Apacer

RoHS Compliant

PCI Express Flash Drive

Industrial PV19E-25W U.3 Product Specifications

May 6, 2024

Version 1.2

Apacer Technology Inc.
1F, No.32, Zhongcheng Rd., Tucheng Dist., New Taipei City, Taiwan, R.O.C
Tel: +886-2-2267-8000 Fax: +886-2-2267-2261
www.apacer.com

Apacer

Specifications Overview:

- **PCIe Interface**
  - Compliant with PCI Express 4.0
  - Compliant with NVMe 1.4
  - Compatible with PCIe Gen4 x4 interface
- **Capacity**
  - 1600, 3200, 6400, 12800, 25600 GB
- **Performance**[1]
  - Interface burst read/write: 8 GB/sec
  - Sequential R/W: Up to 7,470/7,080 MB/sec
  - Random R/W (4K): Up to 1,375K/1,189K IOPS
  - Sustained seq. R/W: Up to 6,700/4,805 MB/sec
  - Sustained rand. R/W: Up to 1,702K/483K IOPS
  - Random R/W latency: 72/9 µs
  - Random R/W QoS: 0.12/0.02 ms
- **Flash Management**
  - Low-Density Parity-Check (LDPC) Code
  - Global Wear Leveling
  - Flash bad-block management
  - Flash Translation Layer: Page Mapping
  - S.M.A.R.T.
  - TRIM
  - Over-provisioning
  - SMART Read Refresh™
  - NVMe Secure Erase
- **Enterprise Features**
  - Namespace
  - Reservation
  - Metadata Protection
  - CorePower
  - AES 256-bit hardware encryption
  - Trusted Computing Group (TCG) Opal 2.0 (optional)
  - Thermal Sensor
  - Thermal Throttling
  - End-to-End Data Protection
- **Temperature Range**
  - Operating (Tc)[2]: 0°C to 70°C
  - Storage (Ta): -40°C to 85°C
- **Supply Voltage**
  - 12V ± 10%
- **Power Consumption**[1]
  - Active mode: 22.54 W
  - Idle mode: 8.17 W
  - Inrush Current: 1.5 A
- **Power Management**[3]
- **NAND Flash Type:** 3D eTLC
- **DRAM Cache for Enhanced Random Performance**
- **Reliability**
  - MTBF: >2,500,000 hours
  - Data Retention: 3 months
  - Endurance
    - 3 DWPD
    - 1600 GB: 8,760 TBW
    - 3200 GB: 17,520 TBW
    - 6400 GB: 35,040 TBW
    - 12800 GB: 70,080 TBW
    - 25600 GB: 56,064 TBW
- **Supports SMBus**
- **Supports NVMe-MI (Management Interface)**
- **Physical Characteristics**
  - Form factor: U.3 15mm
  - Dimensions: 100.10 x 69.85 x 14.65, unit: mm
  - Net weight: 205g ± 5%
- **RoHS Compliant**

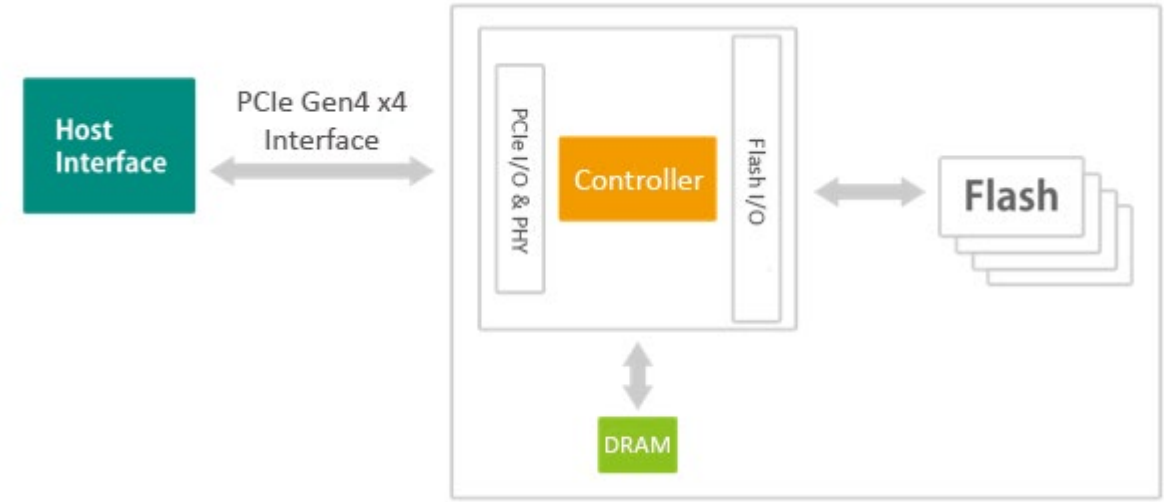
Notes:
1. Varies from capacities. The values for performances and power consumptions presented are typical and may vary depending on flash configurations or platform settings. The term idle refers to the standby state of the device.
2. With specified airflow. See 9. Airflow Profile for more information.
3. APST and ASPM power managements are not supported.

Table of Contents

1. General Description

PV19E-25W U.3 Solid State Disk (SSD) delivers all the advantages of flash disk technology with PCIe Gen4 x4 interface, including being fully compliant with standard U.3 form factor, providing low power consumption compared to traditional hard drive and hot-swapping when removing/replacing/upgrading flash disks. PV19E-25W delivers outstanding performance up to 7,470 MB/s (for sequential read) and 7,080 MB/s (for sequential write) based on eTLC NAND flash with the DDR4. Moreover, the power consumption of U.3 (15mm) SSD is much lower than traditional hard drives, making it the best embedded solution for new platforms.

2. Functional Block



Note: The actual number of NAND flash used on Apacer PV19E-25W varies from capacities. The illustration is for reference only.

