD)	–	–	–	–	–	–	–	–			
	RDARG_C_0	**Read Any Register** transaction provides a way to read all addressed nonvolatile and volatile device registers.	–	65 (CMD)	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	–	–	–	–	–	Figure 31	166	3
			–		ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	–	–	–	–			4
	WRENB_0_0	**Write Enable** sets the Write Enable Latch bit of the Status Register 1 to 1 to enable write, program, and erase transactions.	–	06 (CMD)	–	–	–	–	–	–	–	–	Figure 24		N/A
	WRENV_0_0	**Write Enable Volatile** enable write of volatile Registers.	–	50 (CMD)	–	–	–	–	–	–	–	–			
	WRDIS_0_0	**Write Disable** sets the Write Enable Latch bit of the Status Register 1 to 0 to disable write, program, and erase transactions executaion.	–	04 (CMD)	–	–	–	–	–	–	–	–			
	WRREG_0_1	**Write Register** transaction provides a way to write Status Register 1 and Configuration Registers 1–4	WRENB_0_0	01 (CMD)	Input STR1 data [7:0]	Input CFR1 data [7:0]	Input CFR2 data [7:0]	Input CFR3 data [7:0]	Input CFR4 data [7:0]	–	–	–	Figure 29		

Table 77 4-4-4 transaction table *(continued)*

Function	Transaction name	Description	Prerequisite transaction	Byte 1 (Hex)	Byte 2 (Hex)	Byte 3 (Hex)	Byte 4 (Hex)	Byte 5 (Hex)	Byte 6 (Hex)	Byte 7 (Hex)	Byte 8 (Hex)	Byte 9 (Hex)	Transaction format	Max freq. (MHz)	Address length
Register access	WRARG_C_1	**Write Any Register** transaction provides a way to write all addressed nonvolatile and volatile device registers.	WRENB_0_0	71 (CMD)	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	Input Data [7:0]	–	–	–	–	Figure 30	166	3
					ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	Input Data [7:0]	–	–	–			4
Register access	CLPEF_0_0	**Clear Program and Erase Failure Flags** transaction resets STR1V[5] (Erase failure flag) and STR1V[6] (Program failure flag) **Note** This command may be disabled and the instruction value instead used for a program / erase resume command. See "Configuration Register 3 (CFR3x)" on page 85.	–	30 (CMD)	–	–	–	–	–	–	–	–	Figure 24	166	N/A
			–	82 (CMD)	–	–	–	–	–	–	–	–			
	EN4BA_0_0	**Enter 4 Byte Address Mode** transaction sets the Address Legth bit CFR2V[7] to 1	–	B7 (CMD)	–	–	–	–	–	–	–	–			N/A
	EX4BA_0_0	**Exit 4 Byte Address Mode** transaction sets the Address Legth bit CFR2V[7] to 0	–	B8 (CMD)	–	–	–	–	–	–	–	–			
	RDDLP_0_0	**Read Data Learning Pattern Register** transaction reads the DLP pattern.	–	41 (CMD)	–	–	–	–	–	–	–	–	Figure 27		
	PRDLP_0_1	**Program Data Learning Pattern** transaction programs DLP pattern into the Nonvolatile registers	WRENB_0_0	43 (CMD)	Input DLP data [7:0]	–	–	–	–	–	–	–	Figure 29		
	WRDLP_0_1	**Write Data Learning Pattern** transaction writes DLP pattern into the Volatile register.	WRENB_0_0	4A (CMD)	Input DLP data [7:0]	–	–	–	–	–	–	–			
	WRAUB_0_1	**AutoBoot Register Write** transaction writes AutoBoot pattern into the register.	WRENB_0_0	15 (CMD)	Input Data 1 [7:0]	Input Data 2 [7:0]	(Continue)	–	–	–	–	–			

Table 77 4-4-4 transaction table *(continued)*

Function	Transaction name	Description	Prerequisite transaction	Byte 1 (Hex)	Byte 2 (Hex)	Byte 3 (Hex)	Byte 4 (Hex)	Byte 5 (Hex)	Byte 6 (Hex)	Byte 7 (Hex)	Byte 8 (Hex)	Byte 9 (Hex)	Transaction format	Max freq. (MHz)	Address length
ECC	RDECC_C_0	**Read ECC Status** is used to determine the ECC status of the addressed data unit.	–	19 (CMD)	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	–	–	–	–	–	Figure 31	166	3
			–		ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	–	–	–	–			4
	RDECC_4_0		–	18 (CMD)	ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	–	–	–	–			4
	CLECC_0_0	**Clear ECC Status Register** transaction resets ECC Status Register bit[4] (2-bit ECC Detection), ECC Status Register bit[3] (1-bit ECC Correction), Address Trap Register and ECC Detection Counter.	–	1B (CMD)	–	–	–	–	–	–	–	–	Figure 24		N/A
CRC	DICHK_4_1	**Data Integrity Check** transaction causes the device to perform a Data Integrity Check over a user defined address range.	–	5B (CMD)	Start ADDR [31:24]	Start ADDR [23:16]	Start ADDR [15:8]	Start ADDR [7:0]	End ADDR [31:24]	End ADDR [23:16]	End ADDR [15:8]	End ADDR [7:0]	Figure 28		4
Read flash array	RDAY5_C_0	**Read QPI SDR** transaction reads out the memory contents starting at the given address.	–	EB (CMD)	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	Mode [7:0]	–	–	–	–	Figure 32		3
			–		ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	Mode [7:0]	–	–	–			4
	RDAY2_4_0		–	0C (CMD)	ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	Mode [7:0]	–	–	–			4
	RDAY5_4_0		–	EC (CMD)	ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	Mode [7:0]	–	–	–			4
Read flash array	RDAY6_C_0	**Continuous Read QPI SDR** transaction reads out the memory contents starting at the given address.	RDAY5_C_0	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	Mode [7:0]	–	–	–	–	–	Figure 33		3
				ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	Mode [7:0]	–	–	–	–			4
	RDAY6_4_0		RDAY5_4_0	ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	Mode [7:0]	–	–	–	–			4
	RDAY7_C_0	**Read QPI DDR** transaction reads out the memory contents starting at the given address.	–	ED (CMD)	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	Mode [7:0]	–	–	–	–	Figure 34		3
			–		ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	Mode [7:0]	–	–	–			4
	RDAY7_4_0		–	EE (CMD)	ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	Mode [7:0]	–	–	–			4

Table 77 4-4-4 transaction table *(continued)*

Function	Transaction name	Description	Prerequisite transaction	Byte 1 (Hex)	Byte 2 (Hex)	Byte 3 (Hex)	Byte 4 (Hex)	Byte 5 (Hex)	Byte 6 (Hex)	Byte 7 (Hex)	Byte 8 (Hex)	Byte 9 (Hex)	Transaction format	Max freq. (MHz)	Address length
Read flash array	RDAY8_C_0	**Continuous Read QPI DDR** transaction reads out the memory contents starting at the given address.	RDAY7_C_0	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	Mode [7:0]	–	–	–	–	–	Figure 35	166	3
				ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	Mode [7:0]	–	–	–	–			4
	RDAY8_4_0		RDAY7_4_0	ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	Mode [7:0]	–	–	–	–			4
Program flash array	PRPGE_C_1	**Program Page** programs 256B or 512B data to the memory array in one transaction.	WRENB_0_0	02 (CMD)	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	Input Data 1 [7:0]	Input Data 2 [7:0]	(Continue)	–	–	Figure 30		3
					ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	Input Data 1 [7:0]	Input Data 2 [7:0]	(Continue)	–			4
	PRPGE_4_1		WRENB_0_0	12 (CMD)	ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	Input Data 1 [7:0]	Input Data 2 [7:0]	(Continue)	–			4
Erase flash array	ER004_C_0	**Erase 4KB Sector** transaction sets all the bits of a 4KB sector to 1 (all bytes are FFh).	WRENB_0_0	20 (CMD)	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	–	–	–	–	–	Figure 26		3
					ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	–	–	–	–			4
	ER004_4_0		WRENB_0_0	21 (CMD)	ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	–	–	–	–			4
	ER256_C_0	**Erase 256KB Sector** transaction sets all the bits of a 256KB sector to 1 (all bytes are FFh).	WRENB_0_0	D8 (CMD)	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	–	–	–	–	–			3
					ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	–	–	–	–			4
	ER256_4_0		WRENB_0_0	DC (CMD)	ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	–	–	–	–			4
	ERCHP_0_0	**Erase Chip** transaction sets all bits to 1 (all bytes are FFh) inside the entire flash memory array.	WRENB_0_0	60 or C7 (CMD)	–	–	–	–	–	–	–	–	Figure 24		N/A
Erase flash array	EVERS_C_0	**Evaluate Erase Status** transaction verifies that the last erase operation on the addressed sector was completed successfully.	–	D0 (CMD)	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	–	–	–	–	–	Figure 26		3
			–		ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	–	–	–	–			4
	SEERC_C_0	**Sector Erase Count** transaction outputs the number of erase cycles for the sector of the inputed address from the Sector Erase Count Register.	–	5D (CMD)	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	–	–	–	–	–			3
			–		ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	–	–	–	–			4

Table 77 4-4-4 transaction table *(continued)*

Function	Transaction name	Description	Prerequisite transaction	Byte 1 (Hex)	Byte 2 (Hex)	Byte 3 (Hex)	Byte 4 (Hex)	Byte 5 (Hex)	Byte 6 (Hex)	Byte 7 (Hex)	Byte 8 (Hex)	Byte 9 (Hex)	Transaction format	Max freq. (MHz)	Address length
Suspend / resume	SPEPD_0_0	**Suspend Erase / Program / Data Integrity Check** transaction allows the system to interrupt a programming, erase or data integrity check operation	–	75 (CMD	–	–	–	–	–	–	–	–	Figure 24	166	N/A
	SPEPA_0_0	**Suspend Erase / Program** alternate transaction allows the system to interrupt a programming or erase.	–	85 (CMD)	–	–	–	–	–	–	–	–			
			–	B0 (CMD)	–	–	–	–	–	–	–	–			
	RSEPD_0_0	**Resume Erase / Program / Data Integrity Check** transaction allows the system to resume a programming, erase or data integrity check operation	–	7A (CMD)	–	–	–	–	–	–	–	–			N/A
	RSEPA_0_0	**Resume Erase / Program** alternate transaction allows the system to resume a programming, erase or data integrity check operation	–	8A (CMD)	–	–	–	–	–	–	–	–			
			–	30 (CMD)	–	–	–	–	–	–	–	–			N/A
Secure silicon region array	PRSSR_C_1	**Program Secure Silicon Region** transaction programs data in 1024 bytes of Secure Silicon Region	WRENB_0_0	42 (CMD)	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	Input Data 1 [7:0]	Input Data 2 [7:0]	(Continue)	–	–	Figure 30		3
			–		ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	Input Data 1 [7:0]	Input Data 2 [7:0]	(Continue)	–			4
	RDSSR_C_0	**Read Secure Silicon Region** transaction reads data from the SSR.	–	4B (CMD)	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	–	–	–	–	–	Figure 31		3
			–		ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	–	–	–	–			4
Advanced sector protection	PRASP_0_1	ASP Register Write	WRENB_0_0	2F (CMD)	ASP Low Byte [7:0]	ASP High Byte [7:0]	–	–	–	–	–	–	Figure 29		N/A
	RDDYB_C_0	**Read Dynamic Protection Bit** transaction reads the contents of the DYB Access register.	–	FA (CMD)	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	–	–	–	–	–	Figure 31		3
			–		ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	–	–	–	–			4
	RDDYB_4_0		–	E0 (CMD)	ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	–	–	–	–			

Table 77 4-4-4 transaction table *(continued)*

Function	Transaction name	Description	Prerequisite transaction	Byte 1 (Hex)	Byte 2 (Hex)	Byte 3 (Hex)	Byte 4 (Hex)	Byte 5 (Hex)	Byte 6 (Hex)	Byte 7 (Hex)	Byte 8 (Hex)	Byte 9 (Hex)	Transaction format	Max freq. (MHz)	Address length
Advanced sector protection	WRDYB_C_1	**Write Dynamic Protection Bit** transaction writes to the DYB Access register	WRENB_0_0	FB (CMD)	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	Input Data [7:0]	–	–	–	–	Figure 30	166	3
					ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	Input Data [7:0]	–	–	–			4
	WRDYB_4_1		WRENB_0_0	E1 (CMD)	ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	Input Data [7:0]	–	–	–			
	RDPPB_C_0	**Read Persistent Protection Bit** transaction reads the contents of the PPB Access register	–	FC (CMD)	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	–	–	–	–	–	Figure 31		3
			–		ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	–	–	–	–			4
	RDPPB_4_0		–	E2 (CMD)	ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	–	–	–	–			
	PRPPB_C_0	**Program Persistent Protection Bit** transaction programs / writes the PPB register to enable the sector protection.	WRENB_0_0	FD (CMD)	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	–	–	–	–	–	Figure 26		3
					ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	–	–	–	–			4
	PRPPB_4_0		WRENB_0_0	E3 (CMD)	ADDR [31:24]	ADDR [23:16]	ADDR [15:8]	ADDR [7:0]	–	–	–	–			
	ERPPB_0_0	**Erase Persistent Protection Bit** transaction sets all persistent protection bits to '1'.	WRENB_0_0	E4 (CMD)	–	–	–	–	–	–	–	–	Figure 24		N/A
	WRPLB_0_0	**Write PPB Protection Lock Bit** transaction clears the PPB Lock to 0	WRENB_0_0	A6 (CMD)	–	–	–	–	–	–	–	–			
	RDPLB_0_0	**Read Program Persistent Protection Lock Bit** transaction shifts out the 8-bit PPB Lock register contents with MSb first	–	A7 (CMD)	–	–	–	–	–	–	–	–	Figure 27		
	PGPWD_0_1	**Program Password** transaction programs the 64-bit password to flash device.	WRENB_0_0	E8 (CMD)	Password [7:0]	Password [15:8]	Password [23:16]	Password [31:24]	Password [39:32]	Password [47:40]	Password [55:48]	Password [63:56]	Figure 29		
	PWDUL_0_1	**Password Unlock** transaction sends the 64-bit password to flash device. If the supplied password does not match the hidden password in the Password Register, the device is locked and only a hardware reset or POR will return the device to standby state, ready for new transactions such as a retry of the PWDUL_0_1. If the password does match, the PPB Lock bit is set to '1'.	–	E9 (CMD)	Password [7:0]	Password [15:8]	Password [23:16]	Password [31:24]	Password [39:32]	Password [47:40]	Password [55:48]	Password [63:56]			

Table 77 4-4-4 transaction table *(continued)*

Function	Transaction name	Description	Prerequisite transaction	Byte 1 (Hex)	Byte 2 (Hex)	Byte 3 (Hex)	Byte 4 (Hex)	Byte 5 (Hex)	Byte 6 (Hex)	Byte 7 (Hex)	Byte 8 (Hex)	Byte 9 (Hex)	Transaction format	Max freq. (MHz)	Address length
Reset	SRSTE_0_0	**Software Reset Enable** command is required immediately before a SFRST_0_0 transaction	–	66 (CMD)	–	–	–	–	–	–	–	–	Figure 24	166	N/A
	SFRST_0_0	**Software Reset** transaction restores the device to its initial power up state, by reloading volatile registers from nonvolatile default values	SRSTE_0_0	99 (CMD)	–	–	–	–	–	–	–	–			
Reset	SFRSL_0_0	**Legacy Software Reset** transaction restores the device to its initial power up state, by reloading volatile registers from nonvolatile default values	–	F0 (CMD)	–	–	–	–	–	–	–	–	Figure 24		
Deep power down	ENDPD_0_0	**Enter Deep Power Down Mode** transaction shifts device in the lowest power consumption mode	–	B9 (CMD)	–	–	–	–	–	–	–	–			

7 Electrical characteristics

7.1 Absolute maximum ratings[32-34]

Storage Temperature Plastic Packages	–65°C to +150°C
Ambient Temperature with Power Applied	–65°C to +125°C
V_{CC} (HL-T)	–0.5 V to +4.0 V
V_{CC} (HS-T)	–0.5 V to +2.5 V
Input voltage with respect to Ground (V_{SS})	–0.5 V to V_{CC} + 0.5 V
Output Short Circuit Current	100 mA

Notes
32. See **"Input signal overshoot"** on page 116 for allowed maximums during signal transition.
33. No more than one output may be shorted to ground at a time. Duration of the short circuit should not be greater than one second.
34. Stresses above those listed under **"Absolute maximum ratings[32-34]"** on page 114 may cause permanent damage to the device. This is a stress rating only; functional operation of the device at these or any other conditions above those indicated in the operational sections of this datasheet is not implied. Exposure of the device to absolute maximum rating conditions for extended periods may affect device reliability.

7.2 Operating range

Operating ranges define those limits between which the functionality of the device is guaranteed.

7.2.1 Power supply voltages

V_{CC} (HL-T Devices)	2.7 V to 3.6 V
V_{CC} (HS-T Devices)	1.7 V to 2.0 V

7.2.2 Temperature ranges

Table 78 Temperature ranges[35]

Parameter	Symbol	Devices	Spec		Unit
			Min	Max	
Ambient Temperature	T_A	Industrial / Automotive AEC-Q100 Grade 3	–40	+85	°C
		Industrial Plus / Automotive AEC-Q100 Grade 2		+105	
		Automotive AEC-Q100 Grade 1		+125	

Note
35. Industrial Plus, Automotive Grade-2 and Automotive Grade-1 operating and performance parameters will be determined by device characterization and may vary from standard industrial or Automotive Grade-3 temperature range devices as currently shown in this specification.

7.3 Thermal resistance

Table 79 Thermal resistance

Parameter	Description	Test condition	Device	24-ball BGA	16-lead SOIC	8-contact WSON	Unit
Theta JA	Thermal resistance (Junction to ambient)	Test conditions follow standard test methods and procedures for measuring thermal impedance in accordance with EIA/JESD51. With Still Air (0 m/s).	256T	35.2	36.4	31	°C/W
			512T	40.4	35	32.7	
			01GT	37	28.3	–	
Theta JB	Thermal resistance (Junction to board)		256T	19	9	17.5	°C/W
			512T	14.5	19	12.5	
			01GT	9.7	12	–	
Theta JC	Thermal resistance (Junction to case)		256T	11	8	13.1	°C/W
			512T	8	9.9	13	
			01GT	7.5	7.6	–	

7.4 Capacitance characteristics

Table 80 Capacitance

Package	Input capacitance		Output capacitance	
	Typical	Maximum	Typical	Maximum
24-ball BGA	3.0 pF	6.5 pF	7.0 pF	7.5 pF
16-lead SOIC	4.0 pF		7.5 pF	8.0 pF
8-contact WSON	3.0 pF		6.7 pF	7.5 pF

7.5 Latchup characteristics

Table 81 Latchup specification[36]

Description	Min	Max	Unit
Input voltage with respect to V_{SS} on all input only connections	–1.0	V_{CC} + 1.0	V
Input voltage with respect to V_{SS} on all I/O connections			
V_{CC} Current	–100	+100	mA

Note
36. Excludes power supply V_{CC}. Test conditions: V_{CC} = 1.8 V / 3.0 V, one connection at a time tested, connections not being tested are at V_{SS}.

7.6 DC characteristics

7.6.1 Input signal overshoot

During DC conditions, input or I/O signals should remain equal to or between V_{SS} and V_{CC}. During voltage transitions, inputs or I/Os may overshoot V_{SS} to –1.0 V or overshoot to V_{CC} + 1.0 V, for periods up to 20 ns.

