mercury

Boron 3U VPX Rad-Tolerant SpaceDrive (*SpaceMax* series)
High Reliability, Dual-Host, Solid State Recorder
16 Gbit/s SRIO (8-Lanes), >10 Gbit/s PCIe (8-Lanes)
4.5 TB host capacity remains constant over life

Compact, high performance, high density, Radiation Tolerant storage

- Constant 4.5 TB capacity over life
- RT-by-design components, except NAND
- 100 krad components except Oscillator
- Vectron oscillator >50 krad @10-mrad/s
- SEL LET >60.

- Supports 2 host systems
- Two levels of ECC. BitSweep and 8-bit Horizontal Reed Solomon
- TLC NAND in SLC mode, 60K PE cycles
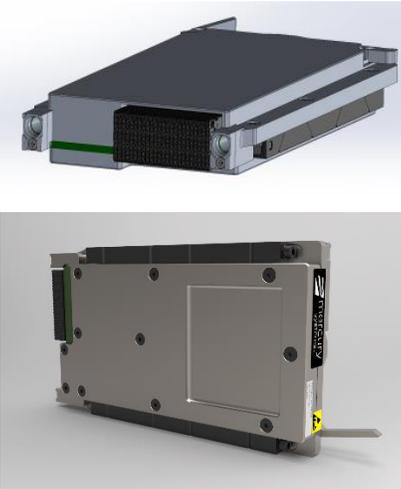- BOM available for pedigree evaluation

Applications Include:
- Satellites and Launch vehicles
- Missiles
- High reliability Ground Stations
- Scientific payloads
- Terrestrial applications with potential for radiation

Industry leading capacity, performance, size, and reliability.

Mercury's *SpaceMax* series of radiation-tolerant SpaceDrives represent the world's first commercially available, storage devices precision-engineered for the harshest operating environments on earth and beyond. Although designed for space applications, this series of compact, high reliability drives are perfect for applications with potential for radiation exposure, including high-altitude aircraft, airborne weapons, and mission-critical ground computing systems.

The RH304T is the first of several planned products in the *SpaceMax* series of Ultra-Fast, high-capacity solid-state data recorders. Utilizing 3D TLC NAND running in SLC mode, these SpaceDrives include all the features of the popular RH3440 and RH3480 models plus enhanced error correction utilizing a two-pass ECC scheme that assures the highest possible reliability with the latest generation 3D TLC NAND running in SLC mode. Designed for fault-tolerance with multiple failed NAND devices, the RH304T enables an immense storage capacity, high performance, and long-term data integrity for applications where device replacement might not be possible.

Highlights
- Sustained/deterministic performance of 16 Gbps, 8-Lanes SRIO, >10 Gbps PCIe
- TID: All RT-By Design components rated at 100 krad (Si) minimum.
  - NAND (B27C) rated at low dose rate, 10 mrad/s (Si). Tested to >100 krad (Si).
  - Vectron oscillator rated at >50 krad at 10mrad/s
- ECC allows Run-Through of SEE events. Optional NAND power cycles prior to commands.
- NAND is screened to EEE-INST-002 level 2. Micron B27C NAND die.
- Supports 2 hosts that can each access the entire 4.5 TB capacity
- SRIO Core available for Versal FPGA implementations. Contact Sales for details.
- Constant host capacity across life
- Mercury proprietary Horizontal Reed Solomon algorithm assures error free operation
- VITA 48.2 (2010) compliant 3U Form-Factor. P2 unpopulated
- Automatic retirement of bad NAND blocks
- Bad block table (Holds NAND defects) supports field upgrades
- Robust suite of health statistics
- Defect mitigation scheme mitigates all factory defects in NAND flash

TECHNICAL SPECIFICATIONS

- **Radiation tolerance**
  - NAND Flash
    - Micron B27C TLC in SLC mode. 16-die PEM package
    - TID tested at low dose rate of 10 mrad/s to 150+ krad (Si)
    - RLAT and DPA per NAND lot
    - NASA EEE-INST-002 (Level 2) screened.
      1040 hrs @ 70°C, HTOL 1000 hrs @ 85°C
    - Optional automatic NAND power cycle before commands
    - Mercury SEL testing: Tested at LET 60, no SEL. Fluence of $1E^7/cm^2$
    - NASA SEL testing: No SEL observed, 45° angle, LET 79.2 (Wilcox 2023)
  - NAND Controller: Microchip RTG4
    - Configuration upsets immunity to LET > 103 MeV.cm2/mg
    - Single-event latch-up (SEL) immunity to LET > 103 MeV.cm^2/mg
    - Registers SEU rate < 10-12 errors/bit-day (GEO Solar Min)
    - SET upset rate < 10-8 errors/bit-day (GEO Solar Min)
    - Total ionizing dose (TID) > 100 krad (Si)
  - All other devices: Radiation-Tolerant-by-design to 100 krad (Si) min