Figure 2-1 Functional Block Diagram

3. Pin Assignments

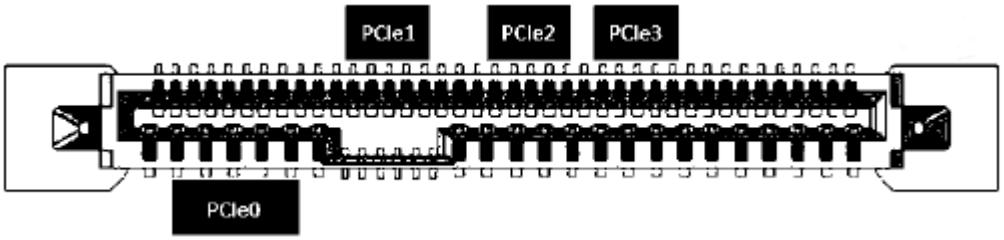


Figure 3-1 U.3 Pin Assignment

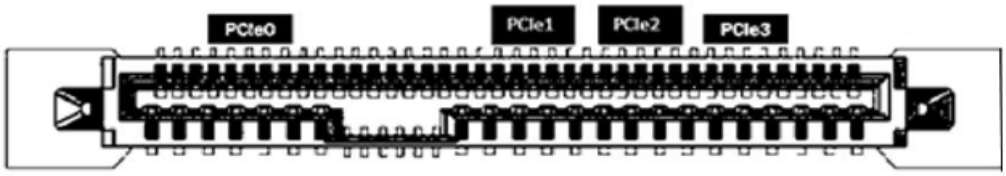


Figure 3-2 U.2 Pin Assignment

Table 3-1 Pin Assignments

Pin No.	Name	Type	Description
P1	WAKE#	Input	Reserved
P2	Reserved	Reserved	Reserved
P3	PWRDIS	Output	Power disable
P4	IfDet#	Input	Interface Type Detect
P5	Ground	Ground	Ground
P6	Ground	Ground	Ground
P7	+5V	Power	Reserved
P8	+5V	Power	Reserved
P9	+5V	Power	Reserved
P10	PRSNT#	Input	Presence detect
P11	Activity#	Input	Activity indicator
P12	Ground	Ground	Ground
P13	+12V Precharge	Power	+12V Precharge power
P14	+12V	Power	+12V power
P15	+12V	Power	+12V power
SG1	Ground	Ground	Ground
SG2	Ground	Ground	Ground
S1	Ground	Ground	Ground
S2	U.3 TX p0	Diff-Pair	Transmitter differential pair, U.3 Lane 0
S3	U.3 TX n0	Diff-Pair	Transmitter differential pair, U.3 Lane 0
S4	Ground	Ground	Ground

Pin No.	Name	Type	Description
S5	U.3 RX n0	Diff-Pair	Receiver differential pair, U.3 Lane 0
S6	U.3 RX p0	Diff-Pair	Receiver differential pair, U.3 Lane 0
S7	Ground	Ground	Ground
S8	Ground	Ground	Ground
S9	U.3 TX p1	Diff-Pair	Transmitter differential pair, U.3 Lane 1
S10	U.3 TX n1	Diff-Pair	Transmitter differential pair, U.3 Lane 1
S11	Ground	Ground	Ground
S12	U.3 RX n1	Diff-Pair	Receiver differential pair, U.3 Lane 1
S13	U.3 RX p1	Diff-Pair	Receiver differential pair, U.3 Lane 1
S14	Ground	Ground	Ground
S15	HPT0	Output	Host port type
S16	Ground	Ground	Ground
S17	U.3 TX p2/ U.2 TX p1	Diff-Pair	Transmitter differential pair, U.3 Lane 2, or U.2 Lane 1
S18	U.3 TX n2/ U.2 TX n1	Diff-Pair	Transmitter differential pair, U.3 Lane 2, or U.2 Lane 1
S19	Ground	Ground	Ground
S20	U.3 RX n2/ U.2 RX n1	Diff-Pair	Receiver differential pair, U.3 Lane 2, or U.2 Lane 1
S21	U.3 RX p2/ U.2 RX p1	Diff-Pair	Receiver differential pair, U.3 Lane 2, or U.2 Lane 1
S22	Ground	Ground	Ground
S23	U.3 TX p3/ U.2 TX p2	Diff-Pair	Transmitter differential pair, U.3 Lane 3, or U.2 Lane 2
S24	U.3 TX n3/ U.2 TX n2	Diff-Pair	Transmitter differential pair, U.3 Lane 3, or U.2 Lane 2
S25	Ground	Ground	Ground
S26	U.3 RX n3/ U.2 RX n2	Diff-Pair	Receiver differential pair, U.3 Lane 3, or U.2 Lane 2
S27	U.3 RX p3/ U.2 RX p2	Diff-Pair	Receiver differential pair, U.3 Lane 3, or U.2 Lane 2
S28	Ground	Ground	Ground
E1	REFCLKB+	Diff-Pair	Reference clock (differential pair) for second x2 port
E2	REFCLKB-	Diff-Pair	Reference clock (differential pair) for second x2 port
E3	+3.3 Vaux	Power	3.3 V auxiliary power
E4	CLKREQ#/PERSTB#	Bi-dir	Clock request/Fundamental reset for second x2 port
E5	PERST#	Output	Fundamental reset
E6	IFDet2#	Input	Interface Type Detect
E7	REFCLK+	Diff-Pair	Reference clock
E8	REFCLK-	Diff-Pair	Reference clock
E9	Ground	Ground	Ground
E10	U.2 TX p0	Diff-Pair	Transmitter differential pair, U.2 Lane 0
E11	U.2 TX n0	Diff-Pair	Transmitter differential pair, U.2 Lane 0
E12	Ground	Ground	Ground
E13	U.2 RX n0	Diff-Pair	Receiver differential pair, U.2 Lane 0
E14	U.2 RX p0	Diff-Pair	Receiver differential pair, U.2 Lane 0
E15	Ground	Ground	Ground
E16	HPT1	Output	Host port type
E17	U.2 TX p3	Diff-Pair	Transmitter differential pair, U.2 Lane 3

Pin No.	Name	Type	Description
E18	U.2 TX n3	Diff-Pair	Transmitter differential pair, U.2 Lane 3
E19	Ground	Ground	Ground
E20	U.2 RX n3	Diff-Pair	Receiver differential pair, U.2 Lane 3
E21	U.2 RX p3	Diff-Pair	Receiver differential pair, U.2 Lane 3
E22	Ground	Ground	Ground
E23	SMCLK	Bi-Dir	SMBus (System Management Bus) clock
E24	SMDAT	Bi-Dir	SMBus (System Management Bus) data
E25	DualPortEn#	Output	Dual-port Enable

4. Product Specifications

4.1 Capacity

Capacity specifications of PV19E-25W are available as shown in Table 4-1.