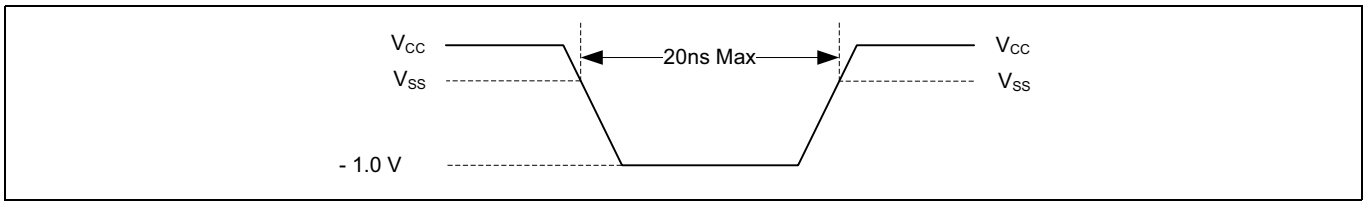


Figure 70 Maximum negative overshoot waveform

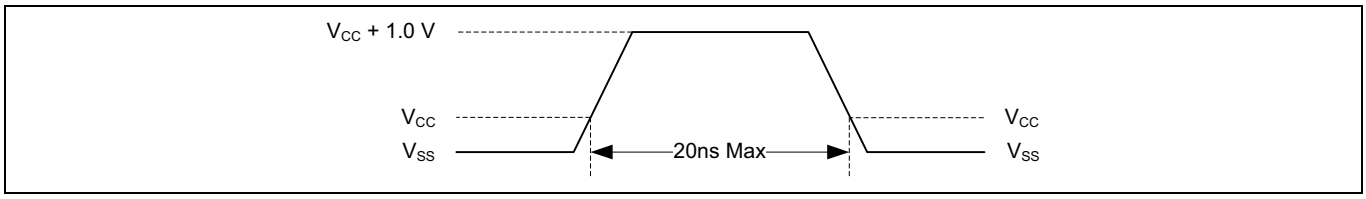


Figure 71 Maximum positive overshoot waveform

7.6.2 DC characteristics (all temperature ranges)

Table 82 DC characteristics[37, 38]

Symbol	Parameter	Test conditions	Min	Typ	Max	Unit	Reference figure
V_{IL}	Input Low Voltage (all V_{CC})	–	V_{CC} × -0.15	–	V_{CC} × 0.35	V	–
V_{IH}	Input High Voltage (all V_{CC})	–	V_{CC} × 0.65	–	V_{CC} × 1.15		
V_{OL}	Output Low Voltage (all V_{CC})	At 0.1 mA	–	–	0.2		
V_{OH}	Output High Voltage (all V_{CC})	At –0.1 mA	V_{CC} – 0.20	–	–		
I_{LI}	Input Leakage Current	V_{CC} = V_{CC} Max, V_{IN} = V_{IH} or V_{SS}, CS# = V_{IH}, 85°C	–	–	±2	µA	
		V_{CC} = V_{CC} Max, V_{IN} = V_{IH} or V_{SS}, CS# = V_{IH}, 105°C	–	–	±3		
		V_{CC} = V_{CC} Max, V_{IN} = V_{IH} or V_{SS}, CS# = V_{IH}, 125°C	–	–	±4		
I_{LO}	Output Leakage Current	V_{CC} = V_{CC} Max, V_{IN} = V_{IH} or V_{SS}, CS# = V_{IH}, 85°C	–	–	±2		
		V_{CC} = V_{CC} Max, V_{IN} = V_{IH} or V_{SS}, CS# = V_{IH}, 105°C	–	–	±3		
		V_{CC} = V_{CC} Max, V_{IN} = V_{IH} or V_{SS}, CS# = V_{IH}, 125°C	–	–	±4		
I_{CC1}	Active Power Supply Current (READ)[38]	SDR @ 50 MHz (HL256T / HS256T) (HL512T / HS512T) (HL01GT / HS01GT)	–	14 / 18 10 / 10 18 / 14	25 / 25 21 / 18 25 / 25	mA	
		SDR @ 166 MHz (HL256T / HS256T) (HL512T / HS512T) (HL01GT / HS01GT)	–	53 53 53	69 / 72 69 / 69 69 / 72		
		DDR @ 102 MHz	–	50	68		
I_{CC2}	Active Power Supply Current (Page Program) (256T / 512T / 01GT)	V_{CC} = V_{CC} Max, CS# = V_{IH}	–	50	58 /58 / 66		
I_{CC3}	Active Power Supply Current (Write Register and Write Any Register) (256T / 512T / 01GT)	V_{CC} = V_{CC} Max, CS# = V_{IH}	–	50	55 / 55 / 66		
I_{CC4}	Active Power Supply Current (Sector Erase) (256T / 512T / 01GT)	V_{CC} = V_{CC} Max, CS# = V_{IH}	–	50	55 / 55 / 66		
I_{CC5}	Active Power Supply Current (Chip Erase) (256T / 512T / 01GT)	V_{CC} = V_{CC} Max, CS# = V_{IH}	–	50	55 / 55 / 66		
I_{SB}	Standby Current (HS256T / HS512T / HS01GT)	RESET#, CS# = V_{CC}; All I/Os = V_{CC} or V_{SS}, 85°C	–	11	160 / 113 / 160	µA	
		RESET#, CS# = V_{CC}; All I/Os = V_{CC} or V_{SS}, 105°C	–		220 / 188 / 220		
		RESET#, CS# = V_{CC}; All I/Os = V_{CC} or V_{SS}, 125°C	–		510 / 340 / 510		
	Standby Current (HL256T / HL512T / HL01GT)	RESET#, CS# = V_{CC}; All I/Os = V_{CC} or V_{SS}, 85°C	–	14	160 / 126 / 160		
		RESET#, CS# = V_{CC}; All I/Os = V_{CC} or V_{SS}, 105°C	–		425 / 188 / 425		
		RESET#, CS# = V_{CC}; All I/Os = V_{CC} or V_{SS}, 125°C	–		560 / 340 / 560		
I_{DPD}	DPD Current (HS256T / HS512T / HS01GT)	RESET#, CS# = V_{CC}; All I/Os = V_{CC} or V_{SS}, 85°C	–	1.3	24 / 18 / 24		
		RESET#, CS# = V_{CC}; All I/Os = V_{CC} or V_{SS}, 105°C	–		26 / 18 / 26		
		RESET#, CS# = V_{CC}; All I/Os = V_{CC} or V_{SS}, 125°C	–		56 / 31 / 56		

Notes
37. Typical values are at T_A = 25°C and V_{CC} = 1.8 V/3.0 V.
38. Outputs unconnected during read data return. Output switching current is not included.

Table 82 DC characteristics[37, 38] *(continued)*

Symbol	Parameter	Test conditions	Min	Typ	Max	Unit	Reference figure
I_{DPD}	DPD Current (HL256T / HL512T / HL01GT)	RESET#, CS# = V_{CC}; All I/Os = V_{CC} or V_{SS}, 85°C	–	2.2	18 / 18 / 26	µA	–
		RESET#, CS# = V_{CC}; All I/Os = V_{CC} or V_{SS}, 105°C	–		18 / 18 / 26		
		RESET#, CS# = V_{CC}; All I/Os = V_{CC} or V_{SS}, 125°C	–		60 / 31 / 60		
I_{POR}	POR Current	RESET#, CS# = V_{CC}; All I/Os = V_{CC} or V_{SS}	–	–	80	mA	
Power Up / Power Down Voltage							
V_{CC} (min)	V_{CC} (minimum operation voltage, HL-T)	–	2.7	–	–	V	Figure 66 / Figure 67
	V_{CC} (minimum operation voltage, HS-T)	–	1.7	–	–		
V_{CC} (cut-off)	V_{CC} (cut off where re-initialization is needed, HL-T)	–	2.4	–	–		Figure 67
	V_{CC} (cut off where re-initialization is needed, HS-T)	–	1.55	–	–		
V_{CC} (Low)	V_{CC} (low voltage for initialization to occur, HL-T)	–	0.7	–	–		
	V_{CC} (low voltage for initialization to occur, HS-T)	–	0.7	–	–		

Notes
37. Typical values are at T_{AI} = 25°C and V_{CC} = 1.8 V/3.0 V.
38. Outputs unconnected during read data return. Output switching current is not included.

7.7 AC test conditions

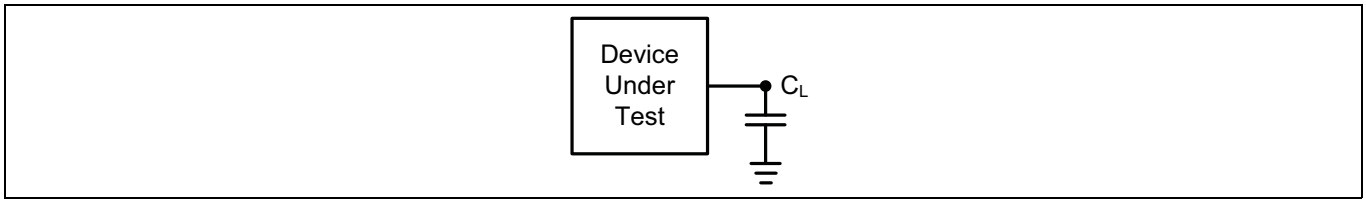


Figure 72 Test setup

Table 83 AC measurement conditions[40]

Parameter	Min	Max	Unit	Reference figure
Load Capacitance (C_L)	–	30	pF	Figure 72
Input Pulse Voltage	0	V_{CC}	V	–
Input Rise (t_{CRT}) and Fall (t_{CFT}) Slew Rates at 133MHz (HL-T)[39]	1.37	–	V/ns	Figure 78
Input Rise (t_{CRT}) and Fall (t_{CFT}) Slew Rates at 166MHz (HL-T)[39]	1.72			
Input Rise (t_{CRT}) and Fall (t_{CFT}) Slew Rates at 133MHz (HS-T)[39]	0.75			
Input Rise (t_{CRT}) and Fall (t_{CFT}) Slew Rates at 166MHz (HS-T)[39]	0.94			
$V_{IL(ac)}$	$-0.30 \times V_{CC}$	$0.30 \times V_{CC}$	V	–
$V_{IH(ac)}$	$0.7 \times V_{CC}$	$1.30 \times V_{CC}$		
$V_{OH(ac)}$	$0.75 \times V_{CC}$	–		
$V_{OL(ac)}$	–	$0.25 \times V_{CC}$		
Input Timing Ref Voltage	$0.5 \times V_{CC}$			
Output Timing Ref Voltage				

Notes
39. Input slew rate measured from input pulse min to max at V_{CC} max.
40. AC characteristics tables assume clock and data signals have the same slew rate (slope).

8 Timing characteristics

Table 84 Timing characteristics[42]

Symbol	Parameter	Min	Typ	Max	Unit	Reference figure
SDR timing characteristics						
f_{CK}	Clock Frequency	DC	–	166	MHz	–
p_{CK}	CK Clock Period	$1/f_{CK}$	–	∞	ns	Figure 78
t_{CH}	Clock High Time	45% p_{CK}	–	55% p_{CK}		
t_{CL}	Clock Low Time		–			
t_{CS}	CS# High Time (Read transactions)	10	–	–		Figure 79
	CS# High Time Between Transactions (Read transactions when Reset feature and Quad mode are both enabled and aborted transaction)	20	–	–		
	CS# High Time (Program / Erase transactions)	50	–	–		
t_{CSS}	CS# Active Setup Time relative to CK ($f_{CK} \leq 50$ MHz / $f_{CK} > 50$ MHz)	5/4	–	–		
t_{CSH0}	CS# Active Hold Time (relative to CK in Mode 0)	4	–	–		
t_{CSH3}	CS# Active Hold Time (relative to CK in Mode 3)	6	–	–		
t_{SU}	Data Setup Time (all V_{CC}) ($f_{CK} \leq 50$ MHz / $f_{CK} > 50$ MHz)	5 / 2	–	–		
t_{HD}	Data Hold Time (all V_{CC}) ($f_{CK} \leq 50$ MHz / $f_{CK} > 50$ MHz)		–	–		
t_V[42]	Clock Low to Output Valid (15pF Loading, 3.0 V – 3.6 V, 30 Ω Output Impedance, 105°C) (HL-T) **Note** Guaranteed by design.	2	–	6.5		Figure 80
	Clock Low to Output Valid (15pF Loading) (HS-T)			6		
	Clock Low to Output Valid (15pF Loading) (HL-T)			8		
	Clock Low to Output Valid (30pF Loading) (HS-T)					
	Clock Low to Output Valid (30pF Loading) (HL-T)			9		
t_{HO}	Output Hold Time	1.5	–	–		
t_{DIS}[41]	CS# Inactive to Output Disable Time (HS-T)	–	–	8		
	CS# Inactive to Output Disable Time (HL-T)	–	–	9		
	CS# Inactive to Output Disable Time (when Reset feature and Quad mode are both enabled)	–	–	20		
t_{WPS}	WP# Setup Time (Applicable as a constraint for write register transactions when STCFWR is set to a 1)	20	–	–		Figure 81
t_{WPH}	WP# Hold Time (Applicable as a constraint for write register transactions when STCFWR is set to a 1)	20	–	–		
t_{IO_SKEW}[48]	Data Skew (First Data Bit to Last Data Bit)	–	–	0.6		–
DDR timing characteristics						
f_{CK}	CK Clock Frequency	DC	–	102	MHz	–

Notes
41. Output HI-Z is defined as the point where data is no longer driven.
42. Applicable across all operating temperature options.
43. If Reset# is asserted during the end of t_{PU}, the device will remain in the reset state and t_{RH} will determine when CS# may go Low.
44. Sum of t_{RP} and t_{RH} must be equal to or greater than t_{RPH}.
45. Typical program and erase times assume the following conditions: 25°C, V_{CC} = 1.8 V and 3.0 V; checkerboard data pattern.
46. The programming time for any OTP programming transaction is the same as t_{PP}.
47. The programming time for the PRPPB_4_0 and PRPPB_C_0 transactions is the same as t_{PP}. The erase time for ERPPB_0_0 transaction is the same as t_{SE}.
48. Values are guaranteed by characterization and not 100% tested in production.
49. Guaranteed by design.
50. The Joint Electron Device Engineering Council (JEDEC) standard JESD22-A117 defines the procedural requirements for performing valid endurance and retention tests based on a qualification specification. This methodology is intended to determine the ability of a flash device to sustain repeated data changes without failure (program/erase endurance) and to retain data for the expected life (data retention). Endurance and retention qualification specifications are specified in JESD47 or may be developed using knowledge-based methods as in JESD94.

Table 84 Timing characteristics[42] *(continued)*

Symbol	Parameter	Min	Typ	Max	Unit	Reference figure
p_{CK}	CK Clock Period	$1/f_{CK}$	–	∞	ns	Figure 78
t_{CH}	Clock High Time	45% p_{CK}	–	55% p_{CK}		
t_{CL}	Clock Low Time		–			
t_{CS}	CS# High Time (Read transactions)	10	–	–		Figure 83
	CS# High Time Between Transactions (Read transactions when Reset feature and Quad mode are both enabled and aborted transaction)	20	–	–		
	CS# High Time (Program / Erase transactions)	50	–	–		
t_{CSS}	CS# Active Setup Time relative to CK ($f_{CK} \leq 50$ MHz / $f_{CK} > 50$ MHz)	5/4	–	–		
t_{CSH0}	CS# Active Hold Time (relative to CK in Mode 0)	4	–	–		Figure 83
t_{SU}	Data Setup Time (all V_{CC})	2	–	–		
t_{HD}	Data Hold Time (all V_{CC})	1.2	–	–		
t_V	Clock Low to Output Valid (15pF Loading, 3.0 V – 3.6 V, 30 Ω Output Impedance, 105°C) (HL-T)	2	–	6.5		Figure 84
	Clock Low to Output Valid (15 pF Loading) (HS-T)	2	–	6		
	Clock Low to Output Valid (15 pF Loading) (HL-T)		–	8		
t_{HO}	Output Hold Time	1.5	–	–		
t_{DIS}	Output Disable Time (HS-T)	–	–	8		
	Output Disable Time (HL-T)	–	–	9		
	CS# Inactive to Output Disable Time (when Reset feature and Quad mode are both enabled)	–	–	20		
t_{IO_SKEW}[48]	Data Skew (First Data Bit to Last Data Bit)	–	–	0.6		–
Power up / Power down timing						
t_{PU}	V_{CC}(min) to Read operation (HL256T / HS256T) (HL512T / HS512T) (HL01GT / HS01GT)	–	–	550 / 600 450 / 500 450 / 500	µs	Figure 66
t_{PD}	V_{CC}(Low) time	25	–	–		Figure 67
t_{VR}[49]	V_{CC} Power Up ramp rate	1	–	–	µs/V	–
t_{VF}	V_{CC} Power Down ramp rate	30	–	–		
Deep power down mode timing						
t_{ENTDPD}[49]	Time to Enter DPD mode	–	–	3	µs	–
t_{EXTDPD}	Time to Exit DPD mode (HL256T / HS256T) (HL512T / HS512T) (HL01GT / HS01GT)	–	–	520 / 570 380 / 430 380 / 430		Figure 65
t_{CSDPD}	Chip Select Pulse Width to Exit DPD	0.02	–	3		
Reset timing[43, 44]						

Notes
41. Output HI-Z is defined as the point where data is no longer driven.
42. Applicable across all operating temperature options.
43. If Reset# is asserted during the end of t_{PU}, the device will remain in the reset state and t_{RH} will determine when CS# may go Low.
44. Sum of t_{RP} and t_{RH} must be equal to or greater than t_{RPH}.
45. Typical program and erase times assume the following conditions: 25°C, V_{CC} = 1.8 V and 3.0 V; checkerboard data pattern.
46. The programming time for any OTP programming transaction is the same as t_{PP}.
47. The programming time for the PRPPB_4_0 and PRPPB_C_0 transactions is the same as t_{PP}. The erase time for ERPPB_0_0 transaction is the same as t_{SE}.
48. Values are guaranteed by characterization and not 100% tested in production.
49. Guaranteed by design.
50. The Joint Electron Device Engineering Council (JEDEC) standard JESD22-A117 defines the procedural requirements for performing valid endurance and retention tests based on a qualification specification. This methodology is intended to determine the ability of a flash device to sustain repeated data changes without failure (program/erase endurance) and to retain data for the expected life (data retention). Endurance and retention qualification specifications are specified in JESD47 or may be developed using knowledge-based methods as in JESD94.

Table 84 Timing characteristics[42] *(continued)*

Symbol	Parameter	Min	Typ	Max	Unit	Reference figure
t_{CSR}	CS# high before DQ3_RESET# Low	50	–	–	ns	Figure 60
t_{RS}	Reset Setup - RESET# High before CS# Low	50	–	–		Figure 56
t_{RH}	Reset Pulse Hold - RESET# Low to CS# Low (HL256T / HS256T) (HL512T / HS512T) (HL01GT / HS01GT)	 550 / 600 450 / 500 450 / 500	–	–	µs	
t_{RP}	RESET# Pulse Width	200	–	–	ns	Figure 56
t_{SR}	Internal Device Reset from Software Reset Transaction (256T / 512T / 01GT)	–	–	90 / 83 / 83	µs	–
JEDEC serial flash reset signaling protocol timing						
t_{CSLW}	Chip Select Low	500	–	–	ns	Figure 63
t_{CSHG}	Chip Select High	500	–	–		
t_{RESET}	Internal device reset (HL256T / HS256T) (HL512T / HS512T) (HL01GT / HS01GT)	–	–	 550 / 600 450 / 500 450 / 500	µs	
t_{SUJ}	Data in Setup Time (w.r.t CS#)	50	–	–	ns	
t_{HDJ}	Data in Hold Time (w.r.t CS#)	50	–	–		
Embedded algorithm (erase, program, and data integrity check) performance[45, 46, 47, 50]						
t_W	Nonvolatile Register Write Time	–	44	357.5	ms	–
t_{PP}	256B Page Programming (4 KB Sector / 256 KB Sector)	–	430 / 480	2175 / 1700	µs	
	512B Page Programming (4 KB Sector / 256 KB Sector)	–	680 / 570	2175 / 1700		
t_{SE}	Sector Erase Time (4 KB physical sectors)	–	42	335	ms	
	Sector Erase Time (256 KB Infineon Endurance Flex architecture disabled)	–	773	2677		
	Sector Erase Time (256 KB Infineon Endurance Flex architecture enabled)	–	773	5869		
t_{BE}	Chip Erase Time (256 Mb)	–	101	348	sec	–
	Chip Erase Time (512 Mb)	–	201	696		
	Chip Erase Time (1 Gb)	–	398	1381		
t_{EES}	Evaluate Erase Status Time for 4 KB physical sectors (HL256T / HS256T) (HL512T / HS512T) (HL01GT / HS01GT)	–	45	 76 / 76 51 / 51 50 / 54	µs	
	Evaluate Erase Status Time for 256 KB physical sectors (HL256T / HS256T) (HL512T / HS512T) (HL01GT / HS01GT)	–	45	 76 / 76 51 / 51 50 / 54		
t_{DIC_SETUP}	Data Integrity Check Calculation Setup Time (256T / 512T / 01GT)	–	50 / 17 / 17	–	µs	
t_{DIC_RATES}	Data Integrity Check Calculation Rate (Calculation rate over a large (>1024-byte) block of data) (256T / 512T / 01GT)	53 / 55 / 55	56 / 65 / 65	–	MBps	
t_{SEC}	Sector Erase Count Time (HL256T / HS256T) (HL512T / HS512T) (HL01GT / HS01GT)	–	55	 87 / 87 63 / 63 63 / 70	µs	–

Notes

41. Output HI-Z is defined as the point where data is no longer driven.
42. Applicable across all operating temperature options.
43. If Reset# is asserted during the end of t_{PU}, the device will remain in the reset state and t_{RH} will determine when CS# may go Low.
44. Sum of t_{RP} and t_{RH} must be equal to or greater than t_{RPH}.
45. Typical program and erase times assume the following conditions: 25°C, V_{CC} = 1.8 V and 3.0 V; checkerboard data pattern.
46. The programming time for any OTP programming transaction is the same as t_{PP}.
47. The programming time for the PRPPB_4_0 and PRPPB_C_0 transactions is the same as t_{PP}. The erase time for ERPPB_0_0 transaction is the same as t_{SE}.
48. Values are guaranteed by characterization and not 100% tested in production.
49. Guaranteed by design.
50. The Joint Electron Device Engineering Council (JEDEC) standard JESD22-A117 defines the procedural requirements for performing valid endurance and retention tests based on a qualification specification. This methodology is intended to determine the ability of a flash device to sustain repeated data changes without failure (program/erase endurance) and to retain data for the expected life (data retention). Endurance and retention qualification specifications are specified in JESD47 or may be developed using knowledge-based methods as in JESD94.

