NVIDIA DRIVE AGX Orin Developer Kit

Product Brief

PB-10417-003_v03 | February 2023

Document History

PB-10417-003_v03

Version	Date	Authors	Description of Change
01	June 27, 2022	JH, VS	Initial Release.

02	September 22, 2022	JH, VS	• Simplified the titles of figures and tables to remove SKU specific product name.
			• Removed support for robotics.
			• Updated Table 1-1 to remove unused terms and added IMU, PPS.
			• Updates in Figure 1-1:
			  > Removed A2B connection.
			  > Reduced UART ports from 5x to 3x and added text to show Aurix includes only 1x UART port.
			  > Changed 6x GPIO to PPS.
			• Updates in Table 1-2:
			  > Fixed mistake on "Performance - INT 8 TOPs" and changed it from 5.2 to 254.
			  > Updated PCIe to show it can be either one PCIe x8 or two PCIe x4.
			  > Grouped cable harness interfaces together.
			  > Updated GPIO to show PPS input only.
			  > Removed A2B column.
			  > Added USB PD into USB 3.2 and show Type-C connector #2 supports PD.
			  > Updated HSSTP to show Type-C connector #1 supports it.
			  > Reduced the number of Orin-X UART ports from 3 to 2.
			• Updated Figure 2-1 to show camera input is "GMSL1/GMSL2" instead of just "GMSL2".
			• Replaced Figure 4-1 with new image.
			• Updated weight in Table 4-1: Dimensions and Weight.
			• Updated Appendix A to include NIC Adapter-10G and added contents for calculating the maximum number of NIC adapters that can be attached together for sharing power based on the current numbers in Table A-5 and Table A-6.

03	February 2, 2023	JH, VS	• Added note to Table 3-3 to define operating temperature. • Added text under Table 4-1 for additional information.

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Chapter 1. Introduction

1.1 Overview

NVIDIA DRIVE AGX Orin™ Developer Kit is an open AI computing platform specifically designed for the autonomous vehicle market to aid in the development of software or hardware applications using the NVIDIA DRIVE Orin-X™ architecture and NVIDIA DRIVE® OS. It enables automakers, Tier 1 automotive suppliers, and other developers to accelerate the development process of autonomous vehicle products.

Note:

The NVIDIA DRIVE AGX Orin System, hereinafter referred to as "developer system", is a modular design with NVIDIA DRIVE Orin™ Module on the mainboard.

All occurrences of "Orin SoC" refer to the NVIDIA DRIVE Orin-X™ SoC.

This document describes the hardware specifications of the developer system.

Table 1-1. Terms and Definitions

Term	Definition
ASIC	Application Specific Integrated Circuit
ATX	Advanced Technology eXtended, a motherboard and power supply configuration specification developed by Intel.
CAN	Controller Area Network
Codec	A device which encodes or decodes a digital data stream
CSI-2	MIPI Camera Serial Interface 2
DeSer	De-Serializer (deserializer)
DP	DisplayPort (VESA® DisplayPort™)
ENET	Ethernet
eMMC	Embedded MMC (embedded storage solution with MMC interface, and flash memory and controller).
FlexRay	An automotive network communications protocol developed by the FlexRay Consortium

Term	Definition
GbE	Gigabit Ethernet
GB	Gigabytes
GMSL GMSL1 GMSL2	Maxim Gigabit Multimedia Serial Link (including generations v1.0 and v2.0) Maxim Gigabit Multimedia Serial Link v1.0 Maxim Gigabit Multimedia Serial Link v2.0
GPIO	General Purpose Input/Output
GPU	Graphics Processor Unit
H-MTD	A Rosenberger 360° fully shielded differential connector system for high-speed interface. • H-MTD Double: 2 differential pairs • H-MTD Quad: 4 differential pairs
HSSTP	A High-Speed Serial Trace Port for transmitting high bandwidth data off-chip, such as Embedded Trace Macrocells from Arm® based cores.
IMU	A device used for measuring an object's gravity and angular rate
JTAG	Joint Test Action Group
LIN	Local Interconnected Network, a serial network protocol used for communication between components in vehicles.
LPDDR5	Low Power DDR5
M.2	A specification for internally mounted computer expansion cards and associated connectors, formerly known as the Next Generation Form Factor (NGFF).
MATE-AX	A TE connectivity's miniaturized coaxial connector system for providing advanced automotive data transmission performance up to 15GHz
MATEnet	A TE connectivity's miniaturized coaxial connector system for automotive
Mini-SAS	A high density, high-speed I/O interface adopted for the SAS 2.1, SAS 3, and PCIe standards.
NOR Flash	One of the two main types of flash memory that uses NOR logic gates
PCIe	Peripheral Component Interconnect (PCI) Express
POC	Power Over Coax
PPS	Pulse per second, a common feature in GPS and IMU to provide timing signal for precision timing synchronization between devices
QSPI	Quad Serial Peripheral Interface
RGMII	Reduced Gigabit Media Independent Interface
SFX PSU	Small form factor power supply that can plug into an ATX style connector
SGMII	Serial Gigabit Media Independent Interface
SMCU	Safety Micro Controller Unit
SoC	System on a Chip
SPI	Serial Peripheral Interface