Table 4-1 Capacity Specifications

Capacity	Total bytes	Total LBA
1600 GB	1,600,321,314,816	3,125,627,568
3200 GB	3,200,631,791,616	6,251,233,968
6400 GB	6,401,252,745,216	12,502,446,768
12800 GB	12,802,494,652,416	25,004,872,368
25600 GB	25,604,978,466,816	50,009,723,568

Notes:
- Display of total bytes varies from operating systems.
- 1 GB = 1,000,000,000 bytes; 1 sector = 512 bytes.
- LBA count addressed in the table above indicates total user storage capacity and will remain the same throughout the lifespan of the device. However, the total usable capacity of the SSD is most likely to be less than the total physical capacity because a small portion of the capacity is reserved for device maintenance usages.

4.2 Performance

Performance of PV19E-25W is listed below in Table 4-2 and 4-3.

Table 4-2 Performance

Performance	Unit	1600 GB	3200 GB	6400 GB	12800 GB	25600 GB
Sequential Read	MB/s	7,470	7,465	7,460	7,460	7,460
Sequential Write		3,625	6,760	7,080	7,070	6,210
4K Random Read	IOPS	1,363,000	1,342,000	1,345,000	1,335,000	1,375,000
4K Random Write		888,000	1,171,000	1,152,000	1,187,000	1,189,000

Notes:
- Results may differ from various flash configurations or host system setting.
- Sequential read/write is based on CrystalDiskMark 8.0.4 with file size 1,000MB.
- Random read/write is measured using IOMeter with Queue Depth 32.

Table 4-3 Sustained Performance

Performance	Unit	1600 GB	3200 GB	6400 GB	12800 GB	25600 GB
Sequential Read	MB/s	6,680	6,680	6,695	6,680	6,700
Sequential Write		3,495	4,655	4,750	4,670	4,805
4K Random Read	IOPS	1,702,000	1,702,000	1,702,000	1,702,000	1,702,000
4K Random Write		297,000	479,000	483,000	389,000	155,000

Note:
- Sustained sequential read/write is measured by using FIO with 128KB and 1024KB of data transfer size in Queue Depth 32 by 1 worker.
- Sustained random read/write is measured by using FIO with 4KB of data transfer size in Queue Depth 32 by 16 worker.

4.3 Latency

Table 4-4 Latency

Performance	Unit	1600 GB	3200 GB	6400 GB	12800 GB	25600 GB
Random Read	µs	72	72	72	72	72
Random Write		9	9	9	9	9

Note: Latency is measured by using the SNIA SSS (Solid State Storage) PTS (Performance Test Specification) with 4KB data transfer size in Queue Depth 1 by 1 worker

4.4 Quality of Service (QoS)

Table 4-5 Quality of Service (QoS)

Quality of Service (99%)	Unit	1600 GB	3200 GB	6400 GB	12800 GB	25600 GB
Random Read	ms	0.10	0.10	0.10	0.10	0.12
Random Write		0.02	0.02	0.02	0.02	0.02

Notes:
- QoS is measured by using StorScore with Queue Depth 1 on 4KB random read and write.
- QoS is measured as the round-trip time taken for 99% of commands to host.

4.5 Environmental Specifications

Environmental specifications of PV19E-25W product are shown in Table 4-6.

Table 4-6 Environmental Specifications

Parameter	Type	Specifications
Temperature	Operating (Tc)	0°C to 70°C
	Non-operating (Ta)	-40°C to 85°C
Vibration	Operating	7.69 GRMS, 20~2000 Hz/random (compliant with MIL-STD-810G)
	Non-operating	4.02 GRMS, 15~2000 Hz/random (compliant with MIL-STD-810G)
Shock	Operating	Acceleration, 50(G)/11(ms)/half sine (compliant with MIL-STD-202G)
	Non-operating	Acceleration, 1500(G)/0.5(ms)/half sine (compliant with MIL-STD-883K)

Notes:
- This Environmental Specification table indicates the conditions for testing the device. Real world usages may affect the results.
- Tc: case temperature; Ta: ambient temperature. The operating temperature is determined by the case temperature. Adequate airflow is advisable as it enables the device to maintain optimal temperatures, especially in environments with heavy workloads.

4.6 Mean Time Between Failures (MTBF)

Mean Time Between Failures (MTBF) is predicted based on reliability data for the individual components in PV19E-25W. The prediction result for PV19E-25W is more than 2,500,000 hours.

Note: The MTBF is predicated and calculated based on “Telcordia Technologies Special Report, SR-332, Issue 3” method.

4.7 Endurance

The endurance of a storage device is predicted by TeraBytes Written and Drive Writes Per Day based on several factors related to usage, such as the amount of data written into the drive, block management conditions, and daily workload for the drive. Thus, key factors, such as Write Amplifications and the number of P/E cycles, can influence the lifespan of the drive.

Table 4-7 Endurance Specifications

Capacity	TeraBytes Written	Drive Writes Per Day
1600 GB	8,760	3
3200 GB	17,520	3
6400 GB	35,040	3
12800 GB	70,080	3
25600 GB	56,064	3

Notes:

- 1 Gigabyte (GB) is equal to 1,000,000,000 bytes; 1 sector is equal to 512 bytes.
- The total actual usable capacity of the SSD may be less than the total physical capacity because internal NAND management, SSD format, SSD partition, operating system and so on.
- The count of User Addressable Sectors is calculated by the formula of IDEMA.
- Depending on whichever occurs first, Apacer guarantees a warranty of 5 years or Terabytes Written.

4.8 Data Retention

Table 4-8 Data Retention

Parameter	Value
Data Retention	3 months

5. Flash Management

5.1 Error Correction/Detection

PV19E-25W implements a hardware ECC scheme, based on the Low Density Parity Check (LDPC). LDPC is a class of linear block error correcting code which has apparent coding gain over BCH code because LDPC code includes both hard decoding and soft decoding algorithms. With the error rate decreasing, LDPC can extend SSD endurance and increase data reliability while reading raw data inside a flash chip.