Table 84 Timing characteristics[42] *(continued)*

Symbol	Parameter	Min	Typ	Max	Unit	Reference figure
t_{BEC1}	Blank Check single 256KB sector	–	13	17	ms	–
t_{BEC2}	Blank Check single 4KB sector	–	1	2		–
$t_{PASSWORD}$	Password Comparison Time	80	100	120	µs	–
Program, erase, or data integrity check suspend/resume timing						
t_{PEDS}	Program/Erase/Data Integrity Check Suspend	–	–	80	µs	–
t_{PEDRS}	Program/Erase/Data Integrity Check Resume to next Program/Erase/Data Integrity Check Suspend (256T / 512T / 01GT)	250 / – / –	100 / 100 / 100	–		

Notes

41. Output HI-Z is defined as the point where data is no longer driven.
42. Applicable across all operating temperature options.
43. If Reset# is asserted during the end of t_{PU}, the device will remain in the reset state and t_{RH} will determine when CS# may go Low.
44. Sum of t_{RP} and t_{RH} must be equal to or greater than t_{RPH}.
45. Typical program and erase times assume the following conditions: 25°C, V_{CC} = 1.8 V and 3.0 V; checkerboard data pattern.
46. The programming time for any OTP programming transaction is the same as t_{PP}.
47. The programming time for the PRPPB_4_0 and PRPPB_C_0 transactions is the same as t_{PP}. The erase time for ERPPB_0_0 transaction is the same as t_{SE}.
48. Values are guaranteed by characterization and not 100% tested in production.
49. Guaranteed by design.
50. The Joint Electron Device Engineering Council (JEDEC) standard JESD22-A117 defines the procedural requirements for performing valid endurance and retention tests based on a qualification specification. This methodology is intended to determine the ability of a flash device to sustain repeated data changes without failure (program/erase endurance) and to retain data for the expected life (data retention). Endurance and retention qualification specifications are specified in JESD47 or may be developed using knowledge-based methods as in JESD94.