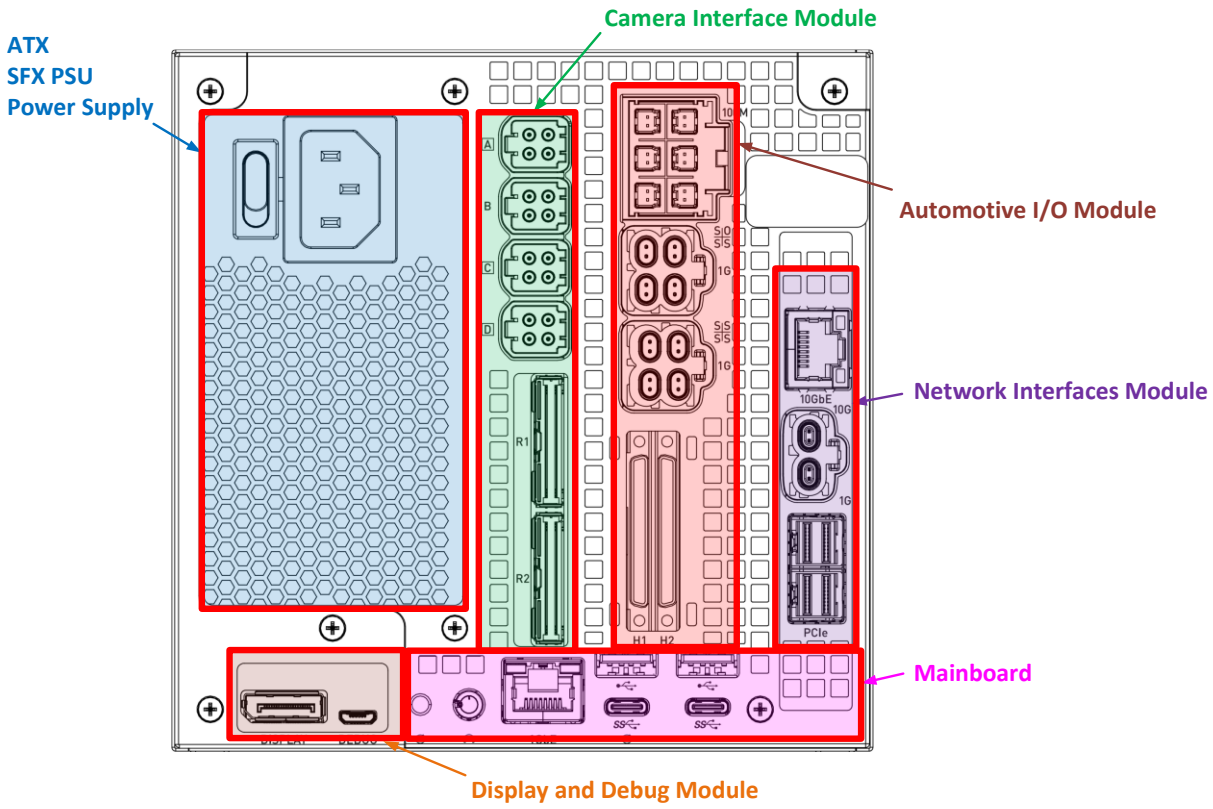
Term	Definition
UART	Universal Asynchronous Receiver/Transmitter
UFS	Universal Flash Storage
USB	Universal Serial Bus
USS	Ultrasonic Sensor
XFI	Up to 10 Gbps high speed chip-to-chip electrical interface for Ethernet applications (SFF INF-8077i, Revision 4.5, 2005)

The developer system is a modular design with multiple modules plugged in to the connectors of a mainboard. Different modules are designed to support different type of interfaces. These plugin modules are listed below:

- **Camera Interface Module**: for camera inputs
- **Automotive I/O Module**: for low/medium/high bandwidth interfaces
- **Network Interfaces Module**: for super high bandwidth interfaces
- **Display and Debug Module**: for development and debugging

Figure 1-1 shows the interface connector panel of the developer system with its interface connectors highlighted in different colors for showing which module they are located.

Figure 1-1. Developer System Modules



For more detailed information of the developer system external connectors, please refer to the NVIDIA document, *NVIDIA DRIVE AGX Orin Developer Kit Mechanical Installation Guide* (DI-10587-001), which contains the necessary connector part numbers, connector pinouts and cables.

1.2 Developer System Hardware Design

The high-level block diagram of the developer system is shown in Figure 1-2.

