Pi 2 Design

Mercury 3B

Hardware Reference Manual

© 2026 PI 2 Design

Table of Contents

1 Warranty 3
2 Operating Specifications 4
2.1 Mercury 3B Operating specifications 4
3 Overview 5
3.1 Introduction 5
3.2 Block Diagram 5
4 On-Board Devices 7
4.1 Overview 7
4.2 Compute Module 4 7
4.2 WM8804 SPDIF Transmitter 7
4.2.1 WM8804 SPDIF Transmitter Notes 8
4.3 Dual High Resolution NDK Clocks 8
4.4 RS-485 Differential Transmitter 8
4.5 I2S Differential Driver 8
5 CM4 Ports and GPIO 9
5.1 Overview 9
5.2 Compute Module 4 Ports 9
5.2.1 CM4 Port Notes 9
5.3 Compute Module 4 GPIO 9
5.3.1 CM4 GPIO Notes 11
6 Mercury 3B Power 12
6.1 Overview 12
7 Mercury 3B Software 14
8 Connector Locations 15
8.1 Overview 15
8.2 Front and Rear PaneL and Interior Views 15
8.3 USB – Front Panel 15
5.15 Micro-SD Card – Front Panel 15
8.4 Status LED's 16
8.5 Power Switch – Front Panel 16
8.6 HDMI 16
8.7 Gigabit Ethernet 16
5.16 I2S Over HDMI 16
8.8 I2S Swap Switch 17
8.9 USB-C 17
5.17 RCA SPDIF 17
8.10 6.35MM AES Balanced 17
10 Document Revisions 18
11 Errata 19
11.15 Overview 19

List of Figures

Figure 1 – Mercury 3B Block Diagram 6
Figure 2 – Mercury 3B Power, Simplified Block Diagram 12
Figure 3 – Mercury 3B Power Control Schematic 12
Figure 4 – Mercury 3B Front Panel 15
Figure 5 – Mercury 3B Rear Panel 15

1 WARRANTY

The enclosed product ("the Product") is warranted by Pi 2 Design for a period of one year for reasonable, individual home use, all as further described and defined below. This warranty runs solely to the individual purchasing the Product and is not transferable or assignable in any respect. This warranty is valid only for so long as the product is used intact as shipped from PI 2 Design. Any attempt or effort to alter the Product, including but not limited to any attempt to solder, de-solder, unplug, replace, add or affix any part or component of or onto the Product, other than components specifically intended for the user to plug and unplug into appropriate sockets and/or Connectors to facilitate intended use and deployment, all as specifically described and authorized in this Product Hardware Reference Manual, shall void this warranty in all respects. Coverage under this warranty requires that the Product be used and stored at all times in conditions with proper electrostatic protection necessary and appropriate for a complex electronic device. These conditions include proper temperature, humidity, radiation, atmosphere and voltage (standard commercial environment, 0C to +70C, <60%RH). Any Product that has been modified without the express, prior written consent of Pi 2 Design is not covered by this warranty. The use or connection of any adapter or component with any device other than a Pi 2 Design Connector or adapter shall void this warranty and the warranty of all other components, parts and modules connected to the rest of the system. Pi 2 Design shall not be responsible for any damage to the Product as a result of a customer's use or application of circuitry not developed or approved by Pi 2 Design for use on or in connection with the Product.

This warranty does not cover defects caused by electrical or temperature fluctuations or from stress resulting from or caused by abuse, misuse or misapplication of the Product. Any evidence of tampering with the serial number on the Product shall immediately void this warranty. Notwithstanding anything to the contrary herein, Pi 2 Design expressly disclaims any implied warranty of merchantability or implied warranty of fitness for a particular purpose in connection with the manufacture or use of the Product.

2 OPERATING SPECIFICATIONS

2.1 MERCURY 3B OPERATING SPECIFICATIONS

Mercury 3B conforms to the following specifications:

Specification	Value
Dimensions	102mm x 125mm x 40mm (4” x 5” x 1.2”)
Weight	~0.5kg (1 lbs.)
Storage Temperature	-20C to +85C (-4F to 185F)
Operating Temperature	0C to +70C (32F to 158F)
Humidity	0% to 95% RH, Non-Condensing
Input Voltage (VIN)	+5.1V +/- 5% DC
Power Consumption	3W Typical, 5W Maximum (No GPU, no USB)

Table 1 – Mercury 3B Operating Specifications

3 OVERVIEW

3.1 INTRODUCTION

Mercury 3B , designed and manufactured by PI 2 Design, is a Compute Module 4 based device designed for Professional, Studio Grade, Digital Audio Streaming. Mercury 3B converts the Compute Module 4 I2S Interface to High-Definition Digital Audio Coax, Balanced AES and I2S over HDMI. These multiple, simultaneously active digital audio outputs allow Mercury 3B to optimally interface with virtually any High-Performance DAC on the market.