8.1 Timing waveforms

8.1.1 Key to timing waveform

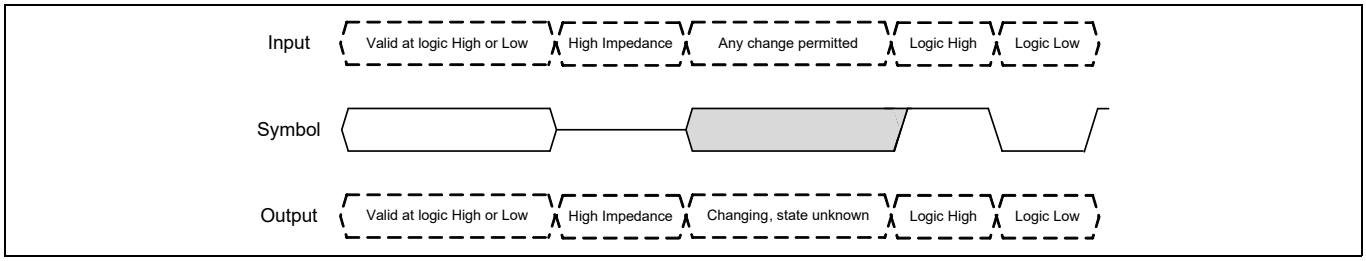


Figure 73 Waveform element meanings

8.1.2 Timing reference levels

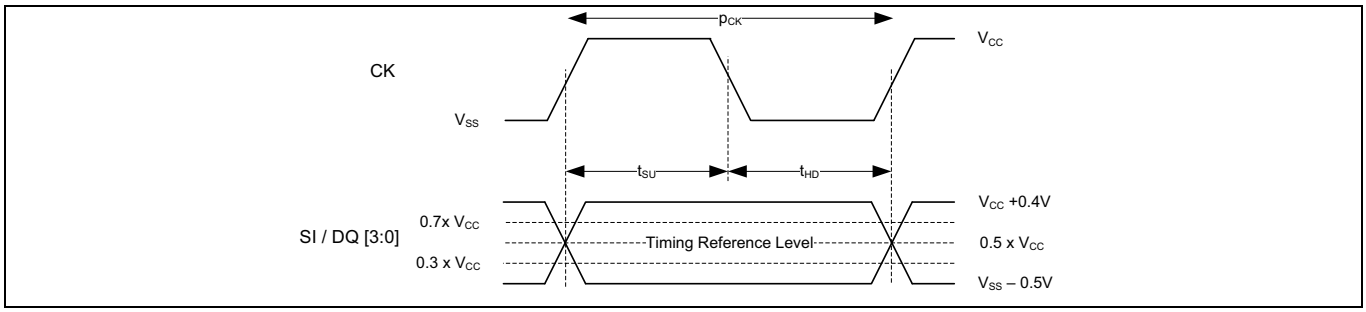


Figure 74 SDR input timing reference levels

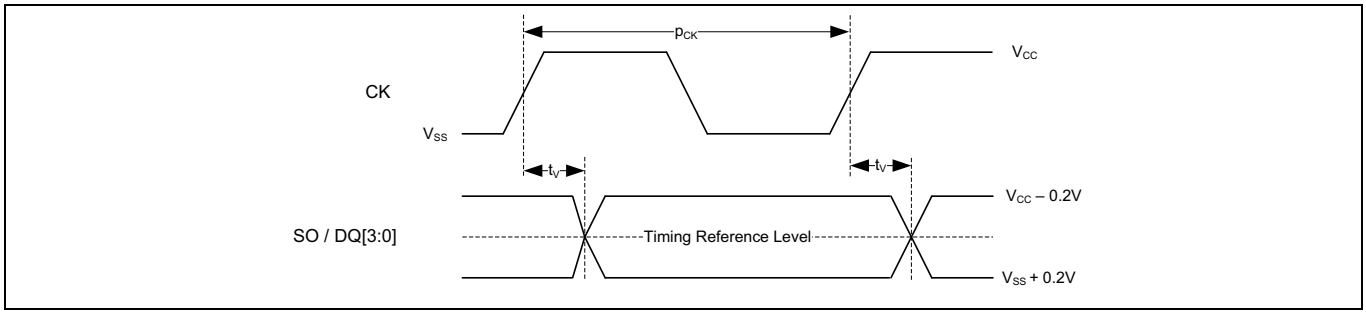


Figure 75 SDR output timing reference level

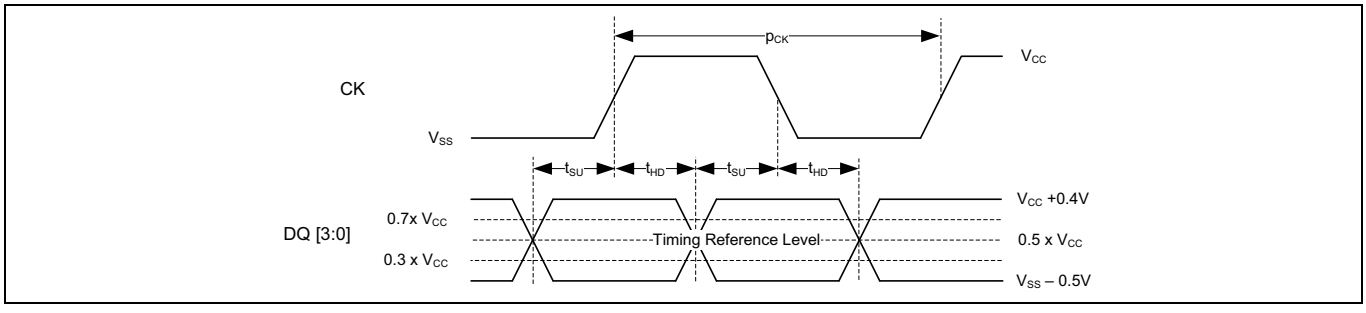


Figure 76 DDR input timing reference level

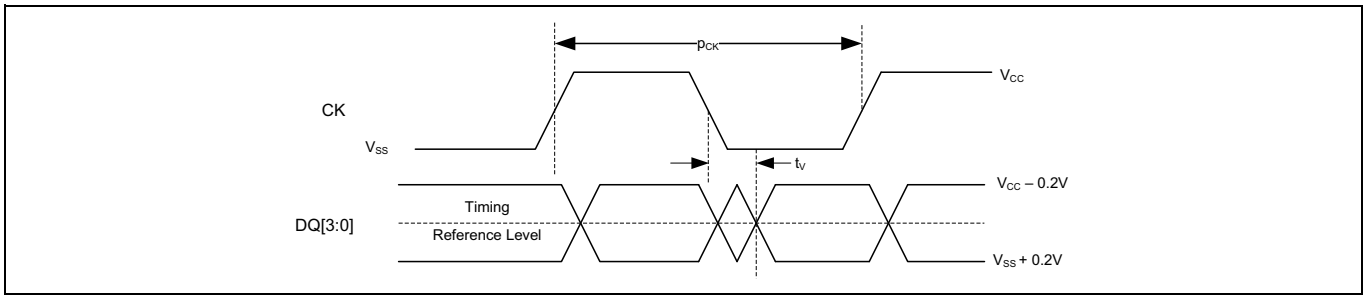


Figure 77 DDR output timing reference level

8.1.3 Clock timing

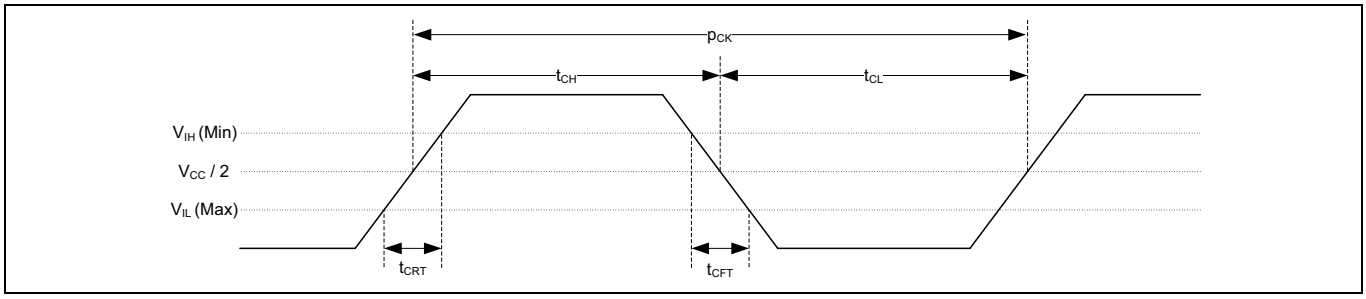


Figure 78 Clock timing

8.1.4 Input / output timing

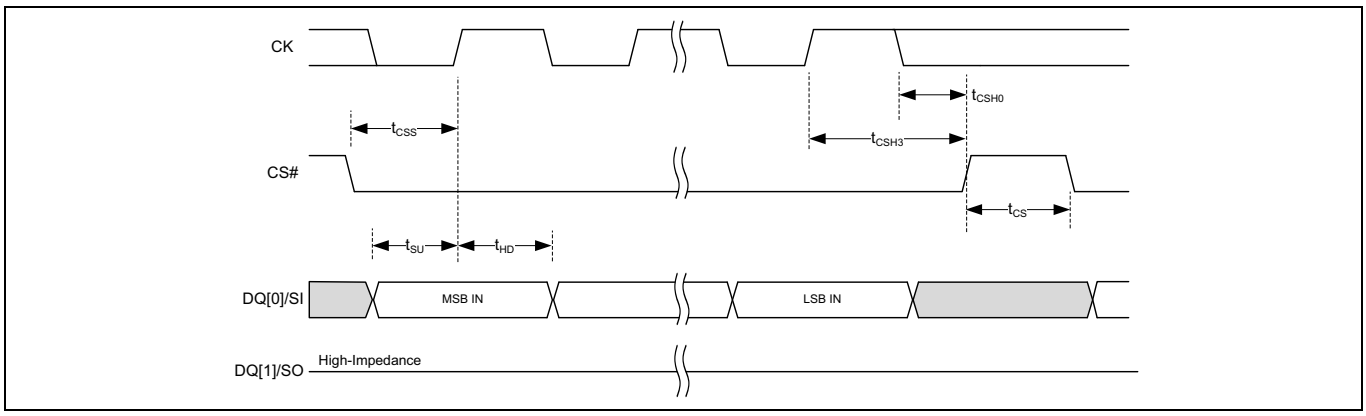


Figure 79 SPI input timing

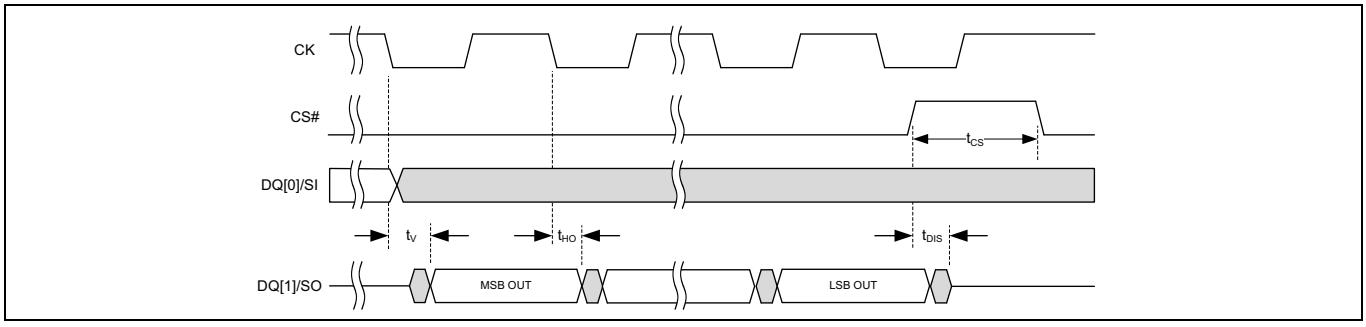


Figure 80 SPI output timing

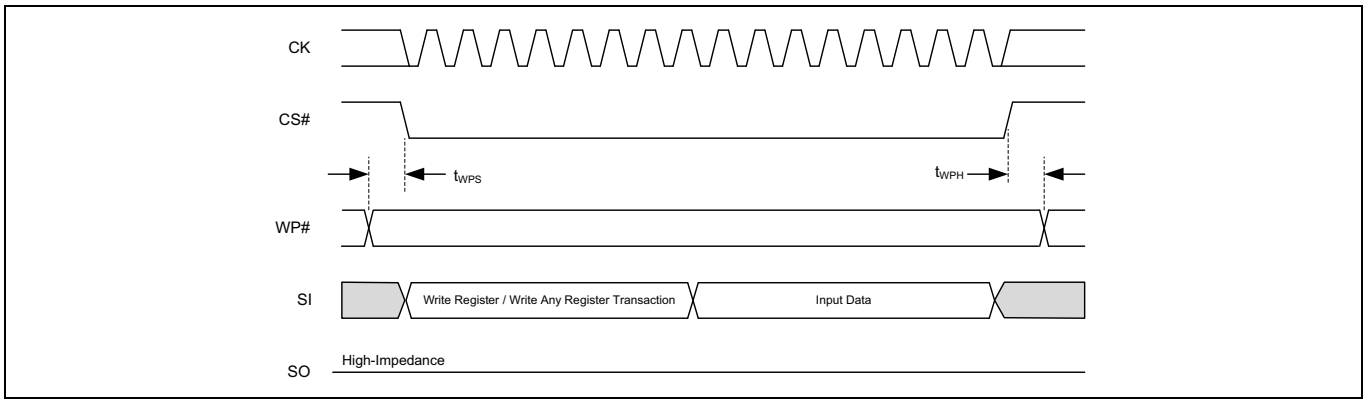


Figure 81 WP# input timing

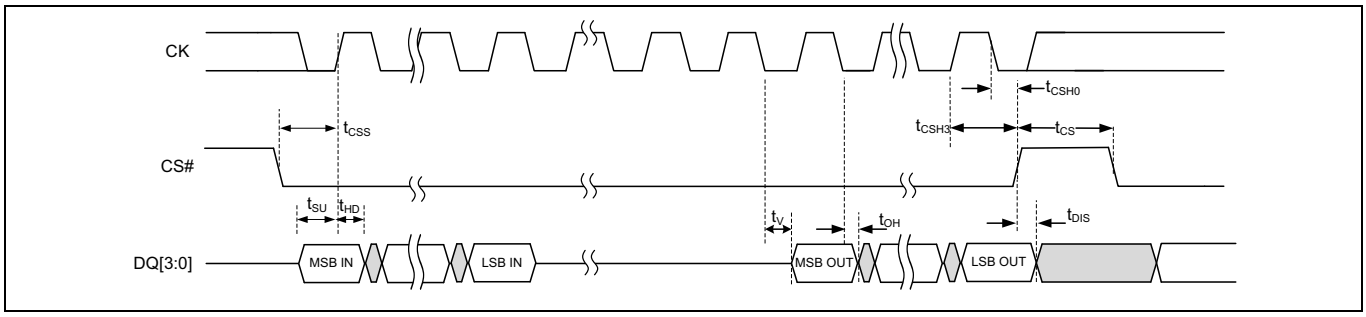


Figure 82 Quad and QPI SDR input and output timing

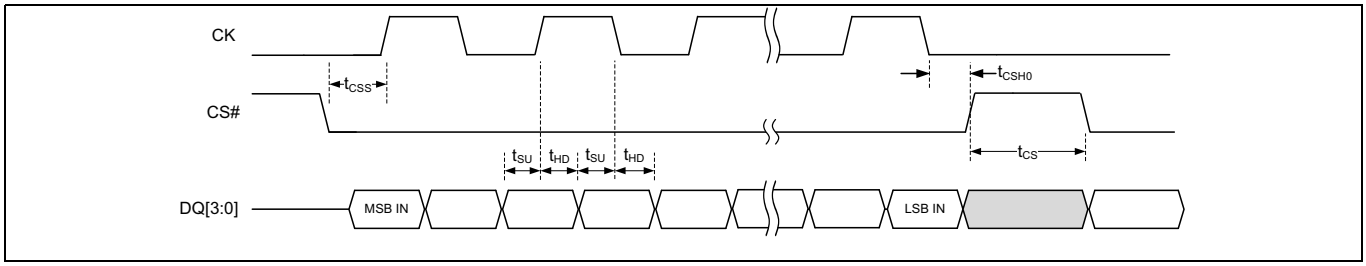


Figure 83 Quad and QPI DDR input timing

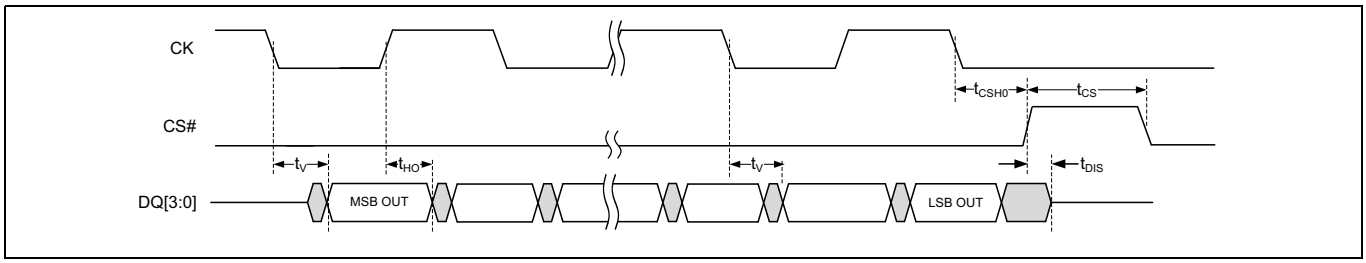


Figure 84 Quad and QPI DDR output timing

9 Device identification

9.1 JEDEC SFDP Rev D

9.1.1 JEDEC SFDP Rev D header table

Table 85 JEDEC SFDP Rev D header table

SFDP byte address	SFDP DWORD name	Data	Description
00h	SFDP Header	53h	This is the entry point for Read SFDP (5Ah) command i.e., location zero within SFDP space ASCII “S”
01h		46h	ASCII “F”
02h		44h	ASCII “D”
03h		50h	ASCII “P”
04h		08h	SFDP Minor Revision (08h = JEDEC JESD216 Revision D)
05h		01h	SFDP Major Revision (01h = JEDEC JESD216 Revision D) This is the original major revision. This major revision is compatible with all SFDP reading and parsing software.
06h		03h	Number of Parameter Headers (zero based, 03h = 4 parameters)
07h		FFh	SFDP Access Protocol (Backward Compatible)
08h	1st Parameter Header	00h	Parameter ID LSB (00h = JEDEC SFDP Basic SPI Flash Parameter)
09h		00h	Parameter Minor Revision (00h = JEDEC JESD216 Revision D)
0Ah		01h	Parameter Major Revision (01h = The original major revision - all SFDP software is compatible with this major revision.
0Bh		14h	Parameter Table Length (14h = 20 DWORDs are in the Parameter table)
0Ch		00h	Parameter Table Pointer Byte 0 (DWORD = 4-byte aligned) JEDEC Basic SPI Flash parameter byte offset = 0100h
0Dh		01h	Parameter Table Pointer Byte 1
0Eh		00h	Parameter Table Pointer Byte 2
0Fh		FFh	Parameter ID MSB (FFh = JEDEC defined legacy Parameter ID)
10h	2nd Parameter Header	84h	Parameter ID LSB (84h = 4-Byte Address Instruction Table)
11h		00h	Parameter Table Minor Revision (00h = JEDEC JESD216 Revision D)
12h		01h	Parameter Table Major Revision (01h = JEDEC JESD216 Revision D)
13h		02h	Parameter Table Length (2h = 2 DWORDs are in the Parameter table)
14h		50h	Parameter Table Pointer Byte 0 (DWORD = 4-byte aligned) 4-Byte Address Instruction Table byte offset = 0150h address
15h		01h	Parameter Table Pointer Byte 1
16h		00h	Parameter Table Pointer Byte 2
17h		FFh	Parameter ID MSB (FFh = JEDEC defined Parameter)
18h	3rd Parameter Header	81h	Parameter ID LSB (81h = JEDEC Sector Map)
19h		00h	Parameter Table Minor Revision (00h = JEDEC JESD216 Revision D)
1Ah		01h	Parameter Table Major Revision (01h = JEDEC JESD216 Revision D)
1Bh		16h	Parameter Table Length (16h = 22 DWORDs are in the Parameter table)
1Ch		C8h	Parameter Table Pointer Byte 0 (DWORD = 4 byte aligned) JEDEC Sector Map = 1C8h address
1Dh		01h	Parameter Table Pointer Byte 1
1Eh		00h	Parameter Table Pointer Byte 2
1Fh		FFh	Parameter ID MSB (FFh = JEDEC defined Parameter)

Table 85 JEDEC SFDP Rev D header table *(continued)*

SFDP byte address	SFDP DWORD name	Data	Description
20h	4th Parameter Header	87h	Parameter ID LSB (87h = JEDEC Status, Control and Configuration Register Map)
21h		00h	Parameter Table Minor Revision (00h = JEDEC JESD216 Revision D)
22h		01h	Parameter Table Major Revision (01h = JEDEC JESD216 Revision D)
23h		1Ch	Parameter Table Length (1Ch = 28 DWORDs are in the Parameter table)
24h		58h	Parameter Table Pointer Byte 0 (DWORD = 4 byte aligned) JEDEC Status, Control and Configuration Register Map = 158h address
25h		01h	Parameter Table Pointer Byte 1
26h		00h	Parameter Table Pointer Byte 2
27h		FFh	Parameter ID MSB (FFh = JEDEC defined Parameter)

9.1.2 JEDEC SFDP Rev D parameter table

For the SFDP data structure, there are three independent parameter tables. Two of the tables have a fixed length and one table has a variable structure and length depending on the device density Ordering Part Number (OPN). The Parameter table is presented as single table in **Table 86**.

Table 86 JEDEC SFDP Rev D parameter table

SFDP byte address	SFDP DWORD name	Data	Description
100h	JEDEC Basic Flash Parameter DWORD-1	E7h	Bits 7:5 = unused = 111b Bit 4 = 50h is Volatile Status Register write instruction and Status Register is default = 0b Bit 3 = Block Protect Bits are nonvolatile / volatile nonvolatile = 0b Bit 2 = Program Buffer > 64Bytes = 1b Bits 1:0 = Uniform 4KB erase is unavailable = 11b
101h		20h	Bits 15:8 = 4KB erase opcode = 20h
102h		FAh	Bit 23 = Unused = 1b Bit 22 = Supports Quad Out (1-1-4) Read = Yes = 1b Bit 21 = Supports Quad I/O (1-4-4) Read = Yes =1b Bit 20 = Supports Dual I/O (1-2-2) Read = Yes = 1b Bit 19 = Supports DDR = Yes = 1b Bit 18:17 = Number of Address Bytes = 3- or 4-Bytes = 01b Bit 16 = Supports Dual Out (1-1-2) Read = No = 0b
103h		FFh	Bits 31:24 = Unused = FFh
104h	JEDEC Basic Flash Parameter DWORD-2	FFh	Density in bits, zero based, 256Mb = 0FFFFFFFh Density in bits, zero based, 512Mb = 1FFFFFFFh Density in bits, zero based, 1Gb = 3FFFFFFFh
105h		FFh	
106h		FFh	
107h		0Fh (256Mb) 1Fh (512Mb) 3Fh (1Gb)	
108h	JEDEC Basic Flash Parameter DWORD-3	48h	Bits 7:5 = number of Quad I/O (1-4-4) Mode cycles = 010b Bits 4:0 = number of Quad I/O Dummy cycles = 01000b (Initial Delivery State)
109h		EBh	Quad I/O instruction code
10Ah		08h	Bits 23:21 = number of Quad Out (1-1-4) Mode cycles = 000b Bits 20:16 = number of Quad Out Dummy cycles = 01000b
10Bh		6Bh	1-1-4 Quad Out instruction code = 6Bh
10Ch	JEDEC Basic Flash Parameter DWORD-4	00h	Bits 7:5 = number of Dual Out (1-1-2) Mode cycles = 000b Bits 4:0 = number of Dual Out Dummy cycles = 00000b
10Dh		FFh	Dual Out instruction code
10Eh		88h	Bits 23:21 = number of Dual I/O (1-2-2) Mode cycles = 100b Bits 20:16 = number of Dual I/O Dummy cycles = 01000b (Initial Delivery State)
10Fh		BBh	Dual I/O instruction code
110h	JEDEC Basic Flash Parameter DWORD-5	FEh	Bits 7:5 RFU = 111b Bit 4 = QPI supported = Yes = 1b Bits 3:1 RFU = 111b Bit 0 = 2-2-2 not supported = 0b
111h		FFh	Bits 15:8 = RFU = FFh
112h		FFh	Bits 23:16 = RFU = FFh
113h		FFh	Bits 31:24 = RFU = FFh
114h	JEDEC Basic Flash Parameter DWORD-6	FFh	Bits 7:0 = RFU = FFh
115h		FFh	Bits 15:8 = RFU = FFh
116h		00h	Bits 23:21 = number of 2-2-2 Mode cycles = 000b Bits 20:16 = number of 2-2-2 Dummy cycles = 00000b
117h		FFh	2-2-2 instruction code
118h	JEDEC Basic Flash Parameter DWORD-7	FFh	Bits 7:0 = RFU = FFh
119h		FFh	Bits 15:8 = RFU = FFh
11Ah		48h	Bits 23:21 = Number of QPI Mode cycles = 010b Bits 20:16 = Number of QPI Dummy cycles = 01000b
11Bh		EBh	QPI mode Quad I/O (4-4-4) instruction code

Table 86 JEDEC SFDP Rev D parameter table *(continued)*

SFDP byte address	SFDP DWORD name	Data	Description
11Ch	JEDEC Basic Flash Parameter DWORD-8	0Ch	Erase type 1 size 2^N Bytes = 2^12 Bytes = 4KB (Initial Delivery State)
11Dh		20h	Erase type 1 instruction
11Eh		00h	Erase type 2 size 2^N Bytes = Not Supported
11Fh		FFh	Erase type 2 instruction = Not Supported = FFh
120h	JEDEC Basic Flash Parameter DWORD-9	00h	Erase type 3 size 2^N Bytes = Not Supported
121h		FFh	Erase type 3 instruction = Not Supported = FFh
122h		12h	Erase type 4 size 2^N Bytes = 2^18 Bytes = 256KB
123h		D8h	Erase type 4 instruction = D8h
124h	JEDEC Basic Flash Parameter DWORD-10	23h	Bits 31:30 = Erase type 4 Erase, Typical time units (00b: 1 ms, 01b: 16 ms, 10b: 128 ms, 11b: 1 s) = 128 ms = 10b Bits 29:25 = Erase type 4 Erase, Typical time count = 00101b (typ erase time = count + 1 * units = 6 * 128 ms = 768 ms) Bits 24:23 = Erase type 3 Erase, Typical time units (00b: 1 ms, 01b: 16 ms, 10b: 128 ms, 11b: 1 s) = 1S = 11b (RFU) Bits 22:18 = Erase type 3 Erase, Typical time count = 11111b (RFU) Bits 17:16 = Erase type 2 Erase, Typical time units (00b: 1 ms, 01b: 16 ms, 10b: 128 ms, 11b: 1 s) = 1S = 11b (RFU) Bits 15:11 = Erase type 2 Erase, Typical time count = 11111b (RFU) Bits 10:9 = Erase type 1 Erase, Typical time units (00b: 1 ms, 01b: 16 ms, 10b: 128 ms, 11b: 1 s) = 16mS = 01b Bits 8:4 = Erase type 1 Erase, Typical time count = 00010b (typ erase time = count + 1 * units = 3 * 16 ms = 48 ms) Bits 3:0 = Count = (Max Erase time / (2 * Typical Erase time)) – 1 = 0011b
125h		FAh	
126h		FFh	
127h		8Bh	
128h	JEDEC Basic Flash Parameter DWORD-11	82h	Bits 31 = Reserved = 1b Bits 30:29 = Chip Erase Typical time units (00b: 16 ms, 01b: 256 ms, 10b: 4 s, 11b: 64 s) = 11b (256M, 512M, and 1G) Bits 28:24 = Chip Erase Typical time count = 00001b (256M), 00011b (512M), and 00110b (1G) Bits 23:19 = Byte Program Typical Time, additional byte = 11111b Bits 18:14 = Byte Program Typical Time, first byte = 11111b Bits 13 = Page Program Typical Time unit (0: 8 µs, 1: 64 µs) = 64 µs = 1b Bits 12:8 = Page Program Typical Time Count = 00111 (typ Program time = count +1 * units = 8 * 64 µs = 512 µs) Bits 7:4 = Page Size (256B) = 2^N bytes = 1000h Bits 3:0 = Count = [Max page program time / (2 * Typical page program time)] – 1 = 0010b
129h		E7h	
12Ah		FFh	
12Bh		E1h for 256M E3h for 512M E6h for 1G	
12Ch	JEDEC Basic Flash Parameter DWORD-12	ECh	Bit 31 = Suspend and Resume supported = 0b Bits 30:29 = Suspend in-progress erase max latency units (00b: 128ns, 01b: 1µs, 10b: 8µs, 11b: 64µs) = 8 µs = 10b Bits 28:24 = Suspend in-progress erase max latency count = 01001b, max erase suspend latency = count +1 * units = 10 * 8 µs = 80 µs Bits 23:20 = Erase resume to suspend interval count = 0001b, interval = count +1 * 64 µs = 2 * 64 µs = 128 µs Bits 19:18 = Suspend in-progress program max latency units (00b: 128ns, 01b: 1us, 10b: 8us, 11b: 64µs) = 8 µs = 10b Bits 17:13 = Suspend in-progress program max latency count = 01001b, max program suspend latency = count +1 * units = 10 * 8 µs = 80 µs Bits 12:9 = Program resume to suspend interval count = 0001b, interval = count + 1 * 64 µs = 2 * 64 µs = 128 µs Bit 8 = Reserved = 1b Bits 7:4 = Prohibited operations during erase suspend = xxx0b: May not initiate a new erase anywhere (erase nesting not permitted) + xx1xb: May not initiate a page program in the erase suspended sector size + x1xxb: May not initiate a read in the erase suspended sector size + 1xxxb: The erase and program restrictions in bits 5:4 are sufficient = 1110b Bits 3:0 = Prohibited Operations During Program Suspend = xxx0b: May not initiate a new erase anywhere (erase nesting not permitted) + xx0xb: May not initiate a new page program anywhere (program nesting not permitted) + x1xxb: May not initiate a read in the program suspended page size + 1xxxb: The erase and program restrictions in bits 1:0 are sufficient = 1100b
12Dh		23h	
12Eh		19h	
12Fh		49h	
130h	JEDEC Basic Flash Parameter DWORD-13	8Ah	Bits 31:24 = Erase Suspend Instruction = 75h Bits 23:16 = Erase Resume Instruction = 7Ah Bits 15:8 = Program Suspend Instruction = 85h Bits 7:0 = Program Resume Instruction = 8Ah
131h		85h	
132h		7Ah	
133h		75h	

Table 86 JEDEC SFDP Rev D parameter table *(continued)*

SFDP byte address	SFDP DWORD name	Data	Description
134h	JEDEC Basic Flash Parameter DWORD-14	F7h	Bits 7:4 = RFU = Fh Bit 3:2 = Status Register Polling Device Busy = 01b: Legacy status polling supported = Use legacy polling by reading the Status Register with 05h instruction and checking WIP bit[0] (0 = ready; 1 = busy). Bits 1:0 = RFU = 11b
135h		66h	Bit 31 = DPD Supported = supported = 0 Bits 30:23 = Enter DPD Instruction = B9h Bits 22:15 = Exit DPD Instruction not supported = 00h Bits 14:13 = Exit DPD to next operation delay units = (00b: 128ns, 01b: 1µs, 10b: 8µs, 11b: 64µs) = 64 µs = 11b Bits 12:8 = Exit DPD to next operation delay count = 00110, Exit DPD to next operation delay = (count+1) * units = (6 + 1) * 64 µs = 448 µs
136h		80h	
137h		5Ch	
138h	JEDEC Basic Flash Parameter DWORD-15	8Ch	Bits 31:24 = RFU = FFh Bit 23 = HOLD or RESET Disable = Supported = 1 Bits 22:20 = Quad Enable Requirements = 101b = 101b: QE is bit 1 of the Status Register-2. Status Register-1 is read using Read Status instruction 05h. Status Register-2 is read using instruction 35h. QE is set via Write Status instruction 01h with two data bytes where bit 1 of the second byte is one. It is cleared via Write Status with two data bytes where bit 1 of the second byte is zero. Bits 19:16 = 0-4-4 Mode Entry Method = xxx1b: Mode Bits[7:0] = A5h Note: QE must be set prior to using this mode + x1xxb: Mode Bit[7:0] = Axh + 1xxxb: RFU = 1101b Bits 15:10 = 0-4-4 Mode Exit Method = xx_xxx1b: Mode Bits[7:0] = 00h will terminate this mode at the end of the current read operation + xx_x1xxb: RFU + xx_1xxxb: Input Fh (mode bit reset) on DQ0-DQ3 for 8 clocks. This will terminate the mode prior to the next read operation. + x1_xxxxb: Mode Bit[7:0] != Axh + 1x_x1xxb: RFU = 11_0101b Bit 9 = 0-4-4 mode supported = 1b Bits 8:4 = 4-4-4 mode enable sequences = x_xx1xb: Issue instruction 38h. + x_1xxxb: Device uses a read-modify-write sequence of operations: read configuration using instruction 65h followed by address 800003h, set bit 6, write configuration using instruction 71h followed by address 800003h. This configuration is volatile. = 01000 Bits 3:0 = 4-4-4 mode disable sequences = xxx1b: Issue FFh instruction + xx0xb: Issue F5h instruction + x1xxb: Device uses a read-modify-write sequence of operations: read configuration using instruction 65h followed by address 800003h, clear bit 6, write configuration using instruction 71h followed by address 800003h. This configuration is volatile. + 1xxxb: Issue the Soft Reset 66/99 sequence = 1100
139h		D6h	
13Ah		DDh	
13Bh		FFh	
13Ch	JEDEC Basic Flash Parameter DWORD-16	F9h	Bits 31:24 = Enter 4-Byte Addressing = xxxx_xxx1b: issue instruction B7h (preceding write enable not required) + xx1x_xxxxb: Supports dedicated 4-Byte address instruction set. Refer to the vendor datasheet for the instruction set definition. + 1xxx_xxxxb: Reserved = 10100001b Bits 23:14 = Exit 4-Byte Addressing = xx_xx1x_xxxxb: Hardware reset + xx_x1xx_xxxxb: Software reset (see bits 13:8 in this DWORD) + xx_1xxx_xxxxb: Power cycle + x1_xxxx_xxxxb: Reserved + 1x_xxxx_xxxxb: Reserved = 11_1110_0000b Bits 13:8 = Soft Reset and Rescue Sequence Support = x1_xxxxb: Issue reset enable instruction 66h, then issue reset instruction 99h. The reset enable, reset sequence may be issued on 1, 2, or 4 wires depending on the device operating mode. + 1x_xxxxb: Exit 0-4-4 mode is required prior to other reset sequences above if the device may be operating in this mode. = 111000b Bit 7 = RFU = 1 Bits 6:0 = Volatile or Nonvolatile Register and Write Enable Instruction for Status Register 1 = xxx_xxx1b: Nonvolatile Status Register 1, powers-up to last written value, use instruction 06h to enable write. + xxx_1xxxb: Nonvolatile/Volatile Status Register 1 powers-up to last written value in the nonvolatile status register, use instruction 06h to enable write to nonvolatile status register. Volatile status register may be activated after power-up to override the nonvolatile status register, use instruction 50h to enable write and activate the volatile status register. + xx1_xxxxb: Status Register 1 contains a mix of volatile and nonvolatile bits. The 06h instruction is used to enable writing of the register. + x1x_xxxxb: Reserved + 1xx_xxxxb: Reserved = 1111001b
13Dh		38h	
13Eh		F8h	
13Fh		A1h	

