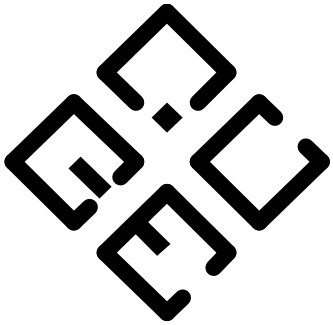

PI 2 Design

MERCURY NANO

Hardware Reference Manual

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Table of Contents

1 Warranty 3
2 Operating Specifications 4
1.1 Mercury Nano Operating specifications 4
3 Overview 5
1.2 Introduction 5
1.3 Block Diagram 5
4 On-Board Devices 7
4.1 Overview 7
4.2 PI3 Model A+ 7
4.3 PCM5102 Clock Master 7
4.3.1 PCM5102 Notes 8
4.4 WM8804 AES Transmitter 8
4.5 Dual High Resolution NDK Clocks 8
4.6 High Speed Differential Transmitter 9
5 PI3 A+ Ports and GPIO 10
4.3.1 PI3 A+ GPIO Notes 11
6 Mercury Nano Power 12
7 Mercury Nano Software 13
8 Connector Locations 14
8.1 Overview 14
8.2 Front and Rear Panels 14
8.3 100Mbit Ethernet 15
8.4 PI3 A+ - HDMI 15
8.5 USB-C Power 15
8.6 XLR AES Balanced 15
8.7 BNC AES Single Ended 15
10 Document Revisions 17
11 Errata 18

List of Figures

Figure 1 – Mercury NanoBlock Diagram 6
Figure 2 – Mercury Nano Front Panel 14
Figure 4 – Mercury Nano Back 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

1.1 MERCURY NANO OPERATING SPECIFICATIONS

Mercury Nano conforms to the following specifications:

Specification	Value
Dimensions	92mm x 72mm x 45mm (3.6” x 2.8” x 1.8”)
Weight	~200g (6.5oz)
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)	+5V +/- 5% DC
Power Consumption	2W Typical, 3W Peak

Table 1 – Mercury Nano Operating Specifications

3 OVERVIEW

1.2 INTRODUCTION

Mercury Nano, designed and manufactured by PI 2 Design, is a Raspberry PI3 Model A+ based device designed for Professional, Studio Grade AES Digital Audio Streaming. Mercury Nano converts the Raspberry PI3 A+ I2S Interface to High-Definition Digital Audio Coax and Balanced. These multiple, simultaneously active digital audio outputs allow Mercury Nano to optimally interface with virtually any High-Performance DAC on the market.

The major features of Mercury Nano are as follows:

- **RASPBERRY PI3 A+ -** This Single Board Computer provides 4 High Performance ARM Cores, 4K HDMI Output, 512MB DRAM and more.
- **ETHERNET -** A Realtek RTL8152 100Mbit Ethernet controller is connected to a standard RJ45
- **HDMI –** A side opening allows access to the HDMI port of the Raspberry PI3 A+.
- **PCM5102 CLOCK MASTER –** A TI PCM5102 is used to provide extremely low jitter clock management for the Mercury Nano. Note – the analog output is unused.
- **AES TRANSMITTER –** The industry standard WM8804 converts the PCM5102 clocks and PI3 A+ I2S data to AES3/SPDIF formatted data at 24-Bit up to the maximum AES Standard data rate of 192Khz.
- **AES COAX OUTPUT –** A 1:1 Isolation Transformer provides Bit Perfect Impedance Controlled Digital Audio Data @ 1V AES Standard Level.
- **AES BALANCED OUTPUT** – A high speed differential transmitter with a 1:1 Isolation Transformer provides balanced audio data via the Professional XLR Connector.
- **HIGH RESOLUTION CLOCKS –** A pair of Ultra-Low Jitter NDK NZ2520SDA oscillators drive the PCM5102Clock Master for the lowest possible jitter noise.
- **ULTRA-LOW NOISE LDO's –** Two Ultra-Low Noise, High-PSRR LDO's supply power to the PCM5102, WM8804 and the NDK Clock's.
- **NOISE FILTER –** An LC Noise Filter is used to reduce the noise from the input 5V by 100:1.
- **LOW NOISE PCB LAYOUT –** 4-layer Split Ground PCB with noise reduction techniques refined from years of High-Speed Mixed-Signal Design work.
- **PRE-PROGRAMMED SD CARD -** Mercury comes with a pre-programmed SD Card for Moode Audio.