The major features of Mercury 3B are as follows:

- **COMPUTE MODULE 4 -** This module provides 4 High Performance ARM Cores, Dual 4K HDMI Output, Gigabit Ethernet, 2/4GB DRAM and more.
- **GIGABIT ETHERNET -** A standard RJ45 Provides the interface to the CM4 Gigabit Ethernet I/F.
- **EXTERNAL USB2.0 -** This connector provides a 480Mbit USB2.0 Host Port
- **EXTERNAL HDMI –** One 4K HDMI Connector allows access to CM4 HDMI Output 0
- **AES TRANSMITTER –** The industry standard WM8804 converts the CM4 I2S stream to AES3/SPDIF formatted data at 24-Bit up to 192Khz Frame Rate
- **AES BALANCED OUTPUT** – An RS-485 Transmitter with a 1:1 Isolation Transformer provides balanced audio data via the Professional 6.35MM Connector
- **SPDIF COAX OUPUT -** A 1:1 Isolation Transformer provides Bit Perfect Impedance Controlled Digital Audio Data @ 1V Consumer Standard Level.
- **DIFFERENTIAL I2S OUTPUT –** An LVDS Differential Transmitter drives the I2S Bus over an HDMI Connector. Pinout is polarity adjustable for maximum flexibility.
- **HIGH RESOLUTION CLOCKS –** A pair of Ultra-Low Noise NDK NZ2520SDA oscillators drive the WM8804 in non-PLL mode for the lowest possible noise.
- **LOW NOISE LDO's –** Two Ultra-Low Noise LP5907 LDO's (6.5 uV noise and 82 dB PSRR) are used to supply the WM8804 and the NDK Clock's.
- **ULTRA-HIGH PSRR NOISE FILTER –** This Filter reduces input PSU switching noise by a factor of 100
- **LOW NOISE PCB LAYOUT –** 4-layer Split Ground PCB with noise reduction techniques refined from years of High-Speed Mixed-Signal Design work.
- **EXTRUDED ALUMINUM ENCLOSURE –** Rugged, Aircraft Grade Aluminum, Anodized for Scratch Resistance
- **PRE-PROGRAMMED SD CARD -** Mercury comes with an SD Card loaded with Volumio, Moode or Ropieee (other OS's TBD)

3.2 BLOCK DIAGRAM

Refer to the following figure for a block diagram of Mercury 3B.