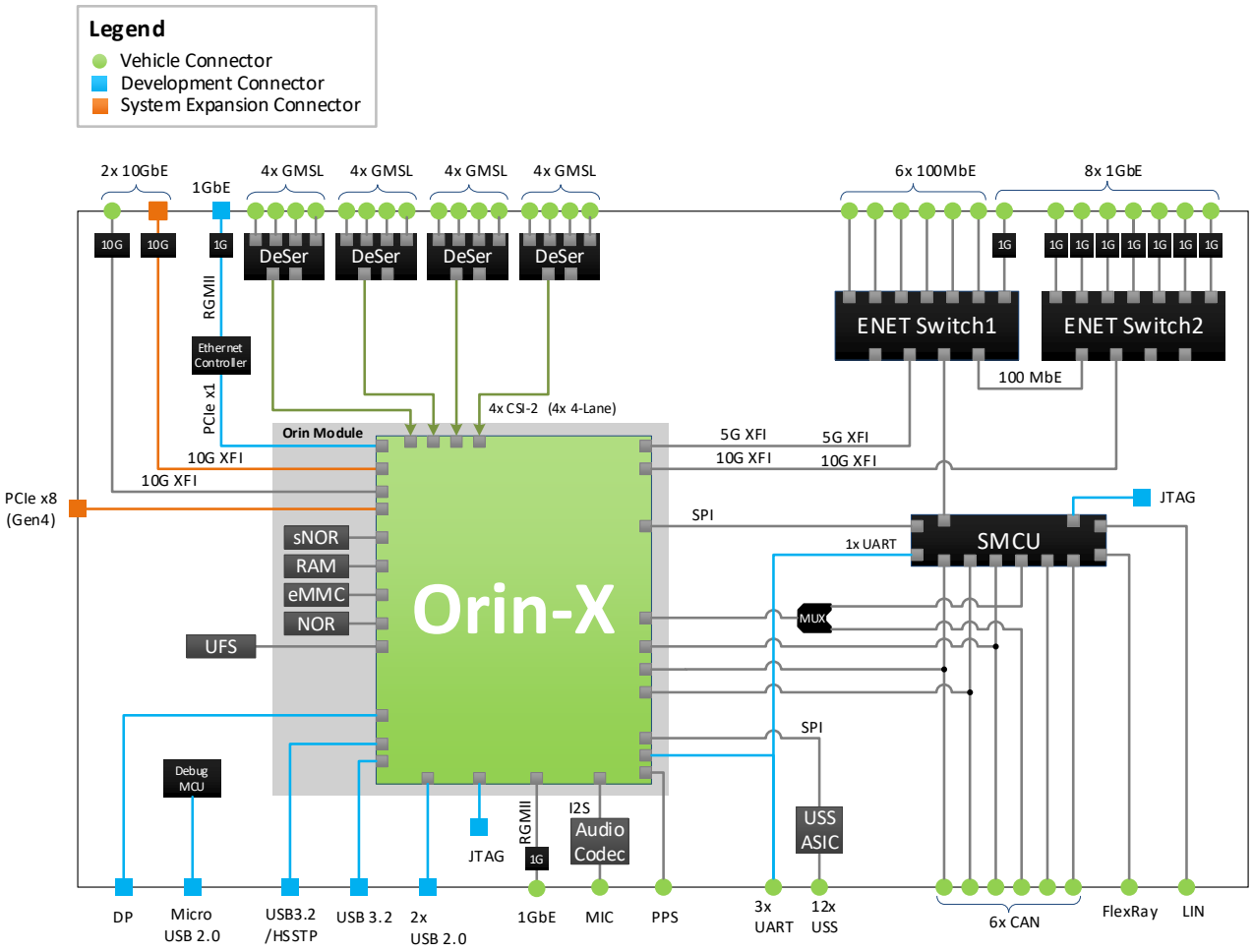
Instead of designing with the Orin SoC chip mounted directly on the board, the developer system mainboard includes connectors for plugging in the NVIDIA DRIVE Orin Module. The Orin SoC power subsystem, the major memory components, and temperature sensor are already on the Orin Module.

A dedicated MCU is needed for hazard analysis and risk assessment in the system design in order to address severe faults and to meet the Automotive Safety Integrity Levels (ASILs) per ISO 26262 standard. This is normally called Safety MCU or SMCU. The developer system uses

the Infineon Aurix SMCU on its Automotive I/O Module. The Aurix SMCU will manage the power of the whole developer system and handle the catastrophic failures. Since Ethernet has been an essential interface in today's automotive designs, this module also includes two Ethernet switches for handling the requirement of passing Ethernet data packets between Orin SoC, Aurix SMCU and the Ethernet links from radar or lidar sensors. Other industry standard interfaces, such as LIN, CAN, FlexRay, and USS are also implemented on this module.

> **Note:**
> The developer system is for software or hardware application development. Some components for system debugging are not automotive grade. The developer system is also not ISO 26262 compliant.

Figure 1-2. High-Level Block Diagram



As autonomous vehicles require more and more high-resolution cameras, the Camera Interface Module of the developer system includes Maxim GMSL2 deserializers for supporting cameras with uncompressed data stream up to 6Gbps.

The developer system is powerful enough to support today's design requirement. In case more performance is needed, the developer system includes a Network Interfaces Module for system expansion. This module supports super high-bandwidth Ethernet at 10Gbps and PCIe x8 Gen4 at 16Gbps per lane.

For assisting with development and debug, the developer system also includes a Display and Debug Module with DisplayPort output for connecting the captured camera, radar, or lidar images to a DisplayPort monitor. This module also includes a USB connector connecting to a debug MCU on the mainboard that can be used to access the I2C and the debug UART ports of the Orin SoC and the Aurix SMCU through the Micro USB connector.

1.3 Developer System Product Features

Table 1-2 lists the features of the developer system.