5.2 Bad Block Management

Current production technology is unable to guarantee total reliability of NAND flash memory array. When a flash memory device leaves factory, it comes with a minimal number of initial bad blocks during production or out-of-factory as there is no currently known technology that produce flash chips free of bad blocks. In addition, bad blocks may develop during program/erase cycles. Since bad blocks are inevitable, the solution is to keep them in control. Apacer flash devices are programmed with ECC, page mapping technique and S.M.A.R.T to reduce invalidity or error. Once bad blocks are detected, data in those blocks will be transferred to free blocks and error will be corrected by designated algorithms.

5.3 Global Wear Leveling

Flash memory devices differ from Hard Disk Drives (HDDs) in terms of how blocks are utilized. For HDDs, when a change is made to stored data, like erase or update, the controller mechanism on HDDs will perform overwrites on blocks. Unlike HDDs, flash blocks cannot be overwritten and each P/E cycle wears down the lifespan of blocks gradually. Repeatedly program/erase cycles performed on the same memory cells will eventually cause some blocks to age faster than others. This would bring flash storages to their end of service term sooner. Global wear leveling is an important mechanism that levels out the wearing of all blocks so that the wearing-down of all blocks can be almost evenly distributed. This will increase the lifespan of SSDs.

5.4 Flash Translation Layer – Page Mapping

Page mapping is an advanced flash management technology whose essence lies in the ability to gather data, distribute the data into flash pages automatically, and then schedule the data to be evenly written. Page-level mapping uses one page as the unit of mapping. The most important characteristic is that each logical page can be mapped to any physical page on the flash memory device. This mapping algorithm allows different sizes of data to be written to a block as if the data is written to a data pool and it does not need to take extra operations to process a write command. Thus, page mapping is adopted to increase random access speed and improve SSD lifespan, reduce block erase frequency, and achieve optimized performance and lifespan.

5.5 TRIM

TRIM is a feature which helps improve the read/write performance and speed of solid-state drives (SSD). Unlike hard disk drives (HDD), SSDs are not able to overwrite existing data, so the available space gradually becomes smaller with each use. With the TRIM command, the operating system can inform the SSD which blocks of data are no longer in use and can be removed permanently. Thus, the SSD will perform the erase action, which prevents unused data from occupying blocks all the time.

5.6 Over-provisioning

Over-provisioning (OP) is a certain portion of the SSD capacity exclusively for increasing Garbage Collection (GC) efficiency, especially when the SSD is filled to full capacity or performs a heavy mixed-random workload. OP has the advantages of providing extended life expectancy, reliable data integrity, and high sustained write performance.

5.7 SMART Read Refresh™

Apacer's SMART Read Refresh plays a proactive role in avoiding read disturb errors from occurring to ensure health status of all blocks of NAND flash. Developed for read-intensive applications in particular, SMART Read Refresh is employed to make sure that during read operations, when the read operation threshold is reached, the data is refreshed by re-writing it to a different block for subsequent use.

5.8 NVMe Secure Erase

NVMe Secure Erase is an NVMe drive sanitize command currently embedded in most of the storage drives. Defined in NVMe specifications, NVMe Secure Erase is part of Format NVM command that allows storage drives to erase all user data areas. The erase process usually runs on the firmware level as most of the NVMe-based storage media currently in the market are built-in with this command. NVMe Secure Erase can securely wipe out the user data in the drive and protects it from malicious attack.

6. Security and Reliability Features

6.1 CorePower

If the voltage supply is cut, for instance, accidental power off or sudden blackout, the data would be shortly lost. To protect SSD data integrity from this disastrous scenario, Apacer has developed the hardware-based technology named Apacer CorePower. The CorePower equips SSDs with electrolytic capacitors that can deliver urgent power current so that the flash controller can take this extended moment to flush cached data and essential metadata into NAND Flash blocks.

In addition to electrolytic capacitors which guarantee SSD data integrity, an inbuilt IC detector also serves the same purpose as well as ensures the stability of data transmission. The detector is designed to take proactive measures for the aforementioned disastrous scenario. When supply voltage drops below a minimum threshold, the detector will send out signals to the flash controller notifying it to stop operating to prevent poor performance or erratic operation. In the meanwhile, signals will also be sent to DRAM to have cached data flushed into NAND Flash blocks so as to avoid data loss, similar to the function performed by electrolytic capacitors.

PV19E-25W is equipped with Tantalum Capacitors which have lower power leakage, higher operating temperature and higher volume-efficiency (high capacitance in small volume) than many other types of capacitors. The compact size and the high reliability are ideal for embedded computing systems.

6.2 Advanced Encryption Standard

Advanced Encryption Standard (AES) is a specification for the encryption of electronic data. AES has been adopted by the U.S. government since 2001 to protect classified information and is now widely implemented in embedded computing applications. The AES algorithm used in software and hardware is symmetric so that encrypting/decrypting requires the same encryption key. Without the key, the encrypted data is inaccessible to ensure information security.

Notably in flash memory applications, AES 256-bit hardware encryption is the mainstream to protect sensitive or confidential data. The hardware encryption provides better performance, reliability, and security than software encryption. It uses a dedicated processor, which is built inside the controller, to process the encryption and decryption. This enormously shortens the processing time and makes it efficient.

6.3 TCG Opal (optional)

Developed by the Trusted Computing Group (TCG), an organization whose members work together to formulate industry standards, Opal is a set of security specifications used for applying hardware-based encryption to storage devices.

Hardware encryption has many advantages. First of all, it transfers the computational load of the encryption process to dedicated processors, reducing the stress on the host system's CPU. In addition, storage devices complying with Opal specifications are self-encryption devices. Opal specifications also feature boot authentication. When the drive is being accessed, the shadow MBR will request the drive password at boot. The drive will only unlock and decrypt if the correct password is supplied. The other feature is LBA-specific permissions. Users are assigned different permissions for LBA ranges created by the device administrator. Each LBA range is password-protected and can only be accessed by users with the correct key to perform permitted actions (read/write/erase).