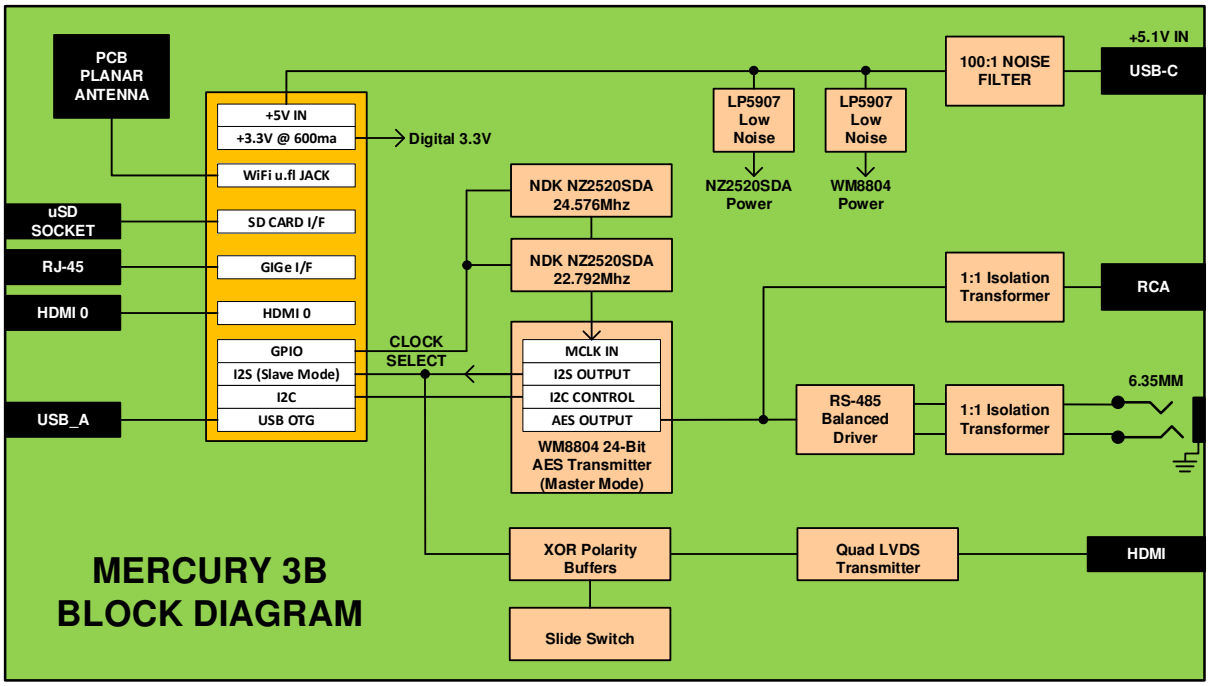

Figure 1 – Mercury 3B Block Diagram

4 ON-BOARD DEVICES

4.1 *OVERVIEW*

Mercury 3B interfaces to the CM4 via a pair of high density Hirose Connectors. This section describes in detail the devices located on the Mercury Streamer.

4.2 COMPUTE MODULE 4

At the core of Mercury 3B is the latest Raspberry Pi Compute Module 4. Designed for low-powered embedded applications, this module runs the software required to perform the Digital Audio Player function as well as other applications. Key features of the CM4 (as used on the Mercury 3B) are as follows:

- Broadcom BCM2711, Quad core Cortex-A72 (ARM v8) 64-bit SoC @ 1.5GHz
- H.265 (HEVC) (4Kp60 decode), H.264 (1080p60 decode, 1080p30 encode)
- OpenGL ES 3.0 graphics
- 2GB or 4GB LPDDR4-3200 SDRAM
- 2.4 GHz, 5.0 GHz IEEE 802.11 b/g/n/ac wireless
- Bluetooth 5.0, BLE
- Gigabit Ethernet PHY supporting IEEE 1588
- USB 2.0 port
- I2C and I2S Peripheral Ports
- HDMI 2.0 port (up to 4Kp60 supported)
- SDIO 2.0

4.2 WM8804 SPDIF TRANSMITTER

The Mercury 3B uses the Cirrus Logic WM8804 AES Digital Audio Transmitter. This device interfaces to the Compute Module 4 via I2S and I2C. The signals used to interface with the WM8804 are shown in the following table.

WM8804 Signal	CM4 Signal	Description
MCLK	-	Unused
BCLK	BCLK	I2S Bit Clock Output to Pi
LRCLK	LRCLK	I2S Word Clock Output to Pi
SDIN	SDOUT	I2S Serial Audio Data Input from Pi
SCL	SCL	I2C Clock from Pi
SDA	SDA	I2C Data to/from Pi

XIN	GPIO6	0 = Select 22.5792Mhz Input Clock for 44.1Khz, 88.2Khz and 176.4Khz Frame Rates 1 = Select 24.576Mhz Input Clock for 48Khz, 92Khz and 192Khz Frame Rates
TXO	-	AES3/SPDIF encoded digital audio output

Table 2 – CM4 to WM8804 Connections

4.2.1 WM8804 SPDIF TRANSMITTER NOTES

1. The WM8804 is controlled using the I2C port. Refer to the WM8804 documentation and installed player software.
2. Mercury 3B is designed to operate the WM8804 in Master mode. In this mode the WM8804 receives its master clock from the Selected NDK Clock and drives MCLK (unused by the CM4), BCLK and LRCLK out. Serial Data in is received from CM4.

4.3 DUAL HIGH RESOLUTION NDK CLOCKS

A pair of NDK NZ2520SDA Ultra-Low Noise clocks provide the critical timing signals for the WM8804. They are selected via Compute Module 4 GPIO6 (0 = 22.5792Mhz and 1 = 24.576Mhz).