Table 1-2. Features per Configuration

Feature		NVIDIA DRIVE AGX Orin Developer System
NVIDIA SoC		NVIDIA DRIVE Orin-X SoC
CPU KDMIPs		Up to 228K
Performance - INT 8 TOPs		Up to 254
Performance - FP32 CUDA TFLOPs		Up to 5.2
System RAM		32GB LPDDR5 (3200 MHz)
QSPI NOR Flash		64MB NOR Boot Flash
eMMC		64GB eMMC 5.1 (HS400)
Security Key Storage		8MB NOR Secure Key Flash (sNOR)
UFS		256GB
Safety MCU (SMCU)		Infineon Aurix TC397
PCIe		Mini-SAS (one PCIe x8 or two PCIe x4)
Camera Input		16 GMSL1/GMSL2 Cameras (four MATE-AX with POC, four cameras per MATE-AX) Four GMSL2 deserializers (Backwards compatible with GMSL1) • MATE-AX [A/C/D]: 3Gbps or 6Gbps per link • MATE-AX [B]: 3Gbps per link
Ethernet	100 MbE	6 (MATEnet, 100BASE-T1)
	1 GbE	1 (RJ45, 1000BASE-T) 8 (two H-MTD Quad, 1000BASE-T1) 1 (½ H-MTD Double, 1000BASE-T1)
	10 GbE	1 (RJ45, 10GBASE-T) 1 (½ H-MTD Double, 10GBASE-T1)
Cable Harness	CAN	3 (Orin-X/SMCU) 2 (SMCU) 1 (Orin-X)
	FlexRay	1
	LIN	1
	GPIO	1 (PPS Input-Only)
	USS	12
Audio Input/Output		3.5mm Audio Jack (Microphone, Line-in/out)
Display Output		DisplayPort
USB 2.0 (Type-A)		2
USB 3.2 (Type-C)		2 (Type-C connector #2 supports Power Delivery up to 60W)
HSSTP		1 (Supported via Type-C connector #1)

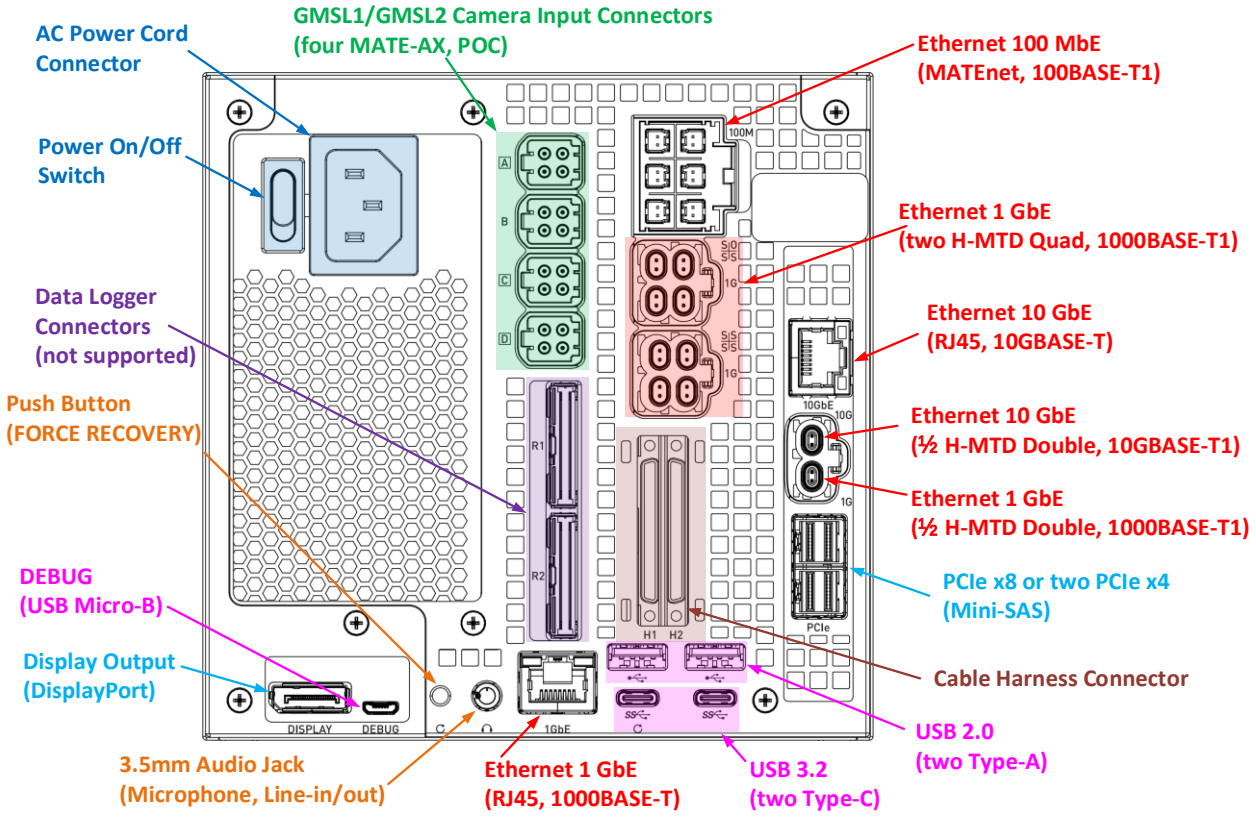
Feature	NVIDIA DRIVE AGX Orin Developer System
UART	2 (Orin-X) 1 (SMCU)
JTAG	1
System Power	200W

Chapter 2. Interface Connections

Figure 2-1 shows the different functions of the developer system interface. The markings on the silkscreen also briefly indicate the following:

- **Interface Type**: for example, PCIe and DISPLAY (DisplayPort).
- **Data Rate**: for example, 100M, 1G, and 10G for the Ethernet port speed.
- **Major Component Connection**: for example, "A", "B", "C", "D" for different GMSL2 deserializers, "O" and "S" for different Ethernet switches.