6.4 Thermal Sensor

Apacer Thermal Sensor is a digital temperature sensor with serial interface. By using a designated pin for transmission, storage device owners are able to read temperature data.

6.5 Thermal Throttling

Thermal throttling can monitor the temperature of the SSD equipped with a built-in thermal sensor via S.M.A.R.T. commands. This method can ensure the temperature of the device stays within temperature limits by drive throttling, i.e. reducing the speed of the drive when the device temperature reaches the threshold level, so as to prevent overheating, guarantee data reliability, and prolong product lifespan. When the temperature exceeds the maximum threshold level, thermal throttling will be triggered to reduce performance step by step to prevent hardware components from being damaged. Performance is only permitted to drop to the extent necessary for recovering a stable temperature to cool down the device's temperature. Once the temperature decreases to the minimum threshold value, transfer speeds will rise back to its optimum performance level.

6.6 End-to-End Data Protection

End-to-End Data Protection is a feature implemented in Apacer SSD products that extends error control to cover the entire path from the host computer to the drive and back, and that ensures data integrity at multiple points in the path to enable reliable delivery of data transfers. Unlike ECC which does not exhibit the ability to determine the occurrence of errors throughout the process of data transmission, End-to-End Data Protection allows SSD controller to identify an error created anywhere in the path and report the error to the host computer before it is written to the drive. This error-checking and error-reporting mechanism therefore guarantees the trustworthiness and reliability of the SSD.

7. Software Interface

7.1 Command Set

Table 7-1 Admin Command List

Identifier	O/M	Supported	Command Description
00h	M	Y	Delete I/O Submission Queue
01h	M	Y	Create I/O Submission Queue
02h	M	Y	Get Log Page
04h	M	Y	Delete I/O Completion Queue
05h	M	Y	Create I/O Completion Queue
06h	M	Y	Identify
08h	M	Y	Abort
09h	M	Y	Set Features
0Ah	M	Y	Get Features
0Ch	M	Y	Asynchronous Event Request
0Dh	O	Y	Namespace Management
10h	O	Y	Firmware Commit
11h	O	Y	Firmware Image Download
14h	O	Y	Device Self-test
15h	O	Y	Namespace Attachment
18h	O	N	Keep Alive
19h	O	-	Directive Send
1Ah	O	-	Directive Receive
1Ch	O	-	Virtualization Management
1Dh	O	Y	NVMe-MI Send
1Eh	O	Y	NVMe-MI Receive
7Ch	O	-	Doorbell Buffer Config
80h	O	Y	Format NVM
81h	O	Y	Security Send
82h	O	Y	Security Receive
84h	O	Y	Sanitize
86h	O	-	Get LBA Status

Table 7-2 I/O Commands

Identifier	O/M	Supported	Command Description
00h	M	Y	Flush
01h	M	Y	Write
02h	M	Y	Read
04h	O	Y	Write Uncorrectable
05h	O	Y	Compare
08h	O	Y	Write Zeroes

Identifier	O/M	Supported	Command Description
09h	O	Y	Dataset Management (Trim only)
0Ch	O	Y	Verify
0Dh	O	Y	Reservation Register
0Eh	O	Y	Reservation Report
11h	O	Y	Reservation Acquire
15h	O	Y	Reservation Release

Table 7-3 Set Feature Commands

Identifier	O/M	Supported	Command Description
00h	-	-	Reserved
01h	M	Y	Arbitration
02h	M	Y	Power Management
03h	O	-	LBA Range Type
04h	M	Y	Temperature Threshold
05h	M	Y	Error Recovery
06h	O	Y	Volatile Write Cache
07h	M	Y	Number Of Queues
08h	M	Y	Interrupt Coalescing
09h	M	Y	Interrupt Vector Configuration
0Ah	M	Y	Write Atomicity Normal
0Bh	M	Y	Asynchronous Event Configuration
0Ch	O	-	Autonomous Power State Transition
0Dh	O	-	Host Memory Buffer
0Eh	O	Y	Timestamp
0Fh	O	Y	Keep Alive Timer
10h	O	-	Host Controlled Thermal Management
11h	O	-	Non-Operational Power State Config
12h	O	-	Read Recovery Level Config
13h	O	-	Predictable Latency Mode Config
14h	O	-	Predictable Latency Mode Window
15h	O	-	LBA Status Information Attributes
16h	O	-	Host Behavior Support
17h	O	Y	Sanitize Config
18h	O	-	Endurance Group Event Configuration
19h -77h	-	-	Reserved (NVMe Reserved)
78h – 7Dh	-	-	Reserved(NVMe MI Reserved)
7Eh	M	Y	Controller Metadata (NVMe MI)
7Fh	M	Y	Namespace Metadata (NVMe MI)
80h	O	-	Software Progress Marker
81h	O	Y	Host Identifier
82h	O	Y	Reservation Notification Mask
83h	O	Y	Reservation Persistence

Identifier	O/M	Supported	Command Description
84h	O	-	Namespace Write Protection Config
85h – BFh	-	-	Command Set Specific (Reserved)
C0h - FFh	O	-	Vendor Specific

Table 7-4 Get Log Page Commands

Identifier	O/M	Supported	Command Description
00h	-	-	Reserved
01h	M	Y	Error Information
02h	M	Y	SMART / Health Information
03h	M	Y	Firmware Slot Information
04h	O	Y	Changed Namespace List
05h	O	Y	Commands Supported and Effects
06h	O	Y	Device Self-test
07h	O	Y	Telemetry Host-Initiated
08h	O	Y	Telemetry Controller-Initiated
09h	O	-	Endurance Group Information
0Ah	O	-	Predictable Latency Per NVM Set
0Bh	O	-	Predictable Latency Event Aggregate
0Ch	O	-	Asymmetric Namespace Access
0Dh	O	Y	Persistent Event Log
0Eh	O	-	LBA Status Information
0Fh	O	-	Endurance Group Event Aggregate
10h – 7Fh	-	-	Reserved
80h	O	Y	Reservation Notification
81h	O	Y	Sanitize Status
82h - FFh	-	-	Reserved