4.4 RS-485 DIFFERENTIAL TRANSMITTER

An RS-485 Differential Transmitter accepts the SPDIF output from the WM8804 and sends it as a balanced pair to the 1:1 Isolation Transformer and then to the 6.35mm connector.

4.5 I2S DIFFERENTIAL DRIVER

A Quad Differential LVDS Driver takes the I2S Bus and converts each signal into a balanced differential signal. This is then connected to an HDMI connector. This device is designed to drive the I2S Bus up to 3 meters.

5 CM4 PORTS AND GPIO

5.1 OVERVIEW

Mercury 3B uses several of the Interface Ports and GPIO from the CM4 for control and status purposes.

5.2 COMPUTE MODULE 4 PORTS

Certain CM4 Port pins are hardwired and are always available when enabled. The usage for these ports on Mercury 3B are listed below in the following table.

PORT/Signal(s)	Mercury 3B Use	Description
Ethernet	P8	RJ45 Ethernet Port
*LED_ACT	LED1	Green LED, CM4 Activity
*LED_PWR	LED2	Red LED, Power
Analog_IP0-1	Unused	
Camera_GPIO	Unused	
*EXT_RST	*RST	Reset Out to Peripherals
USB_P/N	USB Type A	USB Host on Front Panel
USB_OTG_ID	GND	Host Mode Only
CAM0-1	Unused	
DSI0	Unused	
DSI1	Unused	
PCIe	Unused	
HDMI0	P4	External Micro-HDMI Connector
HDMI1	Unused	

Table 3 – CM4 Ports and Usage

5.2.1 CM4 PORT NOTES

1. Ports marked unused are unavailable and not connected on Mercury 3B.

5.3 COMPUTE MODULE 4 GPIO

The CM4 provides a large number of General Purpose I/O (GPIO) pins. These pins also can be assigned to alternate functions as defined in the CM4 documentation. The usage of these pins (and alternate functions) on Mercury 3B are described in the following

table.

GPIO	DIR	AF	PUP PDN	Mercury Streamer Usage	Description/Notes
0	-			unused	
1	-			unused	
2	I/O	I2C1	PUP	SDA	I2C Data for WM8804
3	I/O	I2C1	PUP	SCL	I2C Clock for WM8804
4	-			unused	
5	-			unused	
6	I/O			GPIO6	WM8804 Master Clock Select
7	-			unused	
8	-			unused	
9	-			unused	
10	-			unused	
11	-			unused	
12	-			unused	
13	-			unused	
14	-			unused	
15	-			unused	
16	-			unused	
17	-			unused	
18	IN	I2S		BCLK	I2S Bit Clock from WM8804
19	IN	I2S		WCLK	I2S Word Clock from WM8804
20	-			unused	
21	OUT	I2S		SDOUT	I2S Serial Data to WM8804
22	OUT		PUP	PHLD	Power Hold to Power Circuit
23	-			unused	
24	IN		PUP	*PSW	Power On Switch from Power Circuit

GPIO	DIR	AF	PUP PDN	Mercury Streamer Usage	Description/Notes
25	-			unused	
26	-			unused	
27	-			unused	

Table 4 – CM4 Port and GPIO Pin Assignments

5.3.1 CM4 GPIO NOTES

2. DIR is from the point of view of the CM4.
3. Alternate Function (AF) column indicates that the use of this pin requires the pin to be assigned to the named function as defined by the CM4 specifications.
4. PUP/PDN indicates if the GPIO should have its associated Pullup (PUP) or Pulldown (PDN) resistor enabled.
5. An asterisk '*' at the beginning of the name indicates a low true signal.

6 MERCURY 3B POWER

6.1 OVERVIEW

Mercury 3B is designed to be powered from an external +5V source.

See the block diagram below for a simplified view of Mercury 3B power flow.