- **Host interface modes**
  - Dual Port: One host with two Fat Pipes
  - Dual Host: Two hosts with 4-Lanes to each host

- **Recording modes**
  - Linear Mode
    - Data is recorded sequentially, beginning of NAND to the end of NAND
  - Host Addressable mode
    - SpaceDrive is partitioned into 1120 UltraBlocks
    - Each UltraBlock contains 4,076,863,488 bytes and 18,432 SuperPages
    - Each SuperPage contains 221,184 bytes
    - A SuperPage is the minimum write chunk size
    - SuperPages in an UltraBlock must be written sequentially
    - Host system can write to UltraBlocks in any random order as long as
      individual SuperPages in the UltraBlock are written sequentially
  - Host can read any SuperPage, in any UltraBlock, at any time, in both the
    Linear and Host Addressable modes

- **Defect mitigation and spare NAND blocks**
  - Defect mitigation uses spare NAND devices to mitigate factory defect Blocks
  - An additional 15.5% of the total capacity is reserved as spare Blocks
  - Worn Blocks are automatically replaced from spare Blocks
  - Bad block information is saved in rad-tolerant MRAM
  - The Bad Block Tables can be updated on-orbit if required

- **Performance**
  - Dual Port Mode: Writes/Reads using 8-Lanes. Two Fat-Pipes.
  - Dual Host Mode: Serial access with 4-Lanes (1 Fat-Pipe) by each host
  - SRIO lane speed: 3.125 Gbits/s
  - PCIe lane speed: 2.5 Gbits/s
  - SRIO performance: Writes/Reads, 16 Gbits/s (Dual Port Mode)
  - PCIe performance: Writes Up to 10.23 Gbps (Dual Port)
    - Reads, up to 11.80 Gbps (Dual Port)
    - Write/Read, up to 5.1 Gbps (Dual Host Mode)
  - SRIO: Time to fill SpaceDrive in Dual Port Mode: 37.5 minutes
  - SRIO: Time to fill SpaceDrive in Dual Host Mode: 75 minutes

- **VPX connectors**
  - Smith's or TE connectors: minimum of 500 mate/unmate cycles
  - Included TE guide blocks, both model versions (TE or Smith's connectors)
  - Application designers should plan to use TE guide pins for compatibility.
  - Guide block key is adjustable and ships in the 0° position
  - Recommended wedgelock torque: 15-30 in-lbs
  - NOTE: Connector P2 is not installed. The corresponding mating
    connector, J2, must not be installed on customer backplanes.

- **NAND endurance**
  - Minimum of 60,000 drive overwrites (PE cycles)
  - Up to 15 drive over-writes/day for 7 years
  - TBW: 270 PB minimum
  - Minimum 1-month retention at EOL at 72°C
  - Minimum 1-week retention at EOL at 105°C, (unpowered)
  - Drive Erase time: Typically < 60 seconds. Up to 150 sec at EOL.
  - One UltraBlock of isolated "SandBox" storage

- **Other features**
  - 512K MRAM available for host usage
- **Reliability:**
  - Microprocessor-free design, no software
  - Fully simulated, state-machine based design
  - Rad-Tolerant-by-design components
  - Run-through of SEE events through use of strong ECC
  - Optional NAND device power cycle before commands or
    groups of commands.
  - NAND PEMs screened to EEE-INST-002 Level 2
  - Automatic block retirement
- **Error correction (ECC):**
  - Two-passes. Single bit, then 8-bit correction
  - Pass1: Mercury BitSweep algorithm.
  - Pass2: Mercury Horizontal Reed Solomon algorithm
  - Pass1: 20, 1-bit corrections per NAND bus read operation.
  - Pass2: 4, 8-bit corrections every 12 host bytes
  - Abrupt power interruption protection
  - Corruption free state machine design with diary variables
- **Status data**
  - All voltages, 3 temperature sensors
  - Spare blocks remaining, Total Bytes written
  - Erase cycle count, ECC errors
  - Programmable Alert signal indicates system events
- **100% dynamic burn-in at temperature**
- **Physical**
  - Ruggedized construction and assembly
  - Weight: < 750 grams
  - Single 5V supply
  - Typical RMS power

Mode	-40 °C	25 °C	72 °C
Idle	5 W	5.1 W	7 W
Dual Port Write	15 W	16 W	18W
Dual Port Read	12 W	13 W	15 W
Erase	17W	17.5 W	20 W
Dual Host Write	10.8 W	11.5 W	12 W
Dual Host Read	9 W	9.5 W	11.3 W
Dual Host Erase	16.5 W	17 W	19 W