Figure 2-1. Rear Panel Connectors



Chapter 3. Operating and Storage

3.1 Operating Electrical Conditions

3.1.1 Operating Voltage

The developer system integrates a SFX12V Power supply to allow for direct AC power to the developer system.

Table 3-1 lists the power input specification.

Table 3-1. SFX PSU Input Specification

Power Input	Minimum	Nominal	Maximum
AC Voltage (VAC)	90VAC	100 ~ 240VAC	264VAC
AC Current (A)		100VAC: 4A 240VAC: 2A	
Frequency (Hz)	47		63
Note: When installing the developer system in vehicle, NVIDIA recommends using an inverter to convert the DC power of the vehicle battery/alternator to AC for powering the SFX PSU power supply.			

The developer system also sources power to the camera modules with the POC technology via MATE-AX connectors. Each MATE-AX connector has 4 pins, so a maximum number of 16 cameras can be supported.

The POC power output specification for the camera is listed in Table 3-2.

Table 3-2. MATE-AX Pin Power Output Specification

Power Output	Specification
POC Voltage	12V (Nominal)
POC Current (per camera)	500mA (Maximum)
Note: The total current of all 16 cameras is limited to 5A even though the current per camera can be as high as 500mA.	

3.2 Operating and Storage Temperatures

The operating temperature is the ambient temperature range for the operation of the developer system. The storage temperature refers to the temperature at which the developer system can be safely stored when it is not powered on.

3.2.1 Operating Temperature

The system should be operating within the temperature range listed in Table 3-3.

Table 3-3. Operating Temperature

	Minimum	Maximum
Operating Temperature	0°C	45°C
Note: The Operating Temperature range is defined as the ambient temperature at the fan inlet (the cool air intake in Figure 4-1).		

3.2.2 Storage Temperature and Humidity

The system should be stored within the temperature range and humidity listed in Table 3-4.

Table 3-4. Storage Temperature and Humidity

	Minimum	Maximum
Storage Ambient Temperature	- 20°C	65°C
Storage Humidity	5% RH	95% RH

Chapter 4. Mechanical Specification

The dimensions and the weight of the developer system are described in Figure 4-1 and Table 4-1 with connectors on the front and fan on the back. The weight depends on the SKU number because different developer system SKUs may ship with different board modules.

Figure 4-1. System Dimensions

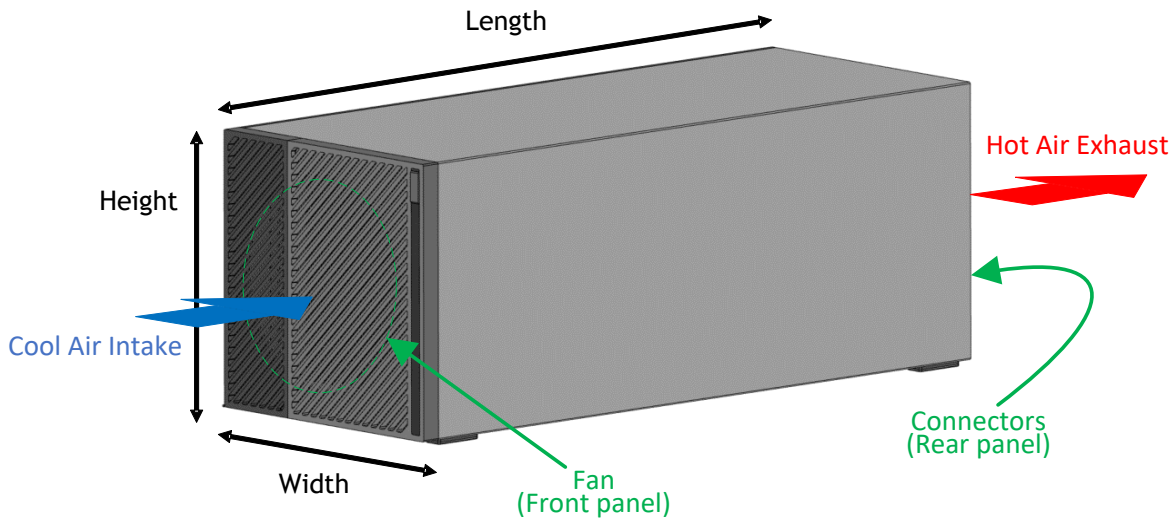


Table 4-1. Dimensions and Weight

Dimensions (mm)	
Length	370
Width	147.7
Height	147.7
Weight (kg)	
Weight	5.6 ± 3%

For additional information regarding mounting options and dimensions of the developer system, please refer to the NVIDIA document, *NVIDIA DRIVE AGX Orin Developer Kit Mechanical Installation Guide* (DI-10587-001).