Table 86 JEDEC SFDP Rev D parameter table *(continued)*

SFDP byte address	SFDP DWORD name	Data	Description
140h	JEDEC Basic Flash Parameter DWORD-17	00h	Not Supported
141h			
142h			
143h			
144h	JEDEC Basic Flash Parameter DWORD-18	00h	Bits 31: 24 = 00h Bit 23 = 1b = JEDEC SPI Protocol Reset implemented as described in JESD252 Bits 22:18 = 01111b Bits 17:0 = 000h
145h		00h	
146h		BCh	
147h		00h	
148h	JEDEC Basic Flash Parameter DWORD-19	00h	Not Supported
149h			
14Ah			
14Bh			
14Ch	JEDEC Basic Flash Parameter DWORD-20	F7h	Bits 31:16 = Not Supported = 1111_1111_1111_1111b Bit 15:12 = 1111b = 4S-4D-4D Data Strobe is not supported Bit 11:8 = 0101b = 100MHz 4S-4D-4D Bit 7:4 = 1111b = 4S-4S-4S Data Strobe is not supported Bit 0:3 = 0111b = 166MHz 4S-4S-4S
14Dh		F5h	
14Eh		FFh	
14Fh		FFh	
150h	JEDEC 4-Byte Address Instructions Parameter DWORD-1	7Bh	Supported = 1, Not Supported = 0 Bits 31:25 = Reserved = 1111_111b Bit 24 = Support for (1-8-8) Page Program Command, Instruction = 8Eh = 0b Bit 23 = Support for (1-1-8) Page Program Command, Instruction = 84h = 0b Bit 22 = Support for (1-8-8) DTR READ Command, Instruction = FDh = 0b Bit 21 = Support for (1-8-8) FAST_READ Command, Instruction = CCh = 0b Bit 20 = Support for (1-1-8) FAST_READ Command, Instruction = 7Ch = 0b Bit 19 = Support for nonvolatile individual sector lock write command, Instruction = E3h = 1b Bit 18 = Support for nonvolatile individual sector lock read command, Instruction = E2h = 1b Bit 17 = Support for volatile individual sector lock Write command, Instruction = E1h = 1b Bit 16 = Support for volatile individual sector lock Read command, Instruction = E0h = 1b Bit 15 = Support for (1-4-4) DTR_Read Command, Instruction = EEh = 1b Bit 14 = Support for (1-2-2) DTR_Read Command, Instruction = BEh = 0b Bit 13 = Support for (1-1-1) DTR_Read Command, Instruction = 0Eh = 0b Bit 12 = Support for Erase Command – Type 4 = 1b Bit 11 = Support for Erase Command – Type 3 = 0b Bit 10 = Support for Erase Command – Type 2 = 0b Bit 9 = Support for Erase Command – Type 1 = 1b Bit 8 = Support for (1-4-4) Page Program Command, Instruction = 3Eh = 0b Bit 7 = Support for (1-1-4) Page Program Command, Instruction = 34h = 0b Bit 6 = Support for (1-1-1) Page Program Command, Instruction = 12h = 1b Bit 5 = Support for (1-4-4) FAST_READ Command, Instruction = ECh = 1b Bit 4 = Support for (1-1-4) FAST_READ Command, Instruction = 6Ch = 1b Bit 3 = Support for (1-2-2) FAST_READ Command, Instruction = BCh = 1b Bit 2 = Support for (1-1-2) FAST_READ Command, Instruction = 3Ch = 0b Bit 1 = Support for (1-1-1) FAST_READ Command, Instruction = 0Ch = 1b Bit 0 = Support for (1-1-1) READ Command, Instruction = 13h = 1b
151h		92h	
152h		0Fh	
153h		FEh	
154h	JEDEC 4-Byte Address Instructions Parameter DWORD-2	21h	Bits 31:24 = D8h / DCh = Instruction fo Erase Type 4 Bits 23:16 = Instruction for Erase Type 3: RFU Bits 15:8 = Instruction for Erase Type 2: RFU Bits 7:0 = 20h / 21h = Instruction for Erase Type 1
155h		FFh	
156h		FFh	
157h		DCh	
158h	Status, Control and Configu-ration Register Map DWORD-1	00h	Bits 31:0 = Address offset for volatile registers = 00800000h
159h		00h	
15Ah		80h	
15Bh		00h	
15Ch	Status, Control and Configu-ration Register Map DWORD-2	00h	Bits 31:0 = Address offset for nonvolatile registers = 00000000h
15Dh		00h	
15Eh		00h	
15Fh		00h	

Table 86 JEDEC SFDP Rev D parameter table *(continued)*

SFDP byte address	SFDP DWORD name	Data	Description
160h	Status, Control and Configuration Register Map DWORD-3	C0h	Bit 31 = Generic Addressable Read Status/Control register command supported for some (or all) registers = 1b Bit 30 = Generic Addressable Write Status/Control register command supported for some (or all) registers = 1b Bits 29:28 = Number of address bytes used for Generic Addressable Read/Write Status/Control register commands = 3 byte (default) = 10b Bit 27:26 = Use the number of bits as defined in bits 3:0 in this DWORD = 10b Bit 25:22 = Number of dummy cycles used for Generic Addressable Read Status/Control register command in (2S-2S-2S) mode not supported = 1111b Bit 21:18 = Number of dummy cycles used for Generic Addressable Read Status/Control register command in (4S-4S-4S) mode = 1 = 0000b Bit 17:14 = Number of dummy cycles used for Generic Addressable Read Status/Control register command in (4S-4D-4D) mode note supported = 1111b Bit 13:10 = Number of dummy cycles used for Generic Addressable Read Status/Control register command in (8S-8S-8S) mode note supported = 1111b Bit 9:6 = Number of dummy cycles used for Generic Addressable Read Status/Control register command in (8D-8D-8D) mode note supported = 1111b Bit 5:4 = Reserved = 00b Bit 3:0 = Number of dummy cycles used for Generic Addressable Read Status/Control register command for volatile registers in (1S-1S-1S) mode = 0000b
161h		FFh	
162h		C3h	
163h		EBh	
164h	Status, Control and Configuration Register Map DWORD-4	C8h	Bit 31 = Generic Addressable Read Status/Control register command for nonvolatile registers supported for some (or all) registers = 1b Bit 30 = Generic Addressable Write Status/Control register command for nonvolatile registers supported for some (or all) registers = 1b Bits 29:28 = Number of address bytes used for Generic Addressable Read/Write Status/Control register commands for nonvolatile registers = 3 byte (default) = 10b Bit 27:26 = Number of dummy bytes used for Generic Addressable Read Status/Control register command for nonvolatile registers in (1S-1S-1S) mode not supported = 10b Bit 25:22 = Number of dummy cycles used for Generic Addressable Read Status/Control register command in (2S-2S-2S) mode not supported = 1111b Bit 21:18 = Number of dummy cycles used for Generic Addressable Read Status/Control register command in (4S-4S-4S) mode = 1 = 1000b Bit 17:14 = Number of dummy cycles used for Generic Addressable Read Status/Control register command in (4S-4D-4D) mode note supported = 1111b Bit 13:10 = Number of dummy cycles used for Generic Addressable Read Status/Control register command in (8S-8S-8S) mode note supported = 1111b Bit 9:6 = Number of dummy cycles used for Generic Addressable Read Status/Control register command in (8D-8D-8D) mode note supported = 1111b Bit 5:4 = Reserved = 00b Bit 3:0 = Number of dummy cycles used for Generic Addressable Read Status/Control register command for non volatile registers in (1S-1S-1S) mode = 1000b
165h		FFh	
166h		E3h	
167h		EBh	
168h	Status, Control and Configuration Register Map DWORD-5	00h	Bits 7:0 = Command used for write access = read only = 00h
169h		65h	Bits 15:8 = Command used for read access = 65h
16Ah		00h	Bits 23:16 = Address of register where WIP is located = 00h (status reg -1 volatile)
16Bh		90h	Bit 31 = Write In Progress (WIP) bit is supported = 1b Bit 30 = Write In Progress polarity, WIP = 1 means write is in progress = 0b Bits 29 = Reserved = 0b Bits 28 = Bit is set /cleared by commands using address = 1b Bit 27 = Not supported = 0b Bits 26:24 = Bit location of WIP bit in register = bit [0] = 000b
16Ch	Status, Control and Configuration Register Map DWORD-6	06h	Bits 7:0 = Command used for write access = 06h
16Dh		05h	Bits 15:8 = Command used for read access = 05h
16Eh		00h	Bits 23:16 = Address of register where WEL is located = 00h (status reg -1 volatile)
16Fh		A1h	Bit 31 = Write Enable (WEL) bit is supported = 1b Bit 30 = Write Enable polarity, WEL = 1 means write is in progress = 0b Bits 29 = Write command is a direct command to set WEL bit = 1b Bits 28 = Bit is accessed by direct commands to set WEL bit = 0b Bit 27 = Local address for WEL bit is found in last byte of the address = 0b Bits 26:24 = Bit location of WEL bit in register = bit [1] = 001b
170h	Status, Control and Configuration Register Map DWORD-7	00h	Bits 7:0 = Command used for write access = read only = 00h = Read Only
171h		65h	Bits 15:8 = Command used for read access = 65h
172h		00h	Bits 23:16 = Address of register where Erase Error is located = 00h
173h		96h	Bit 31 = Program Error bit supported = 1b Bit 30 = Positive polarity (Program Error = 0 means no error, Program Error = 1 means last Program operation created an error) = 0b Bit 29 = The device has separate bits for Program Error and Erase Error = 0b Bits 28 = Bit is set/cleared by commands using address = 1b Bit 27 = 0b Bits 26:24 = Bit location of Program Error bit in register = bit [6] = 110b

Table 86 JEDEC SFDP Rev D parameter table *(continued)*

SFDP byte address	SFDP DWORD name	Data	Description
174h	Status, Control and Configuration Register Map DWORD-8	00h	Bits 7:0 = Command used for write access = read only = 00h = Read Only
175h		65h	Bits 15:8 = Command used for read access = 65h
176h		00h	Bits 23:16 = Address of register where Erase Error is located = 00h
177h		95h	Bit 31 = Erase Error bit supported = 1b Bit 30 = Positive polarity Erase Error = 0 means no error, Erase Error = 1 means last erase operation created an error) = 0b Bit 29 = The device has separate bits for Program Error and Erase Error = 0b Bits 28 = Bit is set/cleared by commands using address = 1b Bit 27 = Reserved = 0b Bits 26:24 = Bit location of erase Error bit in register = bit [5] = 101b
178h	Status, Control and Configuration Register Map DWORD-9	71h	Bits 7:0 = Command used for write access = 71h
179h		65h	Bits 15:8 = Command used for read access = 65h
17Ah		03h	Address of register where wait states bits are located = 800003h (Configuration Reg - 2 volatile)
17Bh		D0h	Bit 31 = Variable number of dummy cycles supported = 1b Bits 30:29 = Number of physical bits used to set wait states - 4 bit = 10b Bits 28 = Bit is set/cleared by commands using address = 1b Bit 27 = Local Address for Variable Dummy Cycle Setting bits in last address = 0b Bits 26:24 = Bit location of LSB of physical bits in register = bit [0] = 000b
17Ch	Status, Control and Configuration Register Map DWORD-10	71h	Bits 7:0 = Command used for write access = 71h
17Dh		65h	Bits 15:8 = Command used for read access = 65h
17Eh		03h	Address of register where wait states bits are located = 03h (Configuration Reg - 2 Nonvolatile)
17Fh		D0h	Bit 31 = Variable number of dummy cycles supported = 1b Bits 30:29 = Number of physical bits used to set wait states - 4 bit = 10b Bits 28 = Bit is set/cleared by commands using address = 1b Bit 27 = Local Address for Variable Dummy Cycle Setting bits in last address = 0b Bits 26:24 = Bit location of LSB of physical bits in register = bit [0] = 000b
180h	Status, Control and Configuration Register Map DWORD-11	00h	Bit 31 = 30 dummy cycles supported = 0b Bit 30:26 = Bit pattern used to set 30 dummy cycles = 00000b Bit 25 = 28 dummy cycles supported = 0b Bit 24:20 = Bit pattern used to set 28 dummy cycles = 00000b Bit 19 = 26 dummy cycles supported = 0b Bit 18:14 = Bit pattern used to set 26 dummy cycles = 00000b Bit 13 = 24 dummy cycles supported = 0b Bit 12:8 = Bit pattern used to set 24 dummy cycles = 00000b Bit 7 = 22 dummy cycles supported = 0b Bit 6:2 = Bit pattern used to set 22 dummy cycles = 00000b Bits 1:0 = Reserved = 00b
181h		00h	
182h		00h	
183h		00h	
184h	Status, Control and Configuration Register Map DWORD-12	B0h	Bit 31 = 20 dummy cycles supported = 0b Bit 30:26 = Bit pattern used to set 20 dummy cycles = 00000b Bit 25 = 18 dummy cycles supported = 0b Bit 24:20 = Bit pattern used to set 18 dummy cycles = 00000b Bit 19 = 16 dummy cycles supported = 0b Bit 18:14 = Bit pattern used to set 16 dummy cycles = 00000b Bit 13 = 14 dummy cycles supported = 1b Bit 12:8 = Bit pattern used to set 14 dummy cycles = 01110b Bit 7 = 12 dummy cycles supported = 1b Bit 6:2 = Bit pattern used to set 12 dummy cycles = 01100b Bits 1:0 = Reserved = 00b
185h		2Eh	
186h		00h	
187h		00h	
188h	Status, Control and Configuration Register Map DWORD-13	88h	Bit 31 = 10 dummy cycles supported = 1b Bit 30:26 = Bit pattern used to set 10 dummy cycles = 01010b Bit 25 = 8 dummy cycles supported = 1b Bit 24:20 = Bit pattern used to set 8 dummy cycles = 01000b Bit 19 = 6 dummy cycles supported = 1b Bit 18:14 = Bit pattern used to set 6 dummy cycles = 00110b Bit 13 = 4 dummy cycles supported = 1b Bit 12:8 = Bit pattern used to set 4 dummy cycles = 00100b Bit 7 = 2 dummy cycles supported = 1b Bit 6:2 = Bit pattern used to set 2 dummy cycles = 00010b Bits 1:0 = Reserved = 00b
189h		A4h	
18Ah		89h	
18Bh		AAh	
18Ch	Status, Control and Configuration Register Map DWORD-14	71h	Bits 7:0 = Command used for write access = 71h
18Dh		65h	Bits 15:8 = Command used for read access = 65h
18Eh		03h	Address of register where wait states bits are located = 800003h (Configuration Reg - 2 Volatile)
18Fh		96h	Bit 31 = QPI Mode Enable Volatile supported = 1b Bit 30 = QPI Mode Enable bit polarity (Positive QPI mode bit = 1 enabled) = 0b Bit 29 = Reserved = 0b Bit 28 = Bit is set/cleared by commands using address = 1b Bit 27 = Local Address for Variable Dummy Cycle Setting bits in last address = 0b Bits 26:24 = Bit location of QPI mode enable in register = bit [6] = 110b

Table 86 JEDEC SFDP Rev D parameter table *(continued)*

SFDP byte address	SFDP DWORD name	Data	Description
190h	Status, Control and Configuration Register Map DWORD-15	71h	Bits 7:0 = Command used for write access = 71h
191h		65h	Bits 15:8 = Command used for read access = 65h
192h		03h	Address of register where wait states bits are located = 03h (Configuration Reg - 2 Nonvolatile)
193h		96h	Bit 31 = QPI Mode Enable Nonvolatile supported = 1b Bit 30 = QPI Mode Enable bit polarity (Positive QPI mode bit = 1 enabled) = 0b Bit 29 = Reserved = 0b Bit 28 = Bit is set/cleared by commands using address = 1b Bit 27 = Local Address for Variable Dummy Cycle Setting bits in last address = 0b Bits 26:24 = Bit location of QPI mode enable in register = bit [6] = 110b
194h	Status, Control and Configuration Register Map DWORD-16	00h	Not Supported
195h		00h	
196h		00h	
197h		00h	
198h	Status, Control and Configuration Register Map DWORD-17	00h	
199h		00h	
19Ah		00h	
19Bh		00h	
19Ch	Status, Control and Configuration Register Map DWORD-18	00h	
19Dh		00h	
19Eh		00h	
19Fh		00h	
1A0h	Status, Control and Configuration Register Map DWORD-19	00h	Not Supported
1A1h		00h	
1A2h		00h	
1A3h		00h	
1A4h	Status, Control and Configuration Register Map DWORD-20	00h	
1A5h		00h	
1A6h		00h	
1A7h		00h	
1A8h	Status, Control and Configuration Register Map DWORD-21	00h	
1A9h		00h	
1AAh		00h	
1ABh		00h	
1ACh	Status, Control and Configuration Register Map DWORD-22	00h	
1ADh		00h	
1AEh		00h	
1AFh		00h	
1B0h	Status, Control and Configuration Register Map DWORD-23	00h	
1B1h		00h	
1B2h		00h	
1B3h		00h	
1B4h	Status, Control and Configuration Register Map DWORD-24	00h	
1B5h		00h	
1B6h		00h	
1B7h		00h	
1B8h	Status, Control and Configuration Register Map DWORD-25	00h	
1B9h		00h	
1BAh		00h	
1BBh		00h	

Table 86 JEDEC SFDP Rev D parameter table *(continued)*

SFDP byte address	SFDP DWORD name	Data	Description
1BCh	Status, Control and Configuration Register Map DWORD-26	71h	Bits 7:0 = Command used for write access = 71h
1BDh		65h	Bits 15:8 = Command used for read access = 65h
1BEh		05h	Address of register where Output Driver Strength volatile bits are located = 800005h (Configuration Reg - 4 Volatile)
1BFh		D5h	Bits 31: 30 = Number of physical bits used to set Output Driver Strength = 3 bits = 11b Bit 29 = Reserved = 0b Bits 28 = Bit is set/cleared by commands using address = 1b Bit 27 = Not supported = 0b Bits 26:24 = Bit location of Least Significant Output Driver Strength bit in register = bit [5] = 101b
1C0h	Status, Control and Configuration Register Map DWORD-27	71h	Bits 7:0 = Command used for write access = 71h
1C1h		65h	Bits 15:8 = Command used for read access = 65h
1C2h		05h	Address of register where Output Driver Strength volatile bits are located = 05h (Configuration Reg - 4 Nonvolatile)
1C3h		D5h	Bits 31: 30 = Number of physical bits used to set Output Driver Strength = 3 bits = 11b Bit 29 = Reserved = 0b Bits 28 = Bit is set/cleared by commands using address = 1b Bit 27 = Not supported = 0b Bits 26:24 = Bit location of Least Significant Output Driver Strength bit in register = bit [5] = 101b
1C4h	Status, Control and Configuration Register Map DWORD-28	00h	Bits 7:0 = Reserved = 00h
1C5h		00h	Bits 15:8 = Reserved = 00h
1C6h		A0h	Bits 31:29 = Bit pattern to support Driver type 0 = 45 Ohm = 000b Bits 28:26 = Bit pattern to support Driver type 1 = 30 Ohm = 101b Bits 25:23 = Bit pattern to support Driver type 2 = 60 Ohm = 011b Bits 22:20 = Bit pattern to support Driver type 3 = 90 Ohm = 010b Bits 19:17 = Bit pattern to support Driver type 4 = Not supported = 000b Bit 16 = Reserved = 0b
1C7h		15h	

Sector Map Parameter Table Notes

Table 87 provides a means to identify how the device address map is configured and provides a sector map for each supported configuration. This is done by defining a sequence of commands to read out the relevant configuration register bits that affect the selection of an address map. When more than one configuration bit must be read, all the bits are concatenated into an index value that is used to select the current address map.