  - Vibration
    - 3-axis, 20Hz – 2000 Hz, 5 Min/axis, 16 gRMS
    - Custom vibration profiles (contact Mercury)

16 gRMS random vibration profile	
Frequency (Hz)	g^2/Hz
20	0.03
50	0.21
800	0.21
2000	0.03

  - Shock
    - 3+, 3- per axis. 18 total
    - Custom shock vibration profiles (contact Mercury)

Frequency (Hz)	g
50	25
100	100
800	800
1300	1000
10000	1000

  - BOM, Schematics, design documents available on request
  - Operating rail temperature: -40 °C to +72 °C
  - Storage temperature: -55 °C to +105 °C
    - Storage above 85 ^{0}C reduces data retention time

IPC compliance:

    Acceptability of Printed Boards
    IPC-A-600

    Qualification for Printed Boards
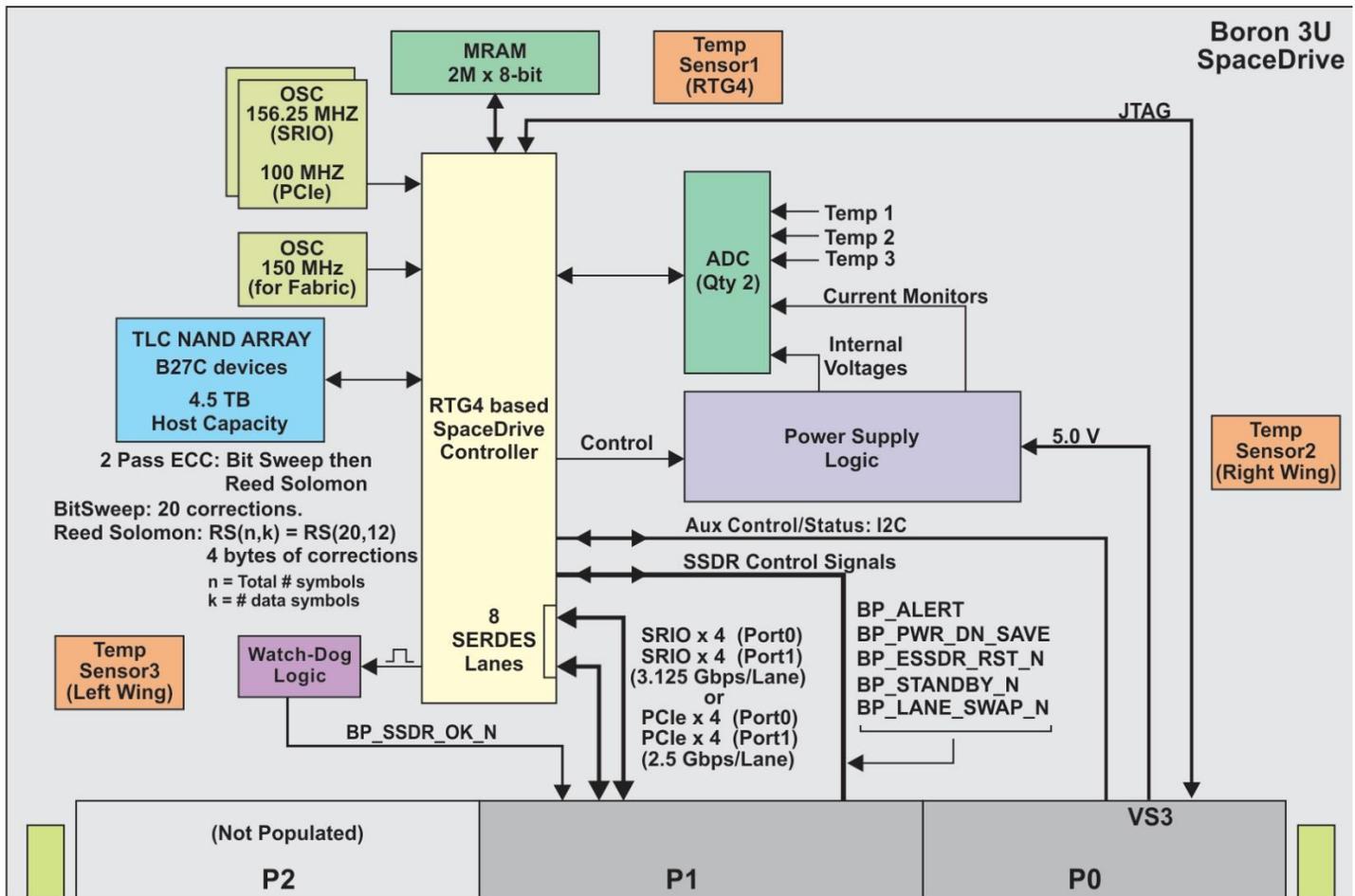   **IPC-A-6011, IPC-A-6013**

    Design and Land Patterns
    IPC-A-2221, IPC-A-2223, IPC-A-2226

    Base Materials for Printed Boards
    IPC-A-4203, IPC-A-4204/11

    Surface Finishes
    IPC-A-4552

    Copper Foils
    IPC-A-4562

Block Diagram

NOTE: Connector P2 is not installed. The corresponding mating connector, J2, must not be installed on customer backplanes.