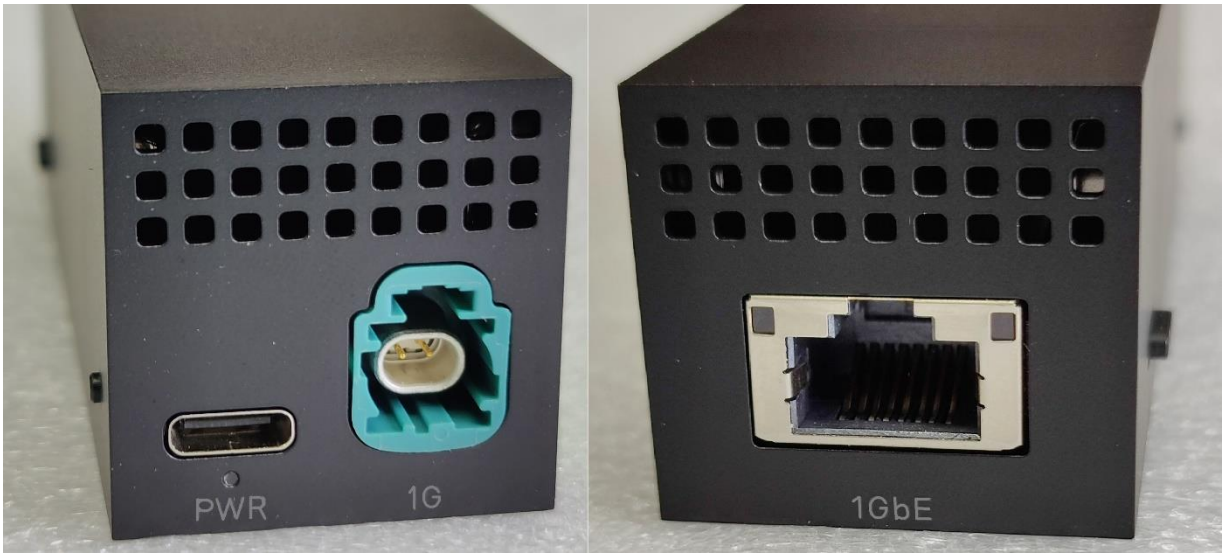
Appendix A. NIC Adapters

A.1 Introduction

The NIC Adapter-1G and NIC Adapter-10G adapters are the NVIDIA DRIVE AGX Orin™ Developer Kit accessories designed for converting the automotive Ethernet from H-MTD to standard RJ45. These NIC adapters share the same specifications in many areas. Therefore, the contents in this appendix apply to both NIC adapters unless specified otherwise.

- **NIC Adapter-1G**: for converting H-MTD 1000BASE-T1 to RJ45 1000BASE-T
- **NIC Adapter-10G**: for converting H-MTD 10GBASE-T1 to RJ45 10GBASE-T

Figure A-1. NIC Adapter Views from Different Angles (NIC Adapter-1G shown)



The high-level block diagrams of the NIC adapters are shown in Figure A-2 and Figure A-3.

Figure A-2. NIC Adapter-1G Block Diagram

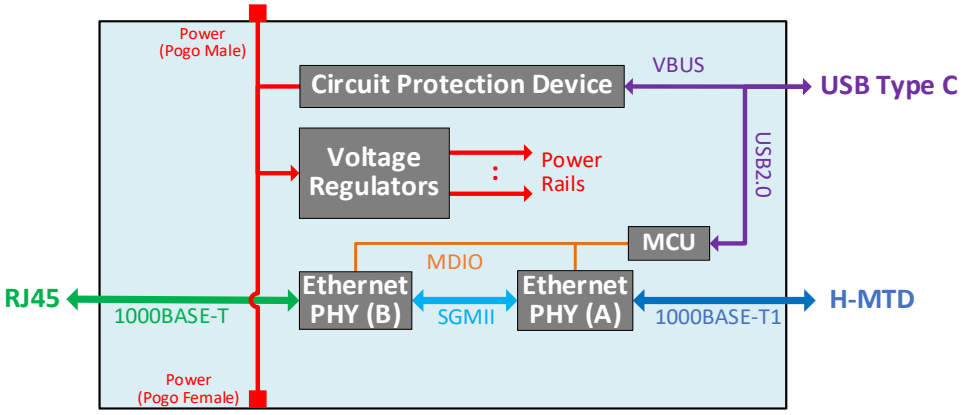
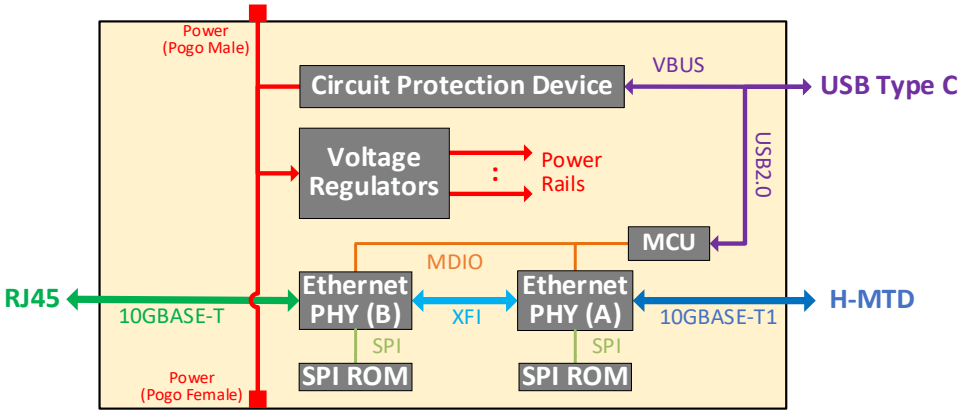