1.3 BLOCK DIAGRAM

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

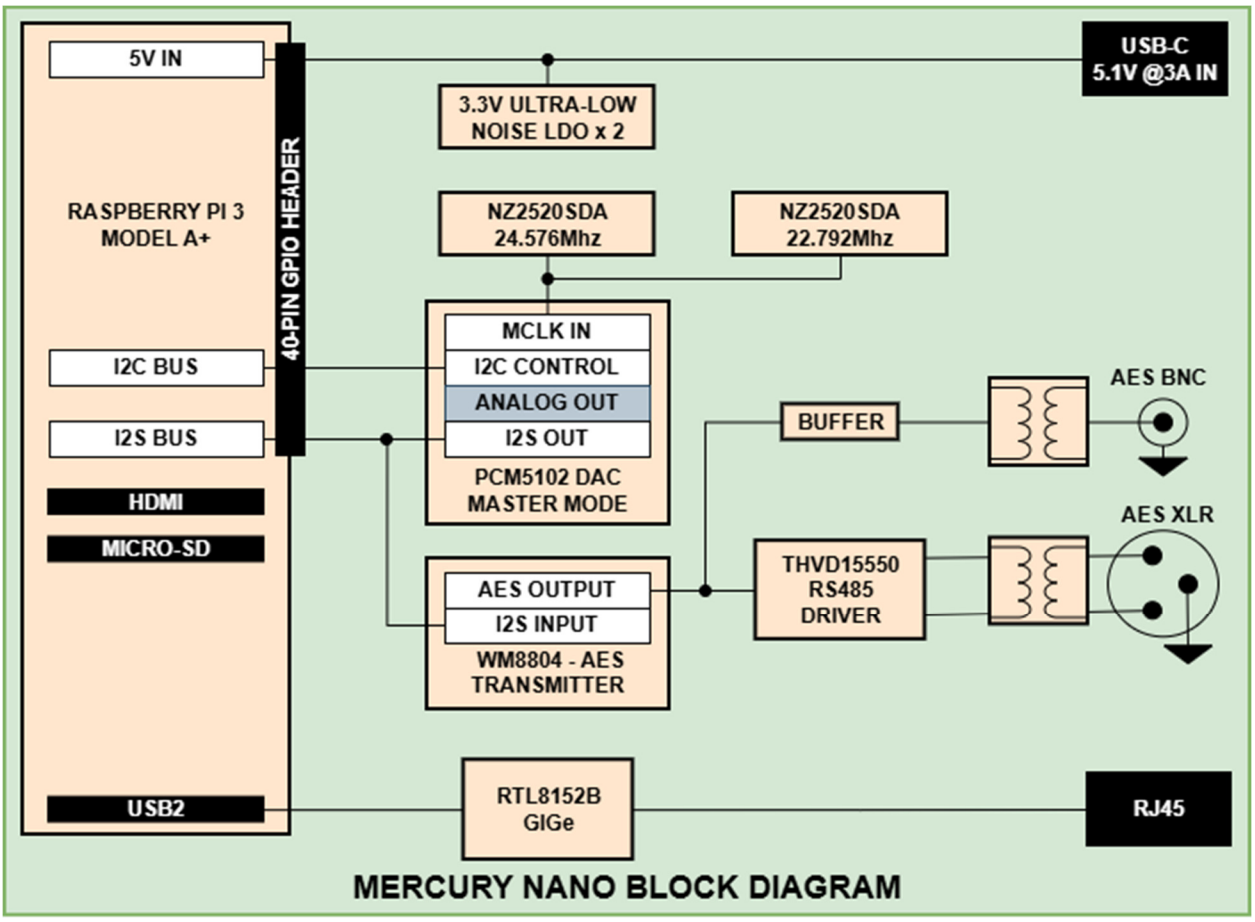

Figure 1 – Mercury NanoBlock Diagram

4 ON-BOARD DEVICES

4.1 OVERVIEW

This section describes in detail the devices located on the Mercury Streamer.