Note: The equipment described herein may require US Government authorization for export purposes. Diversion contrary to US law is prohibited. ER-22-3990

Part Number Guide

R	H3	04T	N	M	6	S	–	x	1	x	I	20	–	2	x

FIELD ⟶ 1 2 3 4 5 6 7 8 9 10 11 12 13 14

Field 1: Product Series **(R)**
R = Mercury Systems, Rad-Tolerant series

Field 2: Form Factor **(H3)**
H3 = PCB uses a 3U VPX form-factor. (Refer to field 9 for specific enclosure form-factor)

Field 3: Host Capacity **(0xT)**
04T = 4.5 TB host capacity with Dual Port and Dual-Host support.

Field 4: Encryption **(N)**
N = No encryption

Field 5: Media Manufacturer **(M)**
M = Micron

Field 6: Media Type **(6)**
6 = 3-Bit 3D TLC NAND, 512 Gbit (B27C die), 16-die PEM package
7 = 3-Bit 3D TLC NAND, 512 Gbit (B47T die), 16-die PEM package (Contact Sales for availability). B47T replaces B27C when existing stock is exhausted.

Field 7: Media operating mode **(S)**
S = TLC NAND in SLC mode

Field 8: Customizable features field 1 **(x)**
0 = Digital ground isolated from chassis/enclosure ground
1 = Digital ground connected to chassis/enclosure ground

Field 9: Customizable features field 3 **(1)**
1 = VITA 48.2, Radon compatible form-factor. 3U levered form-factor (100mm x 160mm x 25.4mm)
Contact Sales for availability of VITA 78 SpaceVPX compatible enclosure options

Field 10: Customizable features field 3 **(0)**
NOTE: Connector P2 is not installed on the Boron SpaceDrive. The corresponding mating connector, J2, must not be installed on customer backplanes.
0 = Smith's VPX Connectors
1 = TE connectivity MultiGig RT 2-R VPX connectors

Field 11: Operating Temperature **(I)**
I = -40 °C to +72 °C rail temperature

Field 12: Design Generation data **(20)**
20 = Generation 2 SpaceMax Series

Field 13: PCB revision **(x)**
2 = Revision 2 PCB

Field 14: Attribute data **(x)**

1 =	Construction:	Leaded (L)		3 =	Construction:	Leaded (L)
	Interface Structure:	2 x4 Lanes (8)			Interface Structure:	2 x4 Lanes (8)
	Interface Type:	SRIO (SR)			Interface Type:	PCIe (PC). **
	Grade:	Engineering Unit (EDU)			Grade:	Engineering Unit (EDU)
2 =	Construction:	Leaded (L)		4 =	Construction:	Leaded (L)
	Interface Structure:	2 x4 Lanes (8)			Interface Structure:	2 x4 Lanes (8)
	Interface Type:	SRIO (SR)			Interface Type:	PCIe (PC). **
	Grade:	Flight unit (FLT)			Grade:	Flight unit (FLT)

NOTE: EDU units are not ruggedized or radiation tolerant and are intended for lab development only.

**** = Contact Sales for availability**

Example part number: **RH304TNM6S-010I20-22 (4.5 TB 3U VITA 48.2 VPX SRIO Flight, Isolated ground, Smith's connector, Rev 2 PCB)**

mercury

Corporate Headquarters

50 Minuteman Road
Andover, MA 01810 USA
+1 978.967.1401 tel
+1 866.627.6951 tel
+1 978.256.3599 fax

International Headquarters
Mercury International

Avenue Eugène-Lance, 38
PO Box 584
CH-1212 Grand-Lancy 1
Geneva, Switzerland
+41 22 884 51 00 tel

Learn more

Visit: mrcy.com/contact-us
Sales contact:
Bill.Sorrentino@mrcy.com

MADE IN USA

N

Revision: 6.1
10/14/2025
DOC-RH304TNM6SXXXIXX

Note: The equipment described herein may require US Government authorization for export purposes. Diversion contrary to US law is prohibited. ER-22-3990