Table 7-5 NVMe Management Interface Commands

Identifier	O/M	Supported	Command Description
00h	M	Y	Read NVMe-MI Data Structure
01h	M	Y	NVM Subsystem Health Status Poll
02h	M	Y	Controller Health Status Poll
03h	M	Y	Configuration Set
04h	M	Y	Configuration Get
05h	M	Y	VPD Read
06h	M	Y	VPD Write
07h	M	Y	Reset
08h	-	-	SES Receive
09h	-	-	SES Send
0Ah	O	-	Management Endpoint Buffer Read
0Bh	O	-	Management Endpoint Buffer Write
0Ch - BFh	O	-	Reserved

Identifier	O/M	Supported	Command Description
C0h -FFh	O	-	Vendor Specific

Notes:
1. “Y” means “Support”.
2. “O” means “Optional, not supported by default”.
3. “-“ means “No support”

Table 7-6 SMBus / I2C Elements Supported

SMBus/I2C Element	SMBus/I2C Address (8bit)	
	Hex Format	Binary Format
FRU Information Device (for NVMe Storage Device)	A6h	1010_011xb
SMBus/I2C Management Endpoint	3Ah	0011_101xb
Basic Management Command	D4h	1101_010xb

7.2 S.M.A.R.T.

SMART, an acronym for Self-Monitoring, Analysis and Reporting Technology, is an open standard that allows a hard disk drive to automatically detect its health and report potential failures. When a failure is recorded by SMART, users can choose to replace the drive to prevent unexpected outage or data loss. Moreover, SMART can inform users of impending failures while there is still time to perform proactive actions, such as copy data to another device.

Table 7-7 SMART Attributes (Log Identifier 02h)

Byte Index	Bytes	Description
[0]	1	Critical Warning
[2:1]	2	Composite Temperature
[3]	1	Available Spare
[4]	1	Available Spare Threshold
[5]	1	Percentage Used
[31:6]	26	Reserved
[47:32]	16	Data Units Read
[63:48]	16	Data Units Written
[79:64]	16	Host Read Commands
[95:80]	16	Host Write Commands
[111:96]	16	Controller Busy Time
[127:112]	16	Power Cycles
[143:128]	16	Power On Hours
[159:144]	16	Unsafe Shutdowns
[175:160]	16	Media And Data Integrity Errors
[191:176]	16	Number Of Error Information Log Entries
[195:192]	4	Warning Composite Temperature Time
[199:196]	4	Critical Composite Temperature Time
[201:200]	2	Temperature Sensor 1 (Current Temperature)
[203:202]	2	Temperature Sensor 2 (N/A)
[205:204]	2	Temperature Sensor 3 (N/A)

Byte Index	Bytes	Description
[207:206]	2	Temperature Sensor 4 (N/A)
[209:208]	2	Temperature Sensor 5 (N/A)
[211:210]	2	Temperature Sensor 6 (N/A)
[213:212]	2	Temperature Sensor 7 (N/A)
[215:214]	2	Temperature Sensor 8 (N/A)
[219:216]	4	Thermal Management Temperature 1 Transition Count
[223:220]	4	Thermal Management Temperature 2 Transition Count
[227:224]	4	Total Time For Thermal Management Temperature 1 (seconds)
[231:228]	4	Total Time For Thermal Management Temperature 2 (seconds)
[511:232]	280	Reserved

Table 7-8 SMART Attributes (Log Identifier D2h)

Byte	Length	Description
[7:0]	8	Device Capacity
[15:8]	8	User Capacity
[23:16]	8	NAND Read
[31:24]	8	NAND Write
[39:32]	8	NAND Erase Sector
[47:40]	8	Wear Range Delta (%)
[55:48]	8	SSD Life Used Percent D3
[56]	1	WP Watermark
[58:57]	2	Highest Temperature
[62:59]	4	Read Fail Count
[66:63]	4	Data E3D Error
[70:67]	4	PHY Error Count
[74:71]	4	Total Bad Block Count
[78:75]	4	Total Early Bad Block Count
[82:79]	4	Total Later Bad Block Count
[86:83]	4	Read Fail Count
[90:87]	4	Program Fail Count
[94:91]	4	Erase Failure Count
[102:95]	8	System Table Copy Count
[110:96]	8	ReadMoveTableCnt
[114:111]	4	Data Read Retry Count
[118:115]	4	RAID ECC Retry Count
[122:119]	4	RAID ECC Failed Count
[130:123]	8	Total Erase Count
[134:131]	4	D2/D3 Max Erase Count
[138:135]	4	D2/D3 Average Erase Count
[142:139]	4	D2/D3 Min Erase Count
[150:143]	8	Background Read Count (N/A)
[154:151]	4	Host Write Uncorrectable Sector Count

Byte	Length	Description
[158:155]	4	PS3 Enter Success (N/A)
[162:159]	4	PS4 Enter Success (N/A)
[166:163]	4	Wear Leveling Count
[168:167]	2	Chip Internal Temperature
[170:169]	2	Thermal Throttling
[172:171]	2	Thermal Throttling Time
[180:173]	8	FW Code Update Count
[188:181]	8	Flash UNC Error Count
[192:189]	4	HB Retry Count
[196:193]	4	SB Retry Count
[511:197]	315	Reserved

8. Electrical Specifications

8.1 Operating Voltage

Table 8-1 lists the supply voltage for PV19E-25W.

Table 8-1 Operating Range

Parameter	1600 GB	3200 GB	6400 GB	12800 GB
12V	± 10%			
12V noise level	240mVp-p, 0-20MHz			
12V min off time	500ms			
3.3V aux	± 15%			

Note: Minimum time between power removed from SSD (Vcc < 100 mV) and power re-applied to the drive.

8.2 Power Consumption

Table 8-2 lists the power consumption for PV19E-25W.

Table 8-2 Power Consumption

Mode	Unit	1600 GB	3200 GB	6400 GB	12800 GB	25600 GB
Read	W	12.24	12.25	13.45	14.65	16.05
Write		12.77	18.83	21.55	22.54	21.92
Idle		5.72	6.23	7.03	8.17	7.83

Notes:
- All values are typical and may vary depending on flash configurations or host system settings.
- Power consumption is measured using CrystalDiskMark 8.0.4 with file size 1,000MB.