4.2 PI3 MODEL A+

Mercury Nano uses the latest Raspberry PI3 Model A+ SBC. This Low-Power Single Board Computer runs the software required to perform the Digital Audio Player function as well as other applications. Mercury Nano interfaces to the PI3 A+ via a 40-PIn GPIO connector. Key features of the PI3 A+ (as used on the Mercury Nano) are as follows

- Broadcom BCM2837B0, Quad core Cortex-A53 (ARM v8) 64-bit SoC @ 1.8GHz
- H.265 (HEVC) (4Kp60 decode), H.264 (1080p60 decode, 1080p30 encode)
- OpenGL ES 1.1 and 2.0 3D graphics support
- 512MB LPDDR2-1600 SDRAM
- 2.4 GHz, 5.0 GHz IEEE 802.11 b/g/n/ac wireless
- Bluetooth 5.0, BLE
- USB2.0 Port
- I2C and I2S Peripheral Ports
- HDMI 2.0 Port (up to 4Kp60 supported)
- SDIO 2.0

4.3 PCM5102 CLOCK MASTER

The Mercury Nano uses the TI PCM5102 DAC as its timing master. The analog output of the PCM5102 is not used. This device operates in master mode and interfaces to the PI3 A+ via I2S and I2C. The signals used to interface with the PCM5102 are shown in the following table.

PCM5102 Signal	PI3 A+ Signal	Description
MCLK	-	Unused by the PI3 A+
BCLK	BCLK	I2S Bit Clock Output to PI3 A+
LRCLK	LRCLK	I2S Word Clock Output to PI3 A+
SDIN	SDOUT	I2S Serial Audio Data Input from PI3 A+
SCL	SCL	I2C Clock from PI3 A+
SDA	SDA	I2C Data to/from PI3 A+

XIN	-	PCM5102 GPIO6 (High True) selects the 22.5792Mhz Input Clock for 44.1Khz, 88.2Khz and 176.4Khz Frame Rates. PCM5102 GPIO3 (High True) selects the 24.576Mhz Input Clock for 48Khz, 92Khz and 192Khz Frame Rates

Table 2 – 3 A+ to PCM5102Connections

4.3.1 PCM5102 NOTES

1. The PCM5102 is controlled using the I2C port. Refer to the PCM5102 documentation and installed player software.
2. Mercury Nano is designed to operate the PCM5102 in Master mode. In this mode the PCM5102 receives its master clock from XIN and drives MCLK (unused by the PI3 A+), BCLK and LRCLK out. Serial Data in is received from PI3 A+.

4.4 WM8804 AES TRANSMITTER

A Cirrus Logic WM8804 AES Digital Audio Transmitter is used to convert the I2 Bus to an AES Digital Audio Stream. This device operates in slave mode and interfaces to the I2S bus of the PCM5102/PI3 A+. The signals used to interface with the WM8804 are shown in the following table.

WM8804 Signal	PCM5102 Signal	Description
MCLK	-	I2S Master Clock from the PCM5102
BCLK	BCLK	I2S Bit Clock from the PCM5102
LRCLK	LRCLK	I2S Word Clock from the PCM5102
SDIN	SDOUT	I2S Serial Audio Data Input from PI
SCL	-	Unused in Slave Mode
SDA	-	Unused in Slave Mode
XIN	-	Clock Selected by the PCM5102
TXO	-	AES3/SPDIF encoded digital audio output

Table 3 – PCM5102/PI3 A+ to WM8804 Connections

4.5 DUAL HIGH RESOLUTION NDK CLOCKS

A pair of NDK NZ2520SDA Ultra-Low Jitter/Noise clocks provide the critical timing signals for the WM8804. They are selected via the PCM5102 GPIO3 (22.5792Mhz) and

GPIO6 (24.576Mhz) signals.