To identify the sector map configuration in device the following configuration bits are read in the following MSb to LSb order to form the configuration map index value:

- CFR3V[3] - 0 = Hybrid Architecture, 1 = Uniform Architecture
- CFR1V[6] - 0 = 4KB parameter grouped together, 1 = 4KB sectors split between bottom and top
- CFR1V[2] - 0 = 4KB parameter sectors at bottom, 1 = 4KB sectors at top
- The value of some configuration bits may make other configuration bit values not relevant (don't care), hence not all possible combinations of the index value define valid address maps. Only selected configuration bit combinations are supported by the SFDP Sector Map Parameter Table (see **Table 88**). Other combinations must not be used in configuring the sector address map when using this SFDP parameter table to determine the sector map. The following index value combinations are supported.

Table 87 Sector map parameter

CFR3V[3]	CFR1V[6]	CFR1V[2]	Index value	Description
0	0	0	00h	4 KB sectors at bottom with remainder 256 KB sectors
0	0	1	01h	4 KB sectors at top with remainder 256 KB sectors
0	1	0	02h	4 KB sectors split between top and bottom with remainder 256 KB sectors
1	0	0	04h	Uniform 256 KB sectors

Table 88 JEDEC SFDP rev D, sector map parameter table

SFDP	SFDP DWORD name	Data	Description
1C8h	JEDEC Sector Map Parameter DWORD-1 Config. Detect-1	FCh	Config. Detect -1 Uniform 256 KB Sectors or Hybrid Sectors Bits 31:24 = Read data mask = 0000_1000b: Select bit 3 of the data byte for UNHYSA value 0 = Hybrid map with 4 KB parameter sectors 1 = Uniform map Bits 23:22 = Configuration detection command address length = 11b: Variable length Bits 21:20 = RFU = 11b Bits 19:16 = Configuration detection command latency = 1111b: variable latency Bits 15:8 = Configuration detection instruction = 65h: Read any register Bits 7:2 = RFU = 111111b Bit 1 = Command Descriptor = 0 Bit 0 = Not the end descriptor = 0
1C9h		65h	
1CAh		FFh	
1CBh		08h	
1CCh	JEDEC Sector Map Parameter DWORD-2 Config. Detect-1	04h	Bits 31:0 = Address Value Configuration Register 3 (bit 3) = 00800004h
1CDh		00h	
1CEh		80h	
1CFh		00h	
1D0h	JEDEC Sector Map Parameter DWORD-3 Config. Detect-2	FCh	Config. Detect-2 4 KB Hybrid Sectors Split between Top and Bottom Bits 31:24 = Read data mask = 0100_0000b: Select bit 6of the data byte for SP4KBS value 0 = 4 KB parameter sectors are grouped together 1 = 4 KB parameter sectors are split between High and Low Addresses Bits 23:22 = Configuration detection command address length = 11b: Variable length Bits 21:20 = RFU = 11b Bits 19:16 = Configuration detection command latency = 1111b: variable latency Bits 15:8 = Configuration detection instruction = 65h: Read any register Bits 7:2 = RFU = 111111b Bit 1 = Command Descriptor = 0 Bit 0 = Not the end descriptor = 0
1D1h		65h	
1D2h		FFh	
1D3h		40h	
1D4h	JEDEC Sector Map Parameter DWORD-4 Config. Detect-2	02h	Bits 31:0 = Address Value Configuration Register 1 (bit 6) = 00800002h
1D5h		00h	
1D6h		80h	
1D7h		00h	
1D8h	JEDEC Sector Map Parameter DWORD-5 Config. Detect-3	FDh	Config Detect-3 4 KB Hybrid Sectors on Top or Bottom Bits 31:24 = Read data mask = 0000_0100b: Select bit 2 of the data byte for TB4KBS value 0 = 4 KB parameter sectors at bottom 1 = 4 KB parameter sectors at top Bits 23:22 = Configuration detection command address length = 11b: Variable length Bits 21:20 = RFU = 11b Bits 19:16 = Configuration detection command latency = 1111b: variable latency Bits 15:8 = Configuration detection instruction = 65h: Read any register Bits 7:2 = RFU = 111111b Bit 1 = Command Descriptor = 0 Bit 0 = End of command descriptor = 1
1D9h		65h	
1DAh		FFh	
1DBh		04h	
1DCh	JEDEC Sector Map Parameter DWORD-6 Config. Detect-3	02h	Bits 31:0 = Address Value Configuration Register 1 (bit 2) = 00800002h
1DDh		00h	
1DEh		80h	
1DFh		00h	
1E0h	JEDEC Sector Map Parameter DWORD-7 Config-0 Header	FEh	Configuration Index 00h 4 KB sectors at bottom with remainder 256KB Bits 31:24 = RFU = FFh Bits 23:16 = Region count (DWORDs - 1) = 02h: Three regions Bits 15:8 = Configuration ID = 00h, 4KB sectors bottom with remainder 256KB Bits 7:2 = RFU = 111111b Bit 1 = Map Descriptor = 1 Bit 0 = Not the end descriptor = 0
1E1h		00h	
1E2h		02h	
1E3h		FFh	
1E4h	JEDEC Sector Map Parameter DWORD-8 Config-0 Region-0	F1h	Region 0 of 4 KB sectors Bits 31:8 = Region size (thirty-two 4 KB) = 0001FFh: Region size as count-1 of 256 Byte units = 32 x 4 KB sectors = 128 KB Count = 128 KB/256 = 512, value = count – 1 = 512 – 1 = 511 = 1FFh Bits 7:4 = RFU = Fh Erase Type not supported = 0 / supported = 1 Bit 3 = Erase Type 4 support = 0b ---Erase Type 4 is 256 KB erase and is not supported in the 4 KB sector Bit 2 = Erase Type 3 support = 0b ---Is not defined Bit 1 = Erase Type 2 support = 0b ---Erase Type 2 is is not defined Bit 0 = Erase Type 1 support = 1b ---Erase Type 1 is 4 KB erase and is supported in the 4 KB sector region
1E5h		FFh	
1E6h		01h	
1E7h		00h	

Table 88 JEDEC SFDP rev D, sector map parameter table *(continued)*

SFDP	SFDP DWORD name	Data	Description
1E8h	JEDEC Sector Map Parameter DWORD-9 Config-0 Region-1	F8h	Region 1 of 128 KB sector Bits 31:8 = Region size = 0001FFh: Region size as count – 1 of 256 Byte units = 1 x 128 KB sectors = 128 KB Count = 128 KB/256 = 512, value = count – 1 = 512 – 1 = 511 = 1FFh Bits 7:4 = RFU = Fh Erase Type not supported = 0 / supported = 1 Bit 3 = Erase Type 4 support = 1b ---Erase Type 4 is 256 KB erase and is supported in the 128 KB sector region Bit 2 = Erase Type 3 support = 0b ---Erase Type 3 is not defined Bit 1 = Erase Type 2 support = 0b ---Erase Type 2 is not defined Bit 0 = Erase Type 1 support = 0b --- Erase Type 1 is 4 KB erase and is not supported in the 4 KB sector region
1E9h		FFh	
1EAh		01h	
1EBh		00h	
1ECh	JEDEC Sector Map Parameter DWORD-10 Config-0 Region-2	F8h	Region 2 Uniform 256 KB sectors Bits 31:8 = 256 Mb device Region size = 01FBFFh: Region size as count – 1 of 128 Byte units = 127 x 256KB sectors = 32,512 KB Count = 32,512 KB/256 = 130,048 value = count – 1 = 130,048 – 1 = 130047 = 01FBFFh Bits 31:8 = 512 Mb device Region size = 03FBFFh: Region size as count – 1 of 256 Byte units = 255 x 256 KB sectors = 65,280 KB Count = 65,280 KB/256 = 261,120 value = count – 1 = 261,120 – 1 = 261119 = 03FBFFh Bits 31:8 = 1 Gb device Region size = 07FBFFh: Region size as count – 1 of 256 Byte units = 511 x 256 KB sectors = 130,816 KB Count = 130,816 KB/256 = 523,364, value = count – 1 = 523,364 – 1 = 523263 = 07FBFFh Bits 7:4 = RFU = Fh Erase Type not supported = 0 / supported = 1 Bit 3 = Erase Type 4 support = 1b ---Erase Type 4 is 256 KB erase and is supported in the 256 KB sector region Bit 2 = Erase Type 3 support = 0b ---Erase Type 3 is not defined Bit 1 = Erase Type 2 support = 0b ---Erase Type 2 is not defined Bit 0 = Erase Type 1 support = 0b --- Erase Type 1 is 4KB erase and is not supported in the 256KB sector region
1EDh		FFh	
1EEh		FBh	
1EFh		01h (256 Mb) 03h (512 Mb) 07h (1 Gb)	
1F0h	JEDEC Sector Map Parameter DWORD-11 Config-3 Header	FEh	Configuration Index 01h 4 KB sectors at Top with remainder 256 KB Bits 31:24 = RFU = FFh Bits 23:16 = Region count (DWORDs – 1) = 02h: Three regions Bits 15:8 = Configuration ID = 01h: 4 KB sectors at top with remainder 256 KB sectors Bits 7:2 = RFU = 111111b Bit 1 = Map Descriptor = 1 Bit 0 = Not the end descriptor = 0
1F1h		01h	
1F2h		02h	
1F3h		FFh	
1F4h	JEDEC Sector Map Parameter DWORD-12 Config-3 Region-0	F8h	Region 0 Uniform 256 KB sectors Bits 31:8 = 256 Mb device Region size = 01FBFFh: Region size as count – 1 of 128 Byte units = 127 x 256 KB sectors = 32,512 KB Count = 32,512 KB/256 = 130,048 value = count – 1 = 130,048 – 1 = 130047 = 01FBFFh Bits 31:8 = 512 Mb device Region size = 03FBFFh: Region size as count – 1 of 256 Byte units = 255 x 256 KB sectors = 65,280 KB Count = 65,280 KB/256 = 261,120 value = count – 1 = 261,120 – 1 = 261119 = 03FBFFh Bits 31:8 = 1 Gb device Region size = 07FBFFh: Region size as count – 1 of 256 Byte units = 511 x 256 KB sectors = 130,816 KB Count = 130,816 KB/256 = 523,264, value = count – 1 = 523,364 – 1 = 523263 = 07FBFFh Bits 7:4 = RFU = Fh Erase Type not supported = 0 / supported = 1 Bit 3 = Erase Type 4 support = 1b ---Erase Type 4 is 256 KB erase and is supported in the 256 KB sector region Bit 2 = Erase Type 3 support = 0b ---Erase Type 3 is not defined Bit 1 = Erase Type 2 support = 0b ---Erase Type 2 is not defined Bit 0 = Erase Type 1 support = 0b ---Erase Type 1 is 4 KB erase and is not supported in the 256 KB sector region
1F5h		FFh	
1F6h		FBh	
1F7h		01h (256 Mb) 03h (512 Mb) 07h (1 Gb)	
1F8h	JEDEC Sector Map Parameter DWORD-13 Config-3 Region-1	F8h	Region 1 of 128 KB sector Bits 31:8 = Region size = 0001FFh: Region size as count – 1 of 256 Byte units = 1 x 128 KB sectors = 128 KB Count = 128 KB/256 = 512, value = count – 1 = 512 – 1 = 511 = 1FFh Bits 7:4 = RFU = Fh Erase Type not supported = 0 / supported = 1 Bit 3 = Erase Type 4 support = 1b ---Erase Type 4 is 256 KB erase and is supported in the 128 KB sector region Bit 2 = Erase Type 3 support = 0b ---Erase Type 3 is not defined Bit 1 = Erase Type 2 support = 0b ---Erase Type 2 is not defined Bit 0 = Erase Type 1 support = 0b ---Erase Type 1 is 4 KB erase and is not supported in the 4 KB sector region
1F9h		FFh	
1FAh		01h	
1FBh		00h	
1FCh	JEDEC Sector Map Parameter DWORD-14 Config-3 Region-2	F1h	Region 2 of 4 KB sectors Bits 31:8 = Region size (thirty-two 4KB) = 0001FFh: Region size as count – 1 of 256 Byte units = 32 x 4 KB sectors = 128 KB Count = 128 KB/256 = 512, value = count – 1 = 512 – 1 = 511 = 1FFh Bits 7:4 = RFU = Fh Erase Type not supported = 0 / supported = 1 Bit 3 = Erase Type 4 support = 0b ---Erase Type 4 is 256 KB erase and is not supported in the 4 KB sector region Bit 2 = Erase Type 3 support = 0b ---Erase Type 3 is not defined Bit 1 = Erase Type 2 support = 0b ---Erase Type 2 is not defined Bit 0 = Erase Type 1 support = 1b ---Erase Type 1 is 4 KB erase and is supported in the 4 KB sector region
1FDh		FFh	
1FEh		01h	
1FFh		00h	

Table 88 JEDEC SFDP rev D, sector map parameter table *(continued)*

SFDP	SFDP DWORD name	Data	Description
200h	JEDEC Sector Map Parameter DWORD-15 Config-1 Header	FEh	Configuration Index 02h 4KB sectors split between Bottom and Top with remainder 256 KB Bits 31:24 = RFU = FFh Bits 23:16 = Region count (DWORDs – 1) = 04h: Five regions Bits 15:8 = Configuration ID = 02h: 4 KB sectors split between bottom and top with remainder 256 KB sectors Bits 7:2 = RFU = 111111b Bit 1 = Map Descriptor = 1 Bit 0 = Not the end descriptor = 0
201h		02h	
202h		04h	
203h		FFh	
204h	JEDEC Sector Map Parameter DWORD-16 Config-1 Region-0	F1h	Region 0 of 4 KB sectors Bits 31:8 = Region size (16 x 4 KB) = 0000FFh: Region size as count – 1 of 256 Byte units = 16 x 4 KB sectors = 64 KB Count = 64 KB/256 = 256, value = count – 1 = 256 – 1 = 255 = FFh Bits 7:4 = RFU = Fh Erase Type not supported = 0 / supported = 1 Bit 3 = Erase Type 4 support = 0b ---Erase Type 4 is 256 KB erase and is not supported in the 4 KB sector region Bit 2 = Erase Type 3 support = 0b ---Erase Type 3 is not defined Bit 1 = Erase Type 2 support = 0b ---Erase Type 2 is not defined Bit 0 = Erase Type 1 support = 1b ---Erase Type 1 is 4 KB erase and is supported in the 4 KB sector region
205h		FFh	
206h		00h	
207h		00h	
208h	JEDEC Sector Map Parameter DWORD-17 Config-1 Region-1	F8h	Region 1 of 192 KB sector Bits 31:8 = Region size = 0002FFh: Region size as count-1 of 256 Byte units = 1 x 192 KB sectors = 192 KB Count = 192 KB/256 = 768, value = count – 1 = 768 – 1 = 767 = 2FFh Bits 7:4 = RFU = Fh Erase Type not supported = 0 / supported = 1 Bit 3 = Erase Type 4 support = 1b ---Erase Type 4 is 256 KB erase and is supported in the 192 KB sector region Bit 2 = Erase Type 3 support = 0b ---Erase Type 3 is not defined Bit 1 = Erase Type 2 support = 0b ---Erase Type 2 is not defined Bit 0 = Erase Type 1 support = 0b --- Erase Type 1 is 4 KB erase and is not supported in the 4 KB sector region
209h		FFh	
20Ah		02h	
20Bh		00h	
20Ch	JEDEC Sector Map Parameter DWORD-18 Config-1 Region-2	F8h	Region 2 Uniform 256 KB sectors Bits 31:8 = 256 Mb device Region size = 01F7FFh: Region size as count – 1 of 128 Byte units = 126 x 256 KB sectors = 32,256 KB Count = 32,256 KB/256 = 129,024 value = count – 1 = 129,024 – 1 = 129,023 = 01F7FFh Bits 31:8 = 512 Mb device Region size = 03F7FFh: Region size as count – 1 of 256 Byte units = 254 x 256 KB sectors = 65,024 KB Count = 65,024 KB/256 = 260,096 value = count – 1 = 260,096 – 1 = 260,095 = 03F7FFh Bits 31:8 = 1 Gb device Region size = 07F7FFh: Region size as count – 1 of 256 Byte units = 510 x 256 KB sectors = 130, 560 KB Count = 130,560 KB/256 = 522,240, value = count – 1 = 522,240 – 1 = 522,239 = 7F7FFh Bits 7:4 = RFU = Fh Erase Type not supported = 0 / supported = 1 Bit 3 = Erase Type 4 support = 1b ---Erase Type 4 is 256 KB erase and is supported in the 256 KB sector region Bit 2 = Erase Type 3 support = 0b ---Erase Type 3 is not defined Bit 1 = Erase Type 2 support = 0b ---Erase Type 2 is not defined Bit 0 = Erase Type 1 support = 0b ---Erase Type 1 is 4 KB erase and is not supported in the 256 KB sector region
20Dh		FFh	
20Eh		F7h	
20Fh		01h (256 Mb) 03h (512 Mb) 07h (1 Gb)	
210h	JEDEC Sector Map Parameter DWORD-19 Config-1 Region-3	F8h	Region 3 of 192 KB sector Bits 31:8 = Region size = 000FFh: Region size as count – 1 of 256 Byte units = 1 x 192 KB sectors = 192 KB Count = 192 KB/256 = 768, value = count – 1 = 768 – 1 = 767 = 2FFh Bits 7:4 = RFU = Fh Erase Type not supported = 0 / supported = 1 Bit 3 = Erase Type 4 support = 1b ---Erase Type 4 is 256 KB erase and is supported in the 192 KB sector region Bit 2 = Erase Type 3 support = 0b ---Erase Type 3 is not defined Bit 1 = Erase Type 2 support = 0b ---Erase Type 22 is not defined Bit 0 = Erase Type 1 support = 0b ---Erase Type 1 is 4 KB erase and is not supported in the 4 KB sector region
211h		FFh	
212h		02h	
213h		00h	
214h	JEDEC Sector Map Parameter DWORD-20 Config-1 Region-5	F1h	Region 5 of 4 KB sectors Bits 31:8 = Region size (16 x 4 KB) = 0000FFh: Region size as count – 1 of 256 Byte units = 16 x 4 KB sectors = 64 KB Count = 64 KB/256 = 256, value = count – 1 = 256 – 1 = 255 = FFh Bits 7:4 = RFU = Fh Erase Type not supported = 0 / supported = 1 Bit 3 = Erase Type 4 support = 0b ---Erase Type 4 is not defined Bit 2 = Erase Type 3 support = 0b ---Erase Type 3 is 256 KB erase and is not supported in the 4 KB sector region Bit 1 = Erase Type 2 support = 0b ---Erase Type 2 is 64 KB erase and is not supported Bit 0 = Erase Type 1 support = 1b ---Erase Type 1 is 4 KB erase and is supported in the 4 KB sector region
215h		FFh	
216h		00h	
217h		00h	
218h	JEDEC Sector Map Parameter DWORD-21 Config-4 Header	FFh	Configuration Index 04h Uniform 256 KB sectors Bits 31:24 = RFU = FFh Bits 23:16 = Region count (DWORDs – 1) = 00h: One region Bits 15:8 = Configuration ID = 04h: Uniform 256 KB sectors Bits 7:2 = RFU = 111111b Bit 1 = Map Descriptor = 1 Bit 0 = End of map descriptor = 1
219h		04h	
21Ah		00h	
21Bh		FFh	

Table 88 JEDEC SFDP rev D, sector map parameter table *(continued)*

SFDP	SFDP DWORD name	Data	Description
21Ch	JEDEC Sector Map Parameter DWORD-22 Config-4 Region-0	F8h	Region 0 Uniform 256 KB sectors Bits 31:8 = 256 Mb device Region size = 01FFFFh: Region size as count – 1 of 128 Byte units = 128 x 256 KB sectors = 32,768 KB Count = 32,768 KB/256 = 131,072 value = count – 1 = 131,072 – 1 = 131,071 = 01FFFFh Bits 31:8 = 512 Mb device Region size = 03FFFFh: Region size as count – 1 of 256 Byte units = 256 x 256 KB sectors = 65,536 KB Count = 65,536 KB/256 = 262,144 value = count – 1 = 262,144 – 1 = 262,143 = 3FFFFh Bits 31:8 = 1 Gb device Region size = 07FFFFh: Region size as count – 1 of 256 Byte units = 512 x 256 KB sectors = 131,072 KB Count = 131,072 KB/256 = 524,288, value = count – 1 = 524,288 – 1 = 524,287 = 7FFFFh Bits 7:4 = RFU = Fh Erase Type not supported = 0 / supported = 1 Bit 3 = Erase Type 4 support = 1b ---Erase Type 4 is 256 KB erase and is supported in the 256 KB sector region Bit 2 = Erase Type 3 support = 0b ---Erase Type 3 is not defined Bit 1 = Erase Type 2 support = 0b ---Erase Type 2 is not defined Bit 0 = Erase Type 1 support = 0b ---Erase Type 1 is 4 KB erase and is not supported in the 256 KB sector region
21Dh		FFh	
21Eh		FFh	
21Fh		01h (256 Mb) 03h (512 Mb) 07h (1 Gb)	