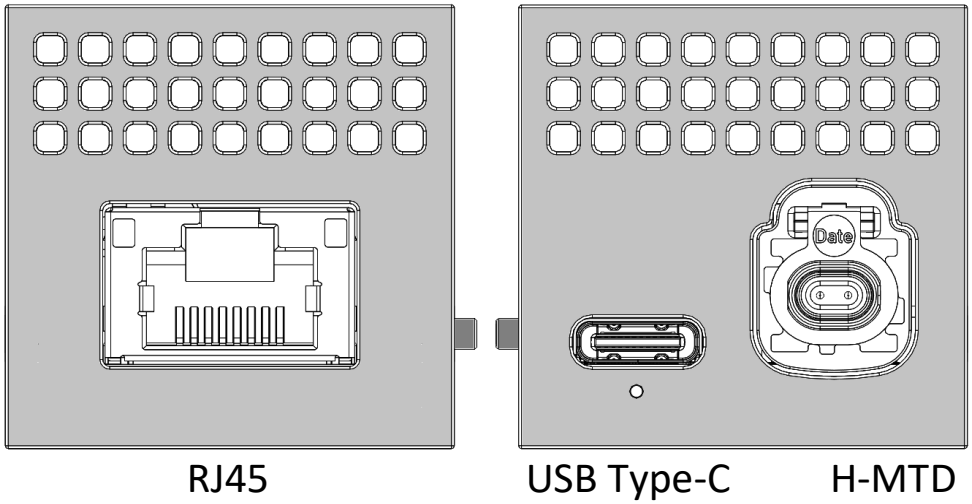
Figure A-3. NIC Adapter-10G Block Diagram



A.2 Interface Connectors

The Ethernet connection panels of the NIC adapters are shown in Figure A-4.

Figure A-4. Ethernet Connection Panels



The connectors of the NIC adapters are listed in Table A-1 and Table A-2.

Table A-1. Connectors on NIC Adapter-1G

Interface	Connector
1000BASE-T1	H-MTD (E6S20A-40MT5-Z)
1000BASE-T	Standard RJ45
USB 2.0	Standard USB Type-C Receptacle (for supplying power)
Power (Pogo Male)	Magnetic Spring-loaded Male Connector
Power (Pogo Female)	Magnetic Spring-loaded Female Connector

Table A-2. Connectors on NIC Adapter-10G

Interface	Connector
10GBASE-T1	H-MTD (E6S20A-40MT5-Z)
10GBASE-T	Standard RJ45
USB 2.0	Standard USB Type-C Receptacle (for supplying power)
Power (Pogo Male)	Magnetic Spring-loaded Male Connector
Power (Pogo Female)	Magnetic Spring-loaded Female Connector

The LED statuses of the NIC adapters are listed in Table A-3 and Table A-4.

Table A-3. LEDs on NIC Adapter-1G

LED Location	Color	Status Description
RJ45 Upper Left	Green	1Gbps Link, No Activity
	Green (Blinking)	1Gbps Link, Activity
	Yellow	100Mbps Link, No Activity
	Yellow (Blinking)	100Mbps Link, Activity
RJ45 Upper Right	Off	No link
	Green	Linked
Power LED under USB Type-C	Off	No power
	White	Powered on

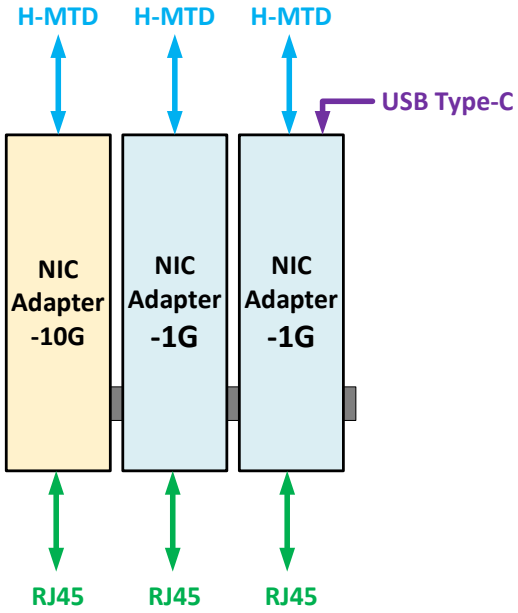
Table A-4. LEDs on NIC Adapter-10G

LED Location	Color	Status Description
RJ45 Upper Left	Green	10Gbps Link
	Yellow	5Gbps or 2.5Gbps Link
RJ45 Upper Right	White	Powered on
	Green	10Gbps Link
Power LED under USB Type-C	Yellow	5Gbps or 2.5Gbps Link
	Green (Solid)	No Activity

The NIC adapter incorporates a power circuit protection device to enable power to adjacent NIC adapters using magnetic spring-loaded pogo pins on the sides of the unit. This allows multiple NIC adapters to be attached together via the mating pogo pins for power sharing. The USB power can be connected to any one of these NIC adapters for powering them all.

Figure A-5 shows an example of attaching three NIC adapters together.