4.6 HIGH SPEED DIFFERENTIAL TRANSMITTER

A High-Speed (50Mbps) Differential Transmitter accepts the AES output from the WM8804 and sends it as a balanced pair to the 1:1 Isolation Transformer and then on to the XLR connector.

5 PI3 A+ PORTS AND GPIO

4.2 OVERVIEW

Mercury Nano uses several of the internal functions and GPIO from the PI3 A+ for control and status purposes.

4.3 PI3 A+ GPIO

The PI3 A+ provides a large number of General Purpose I/O (GPIO) pins. These pins also can be assigned to alternate functions as defined in the PI3 A+ documentation. The usage of these pins (and alternate functions) on Mercury Nano are described in the following table.

GPIO	DIR	AF	PUP PDN	Mercury Nano Usage	Description/Notes
0	I/O	I2C0	PUP	unused	
1	I/O	I2C0	PUP	unused	
2	I/O	I2C1	PUP	SDA	I2C Data for PCM5102
3	I/O	I2C1	PUP	SCL	I2C Clock for PCM5102
4	-			unused	
5	-			unused	
6	-			unused	
7	-			unused	
8	-			unused	
9	-			unused	
10	-			unused	
11	-			unused	
12	-			unused	
13	-			unused	
14	-			unused	
15	-			unused	
16	-			unused	

GPIO	DIR	AF	PUP PDN	Mercury Nano Usage	Description/Notes
17	-			unused	
18	IN	I2S		BCLK	I2S Bit Clock from PCM5102
19	IN	I2S		WCLK	I2S Word Clock from PCM5102
20	-			unused	
21	OUT	I2S		SDOUT	I2S Serial Data to PCM5102
22	-			unused	
23	-			unused	
24	-			unused	
25	-			unused	
26	-			unused	
27	-			unused	

Table 4 – PI3 A+ Port and GPIO PIn Assignments

4.3.1 PI3 A+ GPIO NOTES

1. DIR is from the point of view of the PI3 A+.
2. 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 3 A+ specifications.
3. PUP/PDN indicates if the GPIO should have its associated Pullup (PUP) or Pulldown (PDN) resistor enabled.
4. An asterisk '*' at the beginning of the name indicates a low true signal.

6 MERCURY NANO POWER

4.4 OVERVIEW

Mercury Nano is designed to be powered from an external 5V source via USB-C which is then routed to the PI3 A+ via the GPIO Connector 5V pins.

4.5 POWER INPUT

5 Power for the Mercury Nano comes from the USB-C Connector. CC0 and CC1 are tied low with 5.1K resistors to signal a request for 5V.

7 MERCURY NANO SOFTWARE

5.1 OVERVIEW

Due to the various resources interfaced on the Mercury Nano, both internal and external to the PI3 A+, 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.

5.2 COMPATIBLE DRIVER

Most Audio Player software will support Mercury Nano using the “HifiBerry DAC+” driver.

8 CONNECTOR LOCATIONS

8.1 OVERVIEW

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

8.2 FRONT AND REAR PANELS

This shows the front and rear panels of Mercury Nano.