9.2 Manufacturer and Device ID

Table 89 Manufacturer and Device ID

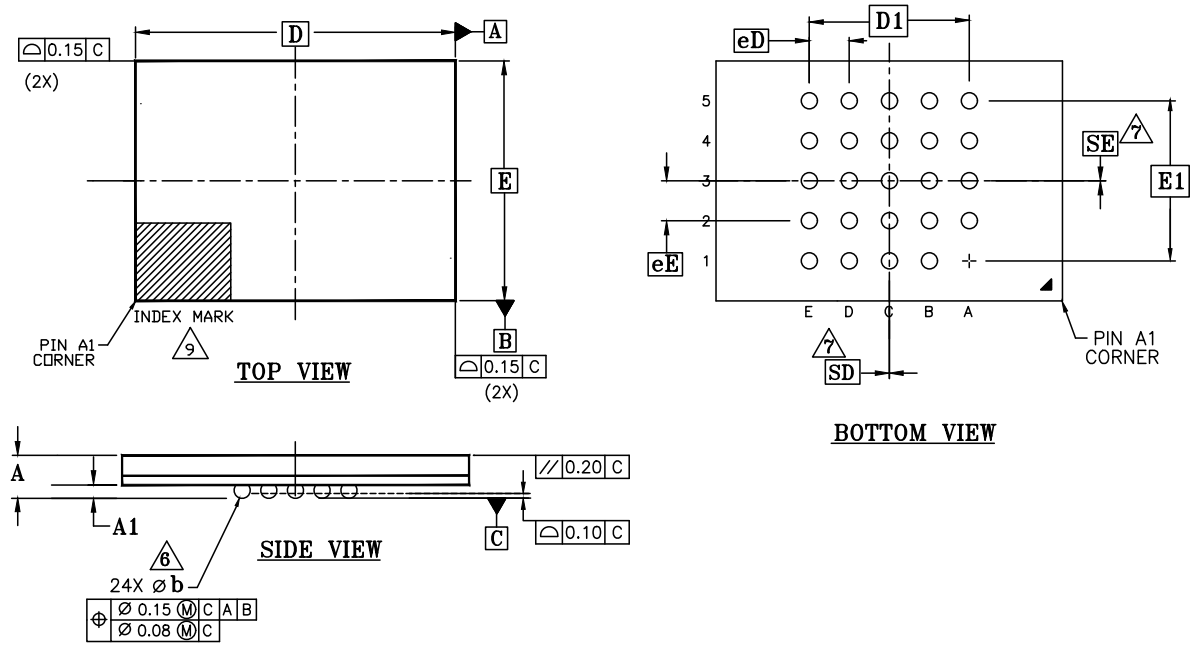
Byte address	Data	Description
00h	34h	Manufacturer ID for Infineon
01h	2Ah (HL-T) / 2Bh (HS-T)	Device ID MSB - Memory Interface Type
02h	19h (256 Mb) / 1Ah (512 Mb) / 1Bh (1 Gb)	Device ID LSB - Density
03h	0Fh	ID Length - number bytes following. Adding this value to the current location of 03h gives the address of the last valid location in the ID legacy address map.
04h	03h (Default Configuration)	Physical Sector Architecture The HS/L-T family may be configured with or without 4 KB parameter sectors in addition to the uniform sectors. 03h = Uniform 256 KB with thirty-two 4 KB Parameter Sectors)
05h	90h (HL-T/HS-T Family)	Family ID

9.3 Unique Device ID

Table 90 Unique Device ID

Byte address	Data	Description
00h to 07h	8-Byte Unique Device ID	64-bit unique ID number

10 Package diagrams



SYMBOL	DIMENSIONS		
	MIN.	NOM.	MAX.
A	-	-	1.00
A1	0.20	-	-
D	8.00 BSC		
E	6.00 BSC		
D1	4.00 BSC		
E1	4.00 BSC		
MD	5		
ME	5		
N	24		
⌀ b	0.35	0.40	0.45
eE	1.00 BSC		
eD	1.00 BSC		
SD	0.00 BSC		
SE	0.00 BSC		

NOTES:

1. DIMENSIONING AND TOLERANCING METHODS PER ASME Y14.5M-1994.
2. ALL DIMENSIONS ARE IN MILLIMETERS.
3. BALL POSITION DESIGNATION PER JEP95, SECTION 3, SPP-020.
4. "e" REPRESENTS THE SOLDER BALL GRID PITCH.
5. SYMBOL "MD" IS THE BALL MATRIX SIZE IN THE "D" DIRECTION.
   SYMBOL "ME" IS THE BALL MATRIX SIZE IN THE "E" DIRECTION.
   N IS THE NUMBER OF POPULATED SOLDER BALL POSITIONS FOR MATRIX SIZE MD X ME.

△6 DIMENSION "b" IS MEASURED AT THE MAXIMUM BALL DIAMETER IN A PLANE PARALLEL TO DATUM C.

△7 "SD" AND "SE" ARE MEASURED WITH RESPECT TO DATUMS A AND B AND DEFINE THE POSITION OF THE CENTER SOLDER BALL IN THE OUTER ROW.
WHEN THERE IS AN ODD NUMBER OF SOLDER BALLS IN THE OUTER ROW "SD" OR "SE" = 0.
WHEN THERE IS AN EVEN NUMBER OF SOLDER BALLS IN THE OUTER ROW, "SD" = eD/2 AND "SE" = eE/2.

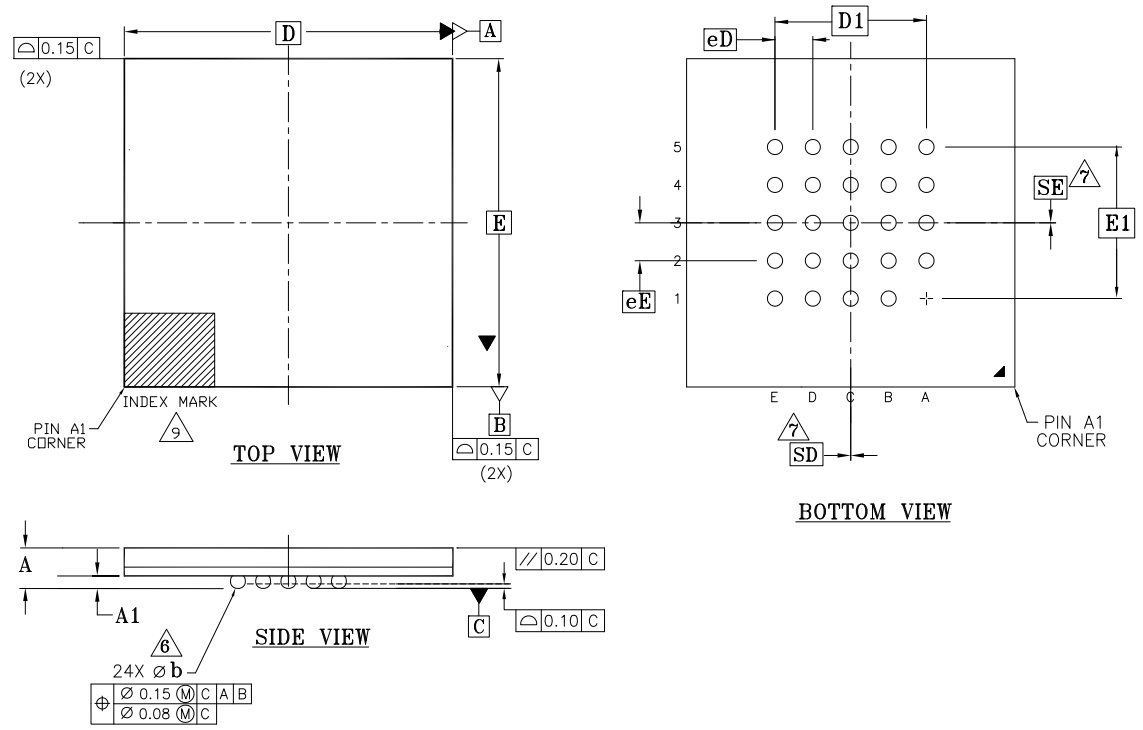
8. "+" INDICATES THE THEORETICAL CENTER OF DEPOPULATED BALLS.

△9. A1 CORNER TO BE IDENTIFIED BY CHAMFER, LASER OR INK MARK, METALLIZED MARK INDENTATION OR OTHER MEANS.

10. JEDEC SPECIFICATION NO. REF: MO-234E

002-15550 *B

Figure 85 24-ball BGA (8.0 × 6.0 × 1.0 mm) package outline (PG-BGA-24), 002-15550



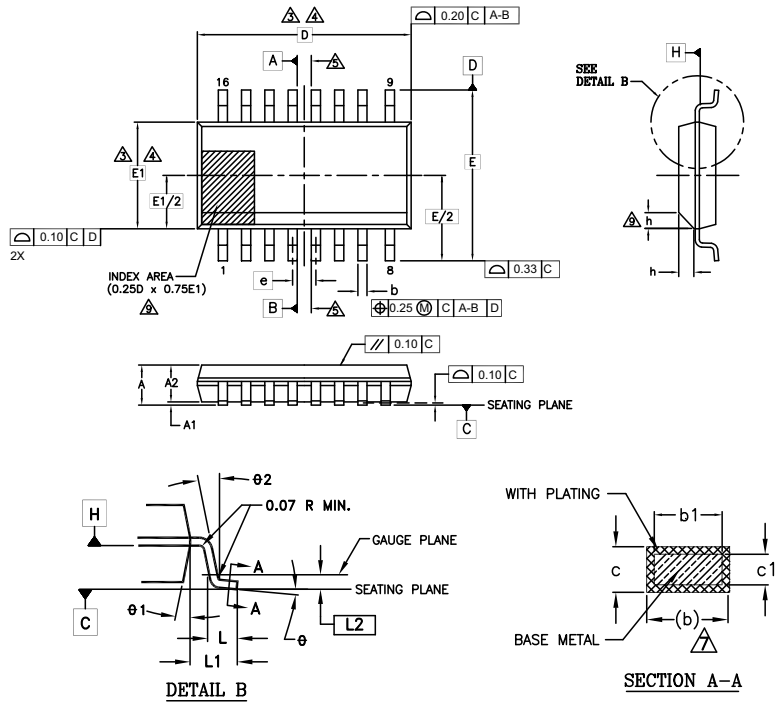
SYMBOL	DIMENSIONS		
	MIN.	NOM.	MAX.
A	-	-	1.00
A1	0.20	-	-
D		8.00 BSC	
E		8.00 BSC	
D1		4.00 BSC	
E1		4.00 BSC	
MD		5	
ME		5	
N		24	
∅ b	0.35	0.40	0.45
eE		1.00 BSC	
eD		1.00 BSC	
SD		0.00 BSC	
SE		0.00 BSC	

NOTES:

1. DIMENSIONING AND TOLERANCING METHODS PER ASME Y14.5M-1994.
2. ALL DIMENSIONS ARE IN MILLIMETERS.
3. BALL POSITION DESIGNATION PER JEP95, SECTION 3, SPP-020.
4. "e" REPRESENTS THE SOLDER BALL GRID PITCH.
5. SYMBOL "MD" IS THE BALL MATRIX SIZE IN THE "D" DIRECTION.
   SYMBOL "ME" IS THE BALL MATRIX SIZE IN THE "E" DIRECTION.
   N IS THE NUMBER OF POPULATED SOLDER BALL POSITIONS FOR MATRIX SIZE MD X ME.
6. DIMENSION "b" IS MEASURED AT THE MAXIMUM BALL DIAMETER IN A PLANE PARALLEL TO DATUM C.
7. "SD" AND "SE" ARE MEASURED WITH RESPECT TO DATUMS A AND B AND DEFINE THE POSITION OF THE CENTER SOLDER BALL IN THE OUTER ROW.
   WHEN THERE IS AN ODD NUMBER OF SOLDER BALLS IN THE OUTER ROW "SD" OR "SE" = 0.
   WHEN THERE IS AN EVEN NUMBER OF SOLDER BALLS IN THE OUTER ROW, "SD" = eD/2 AND "SE" = eE/2.
8. "+" INDICATES THE THEORETICAL CENTER OF DEPOPULATED BALLS.
9. A1 CORNER TO BE IDENTIFIED BY CHAMFER, LASER OR INK MARK, METALLIZED MARK INDENTATION OR OTHER MEANS.
10. JEDEC SPECIFICATION NO. REF: N/A

002-22282 **

Figure 86 24-ball BGA (8.0 × 8.0 × 1.0 mm) package outline (PG-BGA-24), 002-22282



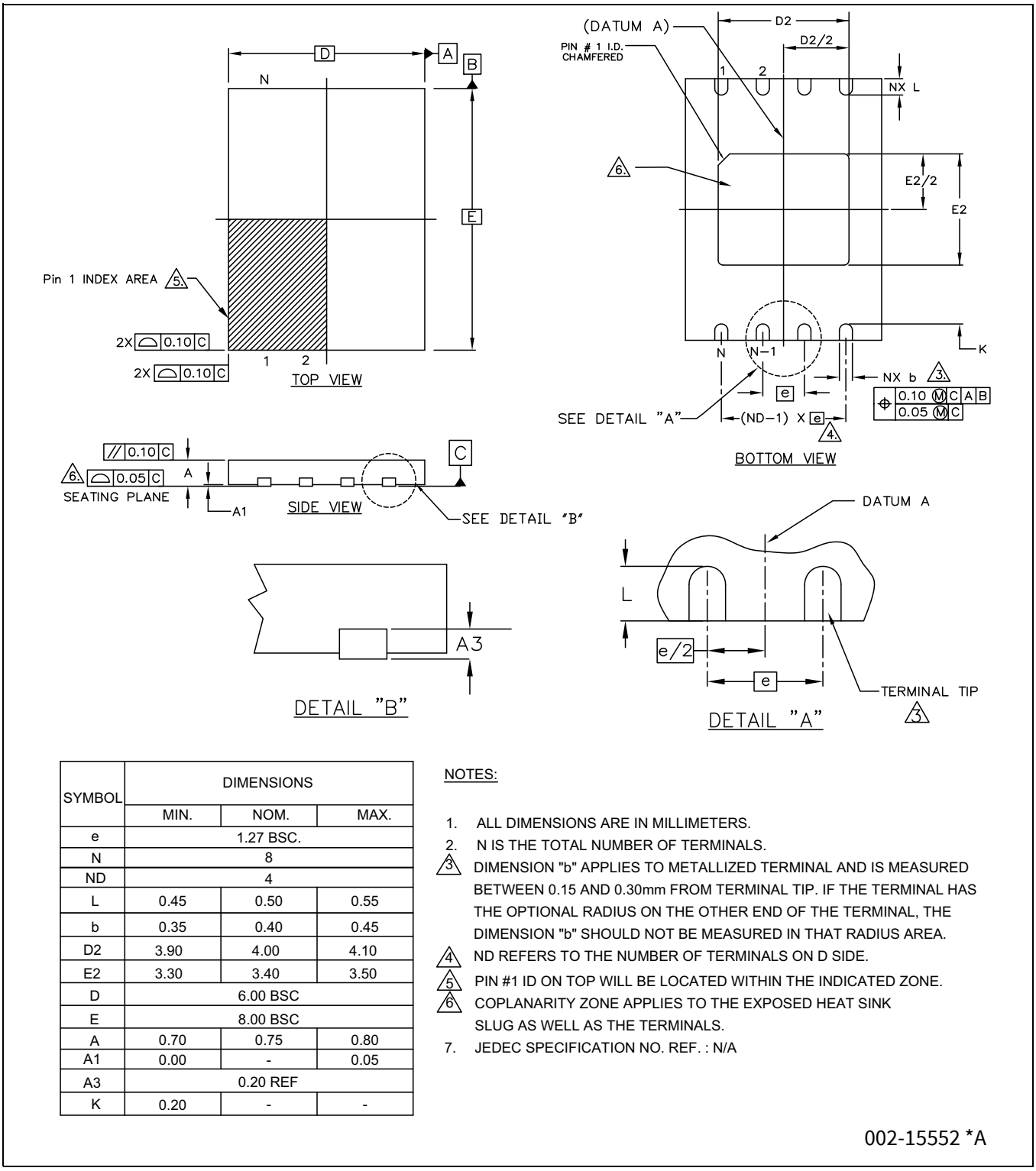
SYMBOL	DIMENSIONS		
	MIN.	NOM.	MAX.
A	2.35	-	2.65
A1	0.10	-	0.30
A2	2.05	-	2.55
b	0.31	-	0.51
b1	0.27	-	0.48
c	0.20	-	0.33
c1	0.20	-	0.30
D	10.30 BSC		
E	10.30 BSC		
E1	7.50 BSC		
e	1.27 BSC		
L	0.40	-	1.27
L1	1.40 REF		
L2	0.25 BSC		
N	16		
h	0.25	-	0.75
θ	0°	-	8°
θ1	5°	-	15°
θ2	0°	-	-

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. DIMENSIONING AND TOLERANCING PER ASME Y14.5M - 1994.
3. DIMENSION D DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS. MOLD FLASH, PROTRUSIONS OR GATE BURRS SHALL NOT EXCEED 0.15 mm PER END. DIMENSION E1 DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSION. INTERLEAD FLASH OR PROTRUSION SHALL NOT EXCEED 0.25 mm PER SIDE. D AND E1 DIMENSIONS ARE DETERMINED AT DATUM H.
4. THE PACKAGE TOP MAY BE SMALLER THAN THE PACKAGE BOTTOM. DIMENSIONS D AND E1 ARE DETERMINED AT THE OUTMOST EXTREMES OF THE PLASTIC BODY EXCLUSIVE OF MOLD FLASH, TIE BAR BURRS, GATE BURRS AND INTERLEAD FLASH, BUT INCLUSIVE OF ANY MISMATCH BETWEEN THE TOP AND BOTTOM OF THE PLASTIC BODY.
5. DATUMS A AND B TO BE DETERMINED AT DATUM H.
6. "N" IS THE MAXIMUM NUMBER OF TERMINAL POSITIONS FOR THE SPECIFIED PACKAGE LENGTH.
7. THE DIMENSIONS APPLY TO THE FLAT SECTION OF THE LEAD BETWEEN 0.10 TO 0.25 mm FROM THE LEAD TIP.
8. DIMENSION "b" DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.10 mm TOTAL IN EXCESS OF THE "b" DIMENSION AT MAXIMUM MATERIAL CONDITION. THE DAMBAR CANNOT BE LOCATED ON THE LOWER RADIUS OF THE LEAD FOOT.
9. THIS CHAMFER FEATURE IS OPTIONAL. IF IT IS NOT PRESENT, THEN A PIN 1 IDENTIFIER MUST BE LOCATED WITHIN THE INDEX AREA INDICATED.
10. LEAD COPLANARITY SHALL BE WITHIN 0.10 mm AS MEASURED FROM THE SEATING PLANE.