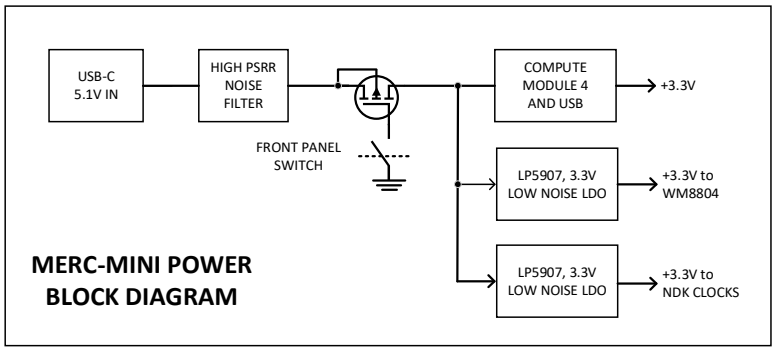

Figure 2 – Mercury 3B Power, Simplified Block Diagram

6.2 POWER CONTROL

This circuit allows software to monitor and control the power state of the Mercury Streamer. It uses two GPIO to perform the Power Hold and Power State functions. This circuit is compatible with the Volumio 503HTA Plug-In. Note that by default the circuit simply follows the state of the Pushbutton Power Switch.

This circuit is shown in the figure below.

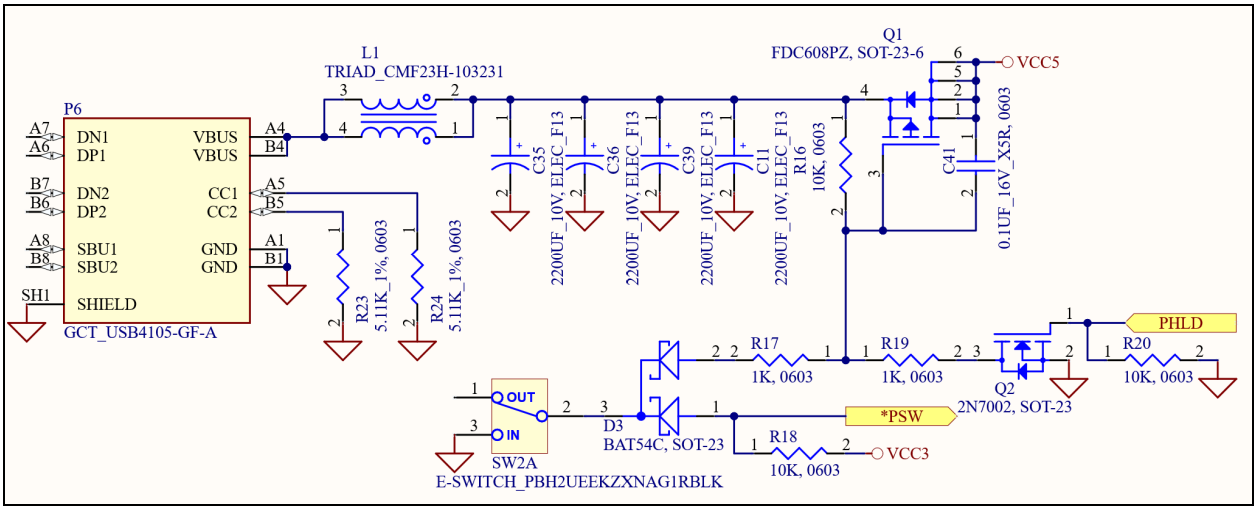

Figure 3 – Mercury 3B Power Control Schematic

6.3 POWER STATUS

As part of the power control circuit, GPIO24 (*PSW) is used to sense the state of the Pushbutton Power Switch. A low indicates that the Power Switch is in the on position (depressed). When high it indicates that the user has placed the switch into the off position (non-depressed) thus opening the on/off switch. Note that for proper operation this circuit requires user software to program GPIO24 as an input with the internal pullup enabled.

6.4 POWER HOLD

GPIO22 (PHLD) allows the CM4 to hold the power on even after the user puts the Power Switch into the off position. After initialization, software can drive GPIO22 high, thus holding the power on regardless of the state of the on/off switch. Driving this low, removes this hold condition. Note that for proper operation this requires user software to program GPIO24 as an output with the internal pullup disabled.

7 MERCURY 3B SOFTWARE

7.1 OVERVIEW

Due to the various resources interfaced on the Mercury 3B , both internal and external to the CM4, it is necessary to initialize a large number of CPU registers and external devices before correct operation can begin. These values and their proper sequencing are beyond the scope of this document.

7.2 COMPATIBLE DRIVER

Most Audio Player software will support Mercury 3B using either the “Pi2design PI2AES” or “HifiBerry Digi+ Pro” driver.

7.3 USB HOST MODE

Unlike the Raspberry Pi 4, the CM4 ROM Firmware does not enable the USB Host functionality by default.