8.3 Inrush Current

Table 8-3 Inrush Current

Inrush Current	1600 GB	3200 GB	6400 GB	12800 GB	25600 GB
12V	1.5A				

9. Airflow Profile

Figure 9-1 depicts the minimum airflow a U.3 15mm (7.68TB) needs to operate without triggering thermal throttling at ambient temperatures varied from 35°C to 65°C.

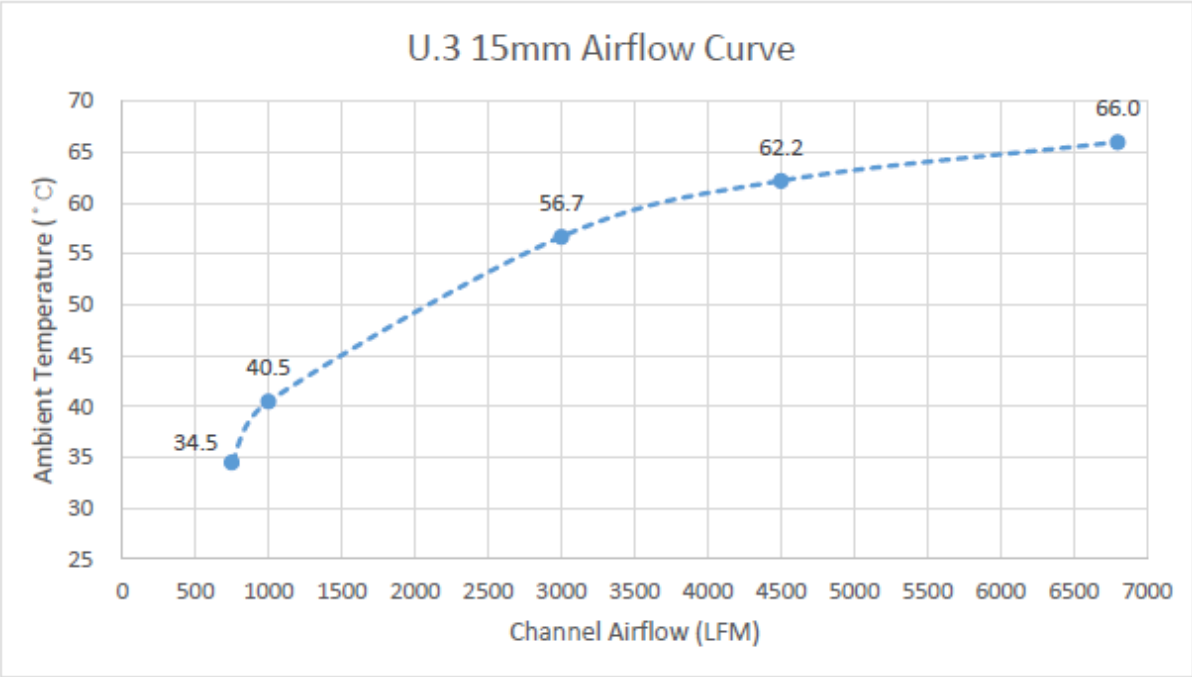


Figure 9-1 U.3 15mm Airflow Curve

10. Mechanical Specifications

Table 10-1 Physical Information

Parameter	Unit	1600 GB	3200 GB	6400 GB	12800 GB	25600 GB
Length	mm	100.10 ± 0.30				
Width		69.85 ± 0.25				
Height		14.65 +0.25/-0.15				
Weight	g ± 5%	198	200	203	205	175.5