002-15547 *A

Figure 87 16-lead SOIC (10.30 × 7.50 × 2.65 mm) package outline (PG-DSO-16), 002-15547



SYMBOL	DIMENSIONS		
	MIN.	NOM.	MAX.
e		1.27 BSC.	
N		8	
ND		4	
L	0.45	0.50	0.55
b	0.35	0.40	0.45
D2	3.90	4.00	4.10
E2	3.30	3.40	3.50
D		6.00 BSC	
E		8.00 BSC	
A	0.70	0.75	0.80
A1	0.00	-	0.05
A3		0.20 REF	
K	0.20	-	-

NOTES:

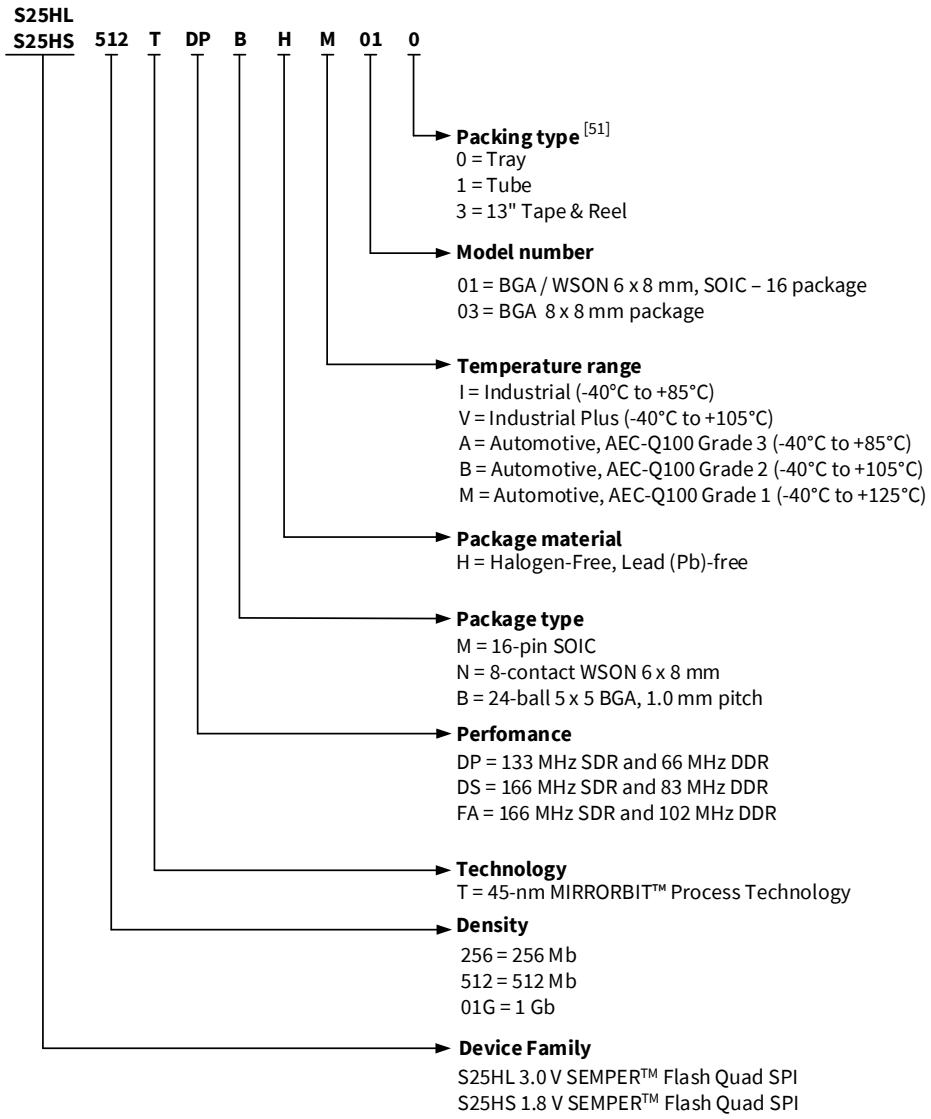
1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. N IS THE TOTAL NUMBER OF TERMINALS.
3. DIMENSION "b" APPLIES TO METALLIZED TERMINAL AND IS MEASURED BETWEEN 0.15 AND 0.30mm FROM TERMINAL TIP. IF THE TERMINAL HAS THE OPTIONAL RADIUS ON THE OTHER END OF THE TERMINAL, THE DIMENSION "b" SHOULD NOT BE MEASURED IN THAT RADIUS AREA.
4. ND REFERS TO THE NUMBER OF TERMINALS ON D SIDE.
5. PIN #1 ID ON TOP WILL BE LOCATED WITHIN THE INDICATED ZONE.
6. COPLANARITY ZONE APPLIES TO THE EXPOSED HEAT SINK SLUG AS WELL AS THE TERMINALS.
7. JEDEC SPECIFICATION NO. REF. : N/A

002-15552 *A

Figure 88 8-lead DFN (6.0 × 8.0 × 0.8 mm) 4.0 × 3.4 mm E-Pad (Sawn) package outline (PG-WSON-8), 002-15552

11 Ordering information

The ordering part number is formed by a valid combination of the following:



Note
51. See Packing and Packaging Handbook on **www.infineon.com** for further information.

11.1 Valid combinations — standard grade

Table 91 lists configurations planned to be supported in volume for this device. Contact your local sales office to confirm availability of specific valid combinations and to check on newly released combinations.

Table 91 Valid combinations — standard grade

Product family	Speed option	Package and materials	Temperature range	Model number	Packing type	Product (x = Packing type)	Package marking
S25HL256T	FA	MH	B	01	0,3	S25HL256TFAMHB01x	S25HL256TFB01
S25HL512T	DP	BH	I, V	01	0, 3	S25HL512TDPBHI01x	25HL512TPI01
						S25HL512TDPBHV01x	25HL512TPV01
		MH	I, V	01	0, 1, 3	S25HL512TDPMHI01x	25HL512TPI01
						S25HL512TDPMHV01x	25HL512TPV01
		NH	I, V	01	0, 1, 3	S25HL512TDPNHI01x	2HL512TPI01
						S25HL512TDPNHV01x	2HL512TPV01
	FA	BH	I, V	01	0, 3	S25HL512TFABHI01x	25HL512TFI01
						S25HL512TFABHV01x	25HL512TFV01
		MH	I, V	01	0, 1, 3	S25HL512TFAMHI01x	25HL512TFI01
						S25HL512TFAMHV01x	25HL512TFV01
		NH	I, V	01	0, 1, 3	S25HL512TFANHI01x	2HL512TFI01
						S25HL512TFANHV01x	2HL512TFV01
S25HS512T	DP	BH	I, V	01	0, 3	S25HS512TDPBHI01x	25HS512TPI01
						S25HS512TDPBHV01x	25HS512TPV01
		MH	I, V	01	0, 1, 3	S25HS512TDPMHI01x	25HS512TPI01
						S25HS512TDPMHV01x	25HS512TPV01
		NH	I, V	01	0, 1, 3	S25HS512TDPNHI01x	2HS512TPI01
						S25HS512TDPNHV01x	2HS512TPV01
	DS	BH	V	01	0, 3	S25HS512TDSBHV01x	25HS512TSV01
		MH	V	01	0, 3	S25HS512TDSMHV01x	25HS512TSV01
	FA	BH	I, V	01	0, 3	S25HS512TFABHI01x	25HS512TFI01
						S25HS512TFABHV01x	25HS512TFV01
		MH	I, V	01	0, 1, 3	S25HS512TFAMHI01x	25HS512TFI01
						S25HS512TFAMHV01x	25HS512TFV01
		NH	I, V	01	0, 1, 3	S25HS512TFANHI01x	2HS512TFI01
						S25HS512TFANHV01x	2HS512TFV01
S25HL01GT	DP	BH	I, V	03	0, 3	S25HL01GTDPBHV03x	25HL01GTPV03
						S25HL01GTDPBHI03x	25HL01GTPI03
		MH	I, V	01	0, 1, 3	S25HL01GTDPMHV01x	25HL01GTPV01
						S25HL01GTDPMHI01x	25HL01GTPI01
	FA	BH	I, V	03	0, 3	S25HL01GTFABHV03x	25HL01GTFV03
						S25HL01GTFABHI03x	25HL01GTFI03
		MH	I, V	01	0, 1, 3	S25HL01GTFAMHI01x	25HL01GTFI01
						S25HL01GTFAMHV01x	25HL01GTFV01
S25HS01GT	DP	BH	I, V	03	0, 3	S25HS01GTDPBHI03x	25HS01GTPI03
						S25HS01GTDPBHV03x	25HS01GTPV03
		MH	I, V	01	0, 1, 3	S25HS01GTDPMHI01x	25HS01GTPI01
						S25HS01GTDPMHV01x	25HS01GTPV01

Table 91 Valid combinations — standard grade *(continued)*

Product family	Speed option	Package and materials	Temperature range	Model number	Packing type	Product (x = Packing type)	Package marking
S25HS01GT	FA	BH	I, V	03	0, 3	S25HS01GTFABHI03x	25HS01GTFI03
						S25HS01GTFABHV03x	25HS01GTFV03
		MH	I, V	01	0, 1, 3	S25HS01GTFAMHI01x	25HS01GTFI01
						S25HS01GTFAMHV01x	25HS01GTFV01

11.2 Valid combinations — automotive grade / AEC-Q100

Table 92 lists configurations that are automotive grade / AEC-Q100 qualified and are planned to be available in volume. The table will be updated as new combinations are released. Contact your local sales representative to confirm availability of specific combinations and to check on newly released combinations.

Production Part Approval Process (PPAP) support is only provided for AEC-Q100 grade products.

Products to be used in end-use applications that require ISO/TS-16949 compliance must be AEC-Q100 grade products in combination with PPAP. Non–AEC-Q100 grade products are not manufactured or documented in full compliance with ISO/TS-16949 requirements.

AEC-Q100 grade products are also offered without PPAP support for end-use applications that do not require ISO/TS-16949 compliance.

Table 92 Valid combinations — automotive grade / AEC-Q100

Product family	Speed option	Package and materials	Temperature range	Model number	Packing type	Ordering part number (x = packing type)	Package marking
S25HL512T	DP	BH	A, B, M	01	0, 3	S25HL512TDPBHA01x	25HL512TPA01
						S25HL512TDPBHB01x	25HL512TPB01
						S25HL512TDPBHM01x	25HL512TPM01
		MH	A, B, M	01	0, 1, 3	S25HL512TDPMHA01x	25HL512TPA01
						S25HL512TDPMHB01x	25HL512TPB01
						S25HL512TDPMHM01x	25HL512TPM01
		NH	A, B, M	01	0, 1, 3	S25HL512TDPNHA01x	2HL512TPA01
						S25HL512TDPNHB01x	2HL512TPB01
						S25HL512TDPNHM01x	2HL512TPM01
	FA	BH	A, B, M	01	0, 3	S25HL512TFABHA01x	25HL512TFA01
						S25HL512TFABHB01x	25HL512TFB01
						S25HL512TFABHM01x	25HL512TFM01
		MH	A, B, M	01	0, 1, 3	S25HL512TFAMHA01x	25HL512TFA01
						S25HL512TFAMHB01x	25HL512TFB01
						S25HL512TFAMHM01x	25HL512TFM01
		NH	A, B, M	01	0, 1, 3	S25HL512TFANHA01x	2HL512TFA01
						S25HL512TFANHB01x	2HL512TFB01
						S25HL512TFANHM01x	2HL512TFM01
S25HS512T	DP	BH	A, B, M	01	0, 3	S25HS512TDPBHA01x	25HS512TPA01
						S25HS512TDPBHB01x	25HS512TPB01
						S25HS512TDPBHM01x	25HS512TPM01
		MH	A, B, M	01	0, 1, 3	S25HS512TDPMHA01x	25HS512TPA01
						S25HS512TDPMHB01x	25HS512TPB01
						S25HS512TDPMHM01x	25HS512TPM01
		NH	A, B, M	01	0, 1, 3	S25HS512TDPNHA01x	2HS512TPA01
						S25HS512TDPNHB01x	2HS512TPB01
						S25HS512TDPNHM01x	2HS512TPM01
	FA	BH	A, B, M	01	0, 3	S25HS512TFABHA01x	25HS512TFA01
						S25HS512TFABHB01x	25HS512TFB01
						S25HS512TFABHM01x	25HS512TFM01

Table 92 Valid combinations — automotive grade / AEC-Q100 *(continued)*

Product family	Speed option	Package and materials	Temperature range	Model number	Packing type	Ordering part number (x = packing type)	Package marking
S25HS512T	FA	MH	A, B, M	01	0, 1, 3	S25HS512TFAMHA01x	25HS512TFA01
						S25HS512TFAMHB01x	25HS512TFB01
						S25HS512TFAMHM01x	25HS512TFM01
		NH	A, B, M	01	0, 1, 3	S25HS512TFANHA01x	2HS512TFA01
						S25HS512TFANHB01x	2HS512TFB01
						S25HS512TFANHM01x	2HS512TFM01
S25HL01GT	DP	BH	A, B, M	03	0, 3	S25HL01GTDPBHA03x	25HL01GTPA03
						S25HL01GTDPBHB03x	25HL01GTPB03
						S25HL01GTDPBHM03x	25HL01GTPM03
		MH	A, B, M	01	0, 1, 3	S25HL01GTDPMHA01x	25HL01GTPA01
						S25HL01GTDPMHB01x	25HL01GTPB01
						S25HL01GTDPMHM01x	25HL01GTPM01
	FA	BH	A, B, M	03	0, 3	S25HL01GTFABHA03x	25HL01GTFA03
						S25HL01GTFABHB03x	25HL01GTFB03
						S25HL01GTFABHM03x	25HL01GTFM03
		MH	A, B, M	01	0, 1, 3	S25HL01GTFAMHA01x	25HL01GTFA01
						S25HL01GTFAMHB01x	25HL01GTFB01
						S25HL01GTFAMHM01x	25HL01GTFM01
S25HS01GT	DP	BH	A, B, M	03	0, 3	S25HS01GTDPBHA03x	25HS01GTPA03
						S25HS01GTDPBHB03x	25HS01GTPB03
						S25HS01GTDPBHM03x	25HS01GTPM03
		MH	A, B, M	01	0, 1, 3	S25HS01GTDPMHA01x	25HS01GTPA01
						S25HS01GTDPMHB01x	25HS01GTPB01
						S25HS01GTDPMHM01x	25HS01GTPM01
	FA	BH	A, B, M	03	0, 3	S25HS01GTFABHA03x	25HS01GTFA03
						S25HS01GTFABHB03x	25HS01GTFB03
						S25HS01GTFABHM03x	25HS01GTFM03
		MH	A, B, M	01	0, 1, 3	S25HS01GTFAMHA01x	25HS01GTFA01
						S25HS01GTFAMHB01x	25HS01GTFB01
						S25HS01GTFAMHM01x	25HS01GTFM01

Revision history

Document revision	Date	Description of changes
*P	2019-06-04	Finalizing document for S25HS512T devices.
*Q	2019-06-21	Finalizing document for S25HL512T devices.
*R	2019-07-03	Finalizing document for S25HL01GT devices.
*S	2019-09-13	Updated **Table 73**: Updated **4-4-4 transaction table**: Updated **Table 77**. Updated **Ordering information**: Updated **Valid combinations — standard grade**: Updated **Table 91**. Removed table “Valid Combinations — Standard Grade (In Production)”. Updated **Valid combinations — automotive grade / AEC-Q100**: Updated **Table 92**. Removed “Valid Combinations — Automotive Grade / AEC-Q100 (In Production)”.
*T	2019-11-26	Finalizing document for S25HS01GT devices.
*U	2019-12-20	Updated **Features**: Updated **Data protection schemes**: Updated **Legacy block protection (LBP)**: Updated **Configuration protection**: Updated **Table 17**. Updated **Device identification**: Updated **JEDEC SFDP Rev D**: Updated **JEDEC SFDP Rev D header table**: Updated **Table 85**. Updated **JEDEC SFDP Rev D parameter table**: Updated **Table 87**.
*V	2019-01-29	Updated **Transaction table**: Updated **1-1-1 transaction table**: Updated **Table 73**. Updated to new template.
*W	2020-03-23	Updated **Electrical characteristics**: Updated **Latchup characteristics**: Updated **Table 81**. Completing Sunset Review.

Document revision	Date	Description of changes
*X	2020-04-22	Updated **Features**: Updated **Error detection and correction**: Updated **ECC error reporting**: Updated **ECC Data Unit status (EDUS)**: Updated **Table 9**. Updated **Registers**: Updated **Configuration Register 2 (CFR2x)**: Updated **Table 48**. Updated **ECC Status Register (ECSV)**: Updated **Table 55**. Updated **Device identification**: Updated **JEDEC SFDP Rev D**: Updated **JEDEC SFDP Rev D header table**: Updated **Table 85**. Updated **JEDEC SFDP Rev D parameter table**: Updated **Table 87**.
*Y	2020-12-01	Updated **Features**: Updated **Read**: Updated **Read Memory Array transactions**: Updated **Read SDR and DDR Quad I/O transaction**: Updated description. Updated **Read QPI SDR and DDR transaction**: Updated description. Updated **Read memory array related registers and transactions**: Updated **Table 29**. Updated **Data learning pattern (DLP)**: Updated description. Updated **Registers**: Updated **Configuration Register 3 (CFR3x)**: Updated **Table 50**. Updated **ECC Address Trap Register (EATV)**: Updated **Table 56**. Updated **Advanced Sector Protection Register (ASPO)**: Updated **Table 58**. Updated **Device identification**: Updated **JEDEC SFDP Rev D**: Updated **JEDEC SFDP Rev D parameter table**: Updated **Table 86**. Updated **Sector Map Parameter Table Notes**: Updated description. Updated **Table 87**.

Revision history

Document revision	Date	Description of changes
*Z	2021-10-18	Updated **Electrical characteristics**: Updated **Thermal resistance**: Updated **Table 79**. Updated **DC characteristics**: Updated **DC characteristics (all temperature ranges)**: Updated **Table 82**. Updated **Timing characteristics**: Updated **Table 84**. Updated **Device identification**: Updated **JEDEC SFDP Rev D**: Updated **JEDEC SFDP Rev D parameter table**: Updated **Table 86**. Migrated to Infineon template. Completing Sunset Review.
AA	2022-01-18	Updated **Address space maps**: Updated **JEDEC JESD216 serial flash discoverable parameters (SFDP) space**: Updated **Table 6** (Replaced JESD216C with JESD216D). Updated **Features**: Updated **Read**: Updated **Read Identification transactions**: Updated **Read Device Identification transaction**: Replaced CFR3V[1:0] with CFR3V[7:6]. Updated **Timing characteristics**: Updated **Table 84**. Updated **Device identification**: Updated **JEDEC SFDP Rev D**: Updated **JEDEC SFDP Rev D parameter table**: Updated **Table 86**.
AB	2022-12-08	Updated **Features**: Updated **Write**: Added **Enter 4 Byte Address Mode**. Added **Exit 4 Byte Address Mode**. Updated **Write transactions related registers and transactions**: Updated **Table 32**. Updated **Electrical characteristics**: Updated **AC test conditions**: Updated **Table 83**. Updated **Timing characteristics**: Updated **Table 84**. Completing Sunset Review.

Revision history

Document revision	Date	Description of changes
AC	2023-03-02	Updated **Features**: Updated description. Updated **Features**: Updated **Error detection and correction**: Updated **ECC error reporting**: Updated **ECC Status Register (ECSV)**: Updated description. Updated **ECC Error Address Trap (EATV)**: Updated description. Updated **ECC Error Detection Counter (ECTV)**: Updated description. Updated **Data protection schemes**: Updated **Legacy block protection (LBP)**: Updated **Configuration protection**: Updated description. Updated **Reset**: Updated description. Updated **JEDEC serial flash reset signaling protocol**: Replaced “CS# signaling reset” with “JEDEC serial flash reset signaling protocol” in heading. Updated description. Updated **Figure 63** (Updated caption only). Updated **Reset behavior**: Updated **Table 38**. Updated **Power modes**: Updated **Deep power down (DPD) mode**: Updated **Enter DPD**: Updated description. Updated **Registers**: Updated **Status Register 1 (STR1x)**: Updated Note 21 referred in **Table 41**. Updated **Status Register 2 (STR2x)**: Updated Note 22 referred in **Table 44**. Updated **Transaction table**: Updated **4-4-4 transaction table**: Updated **Table 77**. Updated **Timing characteristics**: Updated **Table 84**. Updated to new template.
AD	2023-12-18	Updated **Figure 19**. Updated **Figure 35**. Updated **Figure 85**. Updated **Table 92**.

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