To enable the USB 2.0 port on the Compute Module 4, you need to edit the boot config file (/boot/config.txt) and add:

 # Enable USB in Host Mode
dtoverlay=dwc2,dr_mode=host

7.4 WIFI ANTENNA CONFIGURATION

To enable the WiFi Antenna Interface on the Compute Module 4, you need to edit the boot config file (/boot/config.txt) and add:

 # Switch to external antenna
dtparam=ant2

7.5 POWER CONTROL CONFIGURATION

As discussed in the previous section the Mercury 3B uses a pair of GPIO to control the power and allow clean shutdown. To enable this you need to edit the boot config file (/boot/config.txt) and add:

 # Hold power on after we boot
gpio=22=op,dh

 # Trigger shutdown when switch is in off position
dtoverlay=gpio-shutdown,gpio_pin=24,active_low=0,gpio_pull=up,debounce=5000

8 CONNECTOR LOCATIONS

8.1 OVERVIEW

This section provides the type, location, and pinout for the various connectors on the Mercury 3B.

8.2 FRONT AND REAR PANEL AND INTERIOR VIEWS

This shows the front and rear panels of Mercury 3B as well as an internal view of the PCB.

Figure 4 – Mercury 3B Front Panel

Figure 5 – Mercury 3B Rear Panel

8.3 USB – FRONT PANEL

This is a standard USB2.0 Host connector and conforms to the industry standard USB2.0 Pinout. It is connected to the CM4 USB OTG Port.

5.15MICRO-SD CARD – FRONT PANEL

SD1 is a standard Micro-SD Socket and conforms to the industry standard Pinout. It is connected to the CM4 SDIO Port.

8.4 STATUS LED'S

These two LED's indicate CM4 status. Red indicates the Power Status while Green indicates uSD Card activity.

8.5 POWER SWITCH – FRONT PANEL

This is an On-On pushbutton switch. When depressed the unit powers on. When released the unit powers off after shutdown is complete. Note – if the running software does not execute the shutdown command properly, it may be necessary to remove power from the USB-Connector.

8.6 HDMI

This is a standard right angle HDMI female connector and conforms to the industry standard HDMI Pinout. It is connected to CM4 HDMI Port 0.

8.7 GIGABIT ETHERNET

This is a standard CAT5 RJ45 and conforms to the industry Pinout. It is connected to the CM4 Ethernet Port.

5.16 I2S OVER HDMI

This is a standard HDMI Female connector that carries the Differential I2S signal. Pinout conforms to the PS Audio standards. The Pinout for this connector is shown in the following table.

P15 PIN	Name	Description
1	SDO+	I2S Data Plus (Minus when Swap is in the Right Position)
2	GND	Ground
3	SDO-	I2S Data Minus (Plus when Swap is in the Right Position)
4	BCK+	I2S Bit Clock Plus (Minus when Swap is in the Right Position)
5	GND	Ground
6	BCK-	I2S Bit Clock Minus (Plus when Swap is in the Right Position)
7	LRCLK-	I2S Left/Right Clock Plus
8	GND	Ground
9	LRCLK+	I2S Left/Right Clock Minus
10	MCLK+	I2S Master Clock Plus
11	GND	Ground
12	MCLK-	I2S Master Clock Minus

P15 PIN	Name	Description
13	NC	No Connect
14	NC	No Connect
15	P15	Pulled to GND with 10K ohm resistor
16	P16	Pulled to GND with 10K ohm resistor
17	GND	Ground
18	+5V	Connected to +5V via 100 ohm resistor
19	NC	No Connect

Table 5 – I2S Over HDMI Pinout

8.8 I2S SWAP SWITCH

This is a 2-Position Slide Switch. In the Left Position the I2S output is in normal mode. When in the Right Position the SDO and LRCLK signals are polarity swapped

8.9 USB-C

This is a standard USB-C Connector for Power Input only (no data).

5.17 RCA SPDIF

This RCA connector carries the SPDI/F digital audio output

8.106.35MM AES BALANCED

This connector carries the Balanced AES Digital Audio output.

10 DOCUMENT REVISIONS

Date	Revision	Change
1/28/2026	P1	Name Change from Merc-Mini to Mercury 3B
8/14/2026	P1.1	Change “+12V” to “+5V” in Section 6.1

Table 6 – Document Revisions

11 ERRATA

11.15 OVERVIEW

No known errata at this time.