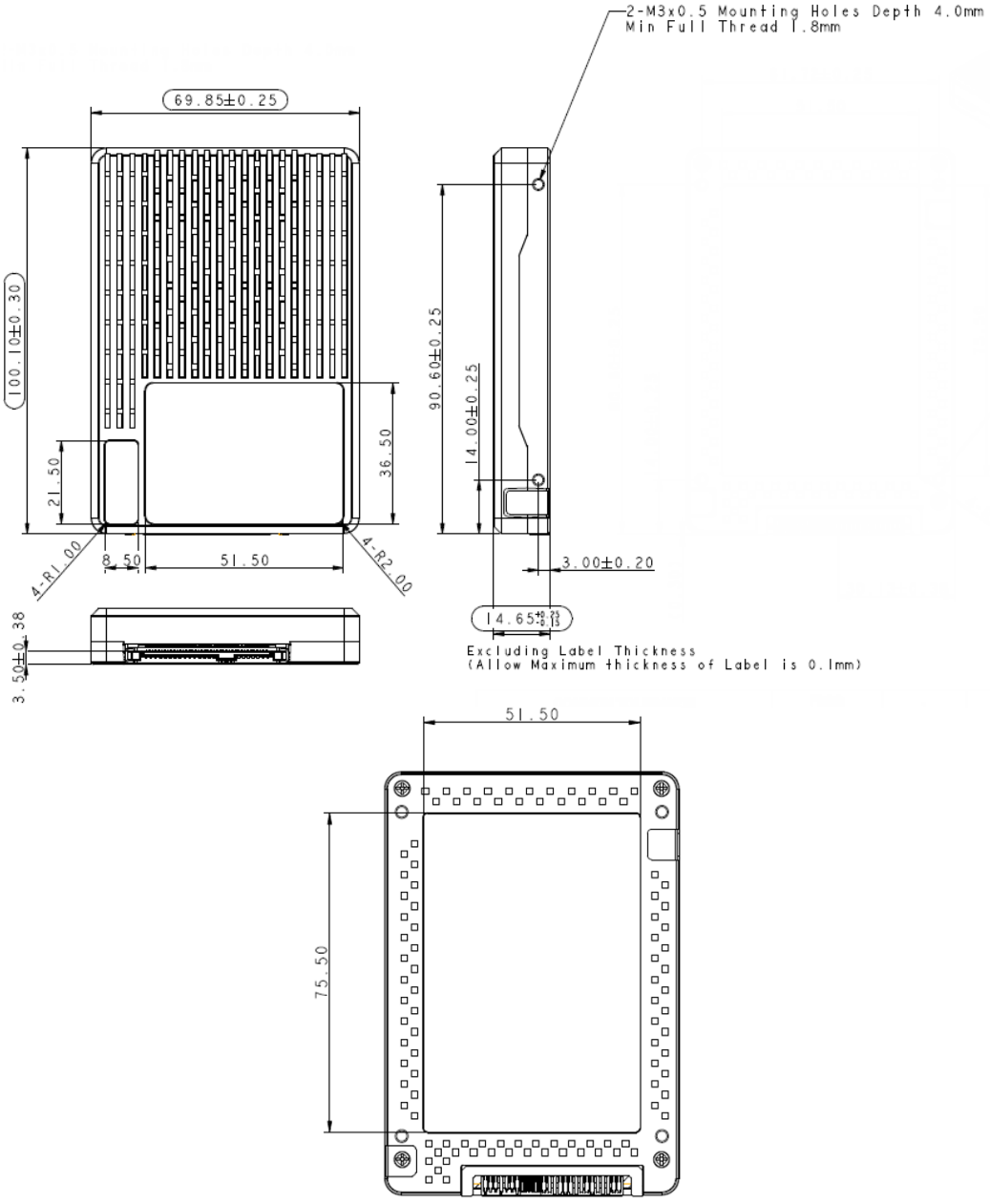


Figure 10-1 Physical Dimensions

11. Product Ordering Information

11.1 Product Code Designations

Apacer's PV19E-25W SSD is available in different configurations and densities. See the chart below for a comprehensive list of options for the PV19E-25W series devices.

Code	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	B	B	6	.	P	6	X	X	G	E	.	X	X	X	X	X

Code 1-3 (Product Line & Form Factor)	PCIe U.3
Code 5-6 (Model/Solution)	PV19E
Code 7-8 (Product Capacity)	CC: 1600GB DN: 3200GB DP: 6400GB DQ: 12800GB DR: 25600GB
Code 9 (Flash Type & Product Temp)	3D TLC Standard Temperature
Code 10 (Product Spec)	U.3
Code 12-14 (Version Number)	Random numbers generated by system
Code 15-16 (Firmware Version)	E1: Thermal Sensor PLP OP E2: Thermal Sensor PLP TCG Opal OP

11.2 Valid Combinations

The following tables list the available models of the PV19E-25W series which are in mass production or will be in mass production. Consult your Apacer sales representative to confirm availability of valid combinations and to determine availability of new combinations.

11.2.1 Without TCG Opal

Capacity	Valid Combination
1600GB	BB6.P6CCGE.001E1
3200GB	BB6.P6DNGE.001E1
6400GB	BB6.P6DPGE.001E1
12800GB	BB6.P6DQGE.001E1
25600GB	BB6.P6DRGE.002E1

11.2.2 With TCG Opal

Capacity	Valid Combination
1600GB	BB6.P6CCGE.002E2
3200GB	BB6.P6DNGE.002E2
6400GB	BB6.P6DPGE.002E2
12800GB	BB6.P6DQGE.002E2
25600GB	BB6.P6DRGE.001E2

Revision History

Revision	Description	Date
0.1	Preliminary release	4/18/2023
0.2	- Added U.3 to form factor - Updated height from 7mm to 15mm and weight on Specifications Overview page and 9. Mechanical Specifications - Updated read/write performance at 1. General Description - Updated sequential/sustained read/write performance, QoS and power consumption on Specifications Overview page, 4. Product Specifications and 8.2 Power Consumption	5/9/2023
0.3	Added 1600, 6400 and 12800GB support	6/1/2023
0.4	- Changed model name from PV19E-25 to PV19E-25W - Updated Performance and Power Consumption on and removed NAND flash type from Specifications Overview page - Updated sequential read/write performance at 1. General Description - Updated Table 4-2, 4-3, 4-4, 4-5, 4-6 and 8-2 for all capacities - Updated weight for 12800GB at Table 9-1	6/7/2023
1.0	- Removed support for form factor U.2 - Removed Table 7-8 SMART Attributes (Log Identifier C0h) - Updated Performance on and added NAND Flash Type to Specifications Overview - Updated 4.2 Performance, 4.3 Latency, 4.4 Quality of Service (QoS), and 8.2 Power Consumption - Added TBW and a note regarding warranty to 4.6 Endurance - Added 4.5 Environmental Specifications, 9. Airflow Profile and 11. Product Ordering Information	10/5/2023
1.1	- Updated Power Consumption on Specifications Overview page and 8.2 Power Consumption - Modified pin name of pins S3, S6, S10, S13, S18, S21, S24, S27, E11, E14, E18, and E21 at Table 3-1	10/11/2023
1.2	Added 25600GB and TCG Opal support	5/6/2024

Global Presence

Taiwan (Headquarters)
Apacer Technology Inc.
1F., No.32, Zhongcheng Rd., Tucheng Dist.,
New Taipei City 236, Taiwan R.O.C.
Tel: 886-2-2267-8000
Fax: 886-2-2267-2261
amtsales@apacer.com

U.S.A.
Apacer Memory America, Inc.
46732 Lakeview Blvd., Fremont, CA 94538
Tel: 1-408-518-8699
Fax: 1-510-249-9551
sa@apacerus.com

Japan
Apacer Technology Corp.
6F, Daiyontamachi Bldg., 2-17-12, Shibaura, Minato-Ku,
Tokyo, 108-0023, Japan
Tel: 81-3-5419-2668
Fax: 81-3-5419-0018
jpservices@apacer.com

Europe
Apacer Technology B.V.
Science Park Eindhoven 5051 5692 EB Son,
The Netherlands
Tel: 31-40-267-0000
Fax: 31-40-290-0686
sales@apacer.nl

China
Apacer Electronic (Shanghai) Co., Ltd
Room D, 22/FL, No.2, Lane 600, JieyunPlaza,
Tianshan RD, Shanghai, 200051, China
Tel: 86-21-6228-9939
Fax: 86-21-6228-9936
sales@apacer.com.cn

India
Apacer Technologies Pvt Ltd,
1874, South End C Cross, 9th Block Jayanagar,
Bangalore-560069, India
Tel: 91-80-4152-9061/62
Fax: 91-80-4170-0215
sales_india@apacer.com