Figure 2 – Mercury Nano Front Panel

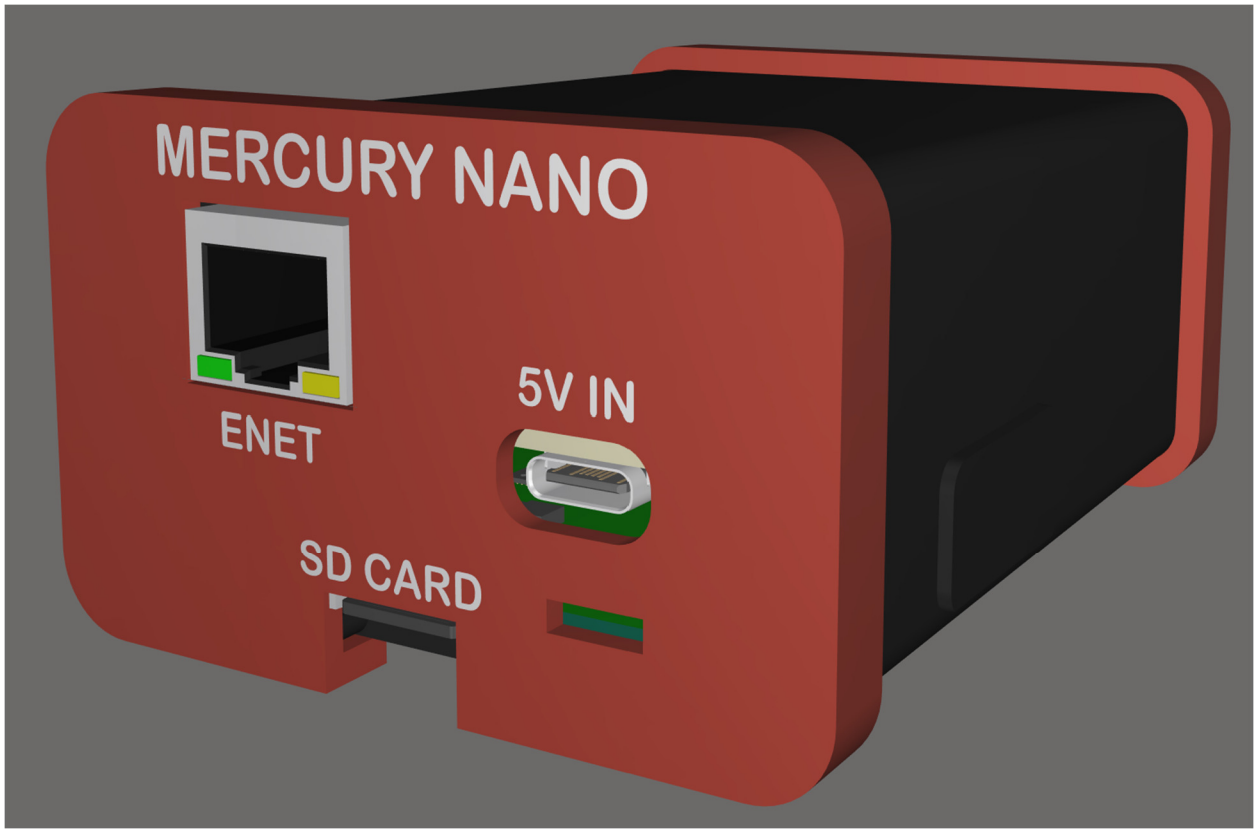

Figure 3 – Mercury Nano Back Panel

8.3 100MBIT ETHERNET

This is a standard CAT5 RJ45 and conforms to the industry pinout. It is connected to the RTL8152 Ethernet Controller.

8.4 PI3 A+ - HDMI

This is a standard HDMI female connector connected to PI3 A+ HDMI Port. Note this port is covered by a removable plug on the side of Mercury Nano.

8.5 USB-C POWER

This is a standard USB-C Connector. CC1 and CC2 are connected to 5.1K Pulldown resistors to request 5V from the attached USB-C Power Supply. This port is for power only.

8.6 XLR AES BALANCED

This 3-pin connector carries the Balanced AES Digital Audio output.

8.7 BNC AES SINGLE ENDED

This right-angle BNC 75-ohm female connector carries the Single Ended AES Digital

Audio output.

10 DOCUMENT REVISIONS

Date	Revision	Change
10/16/26	0.1	Preliminary Release

Table 5 – Document Revisions

11 ERRATA

There are currently no errata for Mercury Nano.