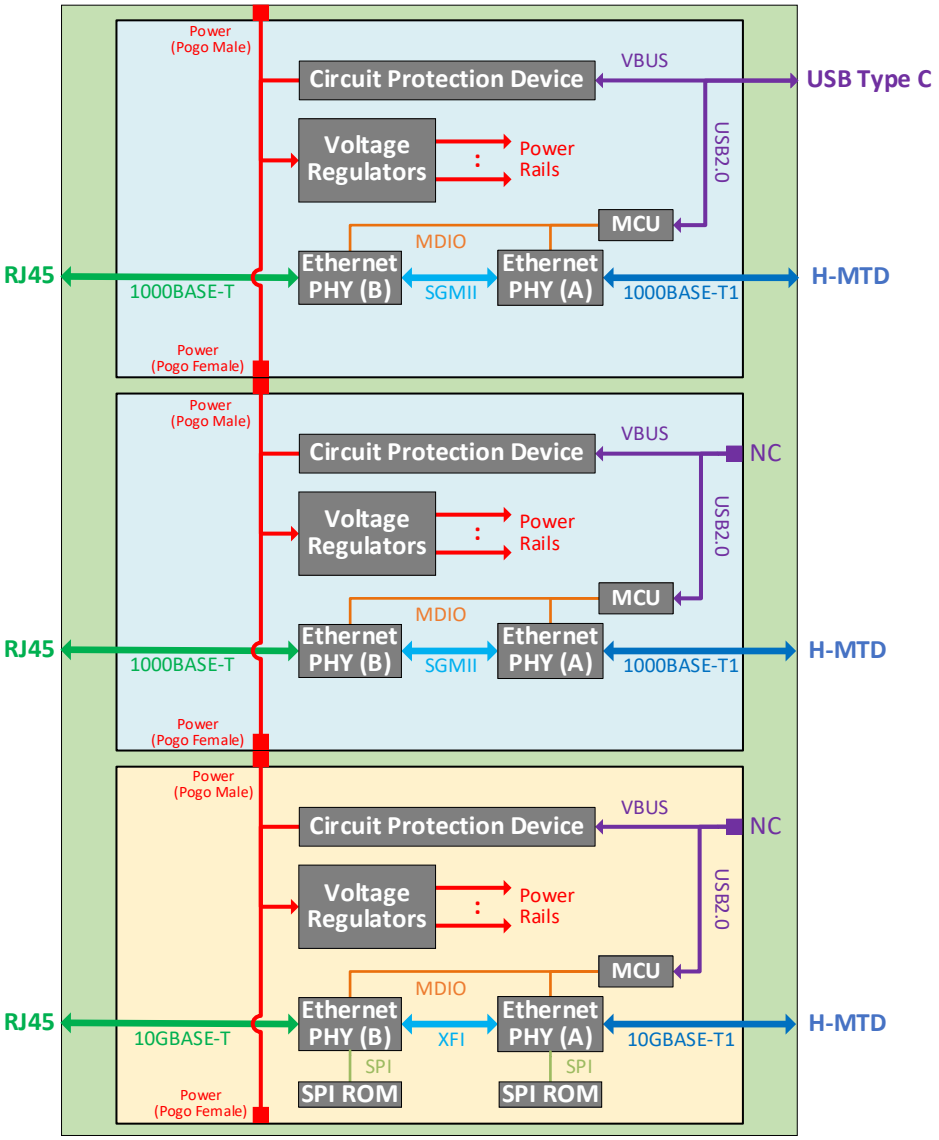
Figure A-5. Example of Attaching three NIC Adapters Together



Please note that the LED definitions between the NIC Adapter-1G and the NIC Adapter-10G are different. For example, as shown in Table A-3, when a NIC Adapter-1G is powered, the white power LED under the USB Type-C connector will be lit. However, as shown in Table A-4, when a NIC Adapter-10G is powered, the white power LED located at the RJ45 upper right corner will be lit instead.

The internal connections of the example of attaching three NIC adapters are shown in Figure A-6.

Figure A-6. Internal Connections of Attaching three NIC Adapters Together



Although multiple NIC adapters can be attached together for sharing power, due to the power available on the USB connector and the power that can be carried over through the pogo pins, only a limited number of NIC adapters can be attached together. Please refer to the current numbers in Table A-5 and Table A-6 to for calculating how many NIC adapters can be attached together for power sharing. For example, if the power (3A) of a NIC Adapter-1G is shared to the other NIC Adapter-1G adapters by attaching them together, then it can only be shared to the other six NIC Adapter-1G adapters because each NIC Adapter-1G requires 0.4A power.

A.3 Operating Conditions

Power to the NIC adapter is supplied a USB Type-C connector. The power input specification for the NIC adapter is shown in Table A-5, which lists the maximum current that can be sourced by the primary adapter when multiple adapters are attached together. On the other hand, Table A-6 provides the required current for the operating conditions of an individual adapter.

A.3.1 Operating Voltage and Current

The power input to the NIC adapter is supplied by the USB Type-C connector with voltage and current listed in Table A-5.

Table A-5. Power Input Voltage and Current

NIC Adapter	Power Input Type	Voltage/Current Range
NIC Adapter-1G	USB Type-C	5V ± 5%, 3A
NIC Adapter-10G	USB Type-C	5V ± 5%, 3A

The operating currents of the NIC adapters are listed in Table A-6.

Table A-6. NIC Adapter Operating Current

NIC Adapter	Power Input Voltage	Current Range
NIC Adapter-1G	5V (using USB Type-C)	0.4A (maximum)
NIC Adapter-10G	5V (using USB Type-C)	1.3A (maximum)

A.3.2 Operating and Storage Temperature

The NIC adapter should be operating within the temperature range listed in Table A-7.

Table A-7. Operating Temperature

	Minimum	Maximum
Operating Temperature	0°C	45°C

The NIC adapter should be stored within the temperature range and humidity listed in Table A-8.

Table A-8. Storage Temperature and Humidity

	Minimum	Maximum
Storage Ambient Temperature	- 20°C	65°C
Storage Humidity	5% RH	95% RH

A.4 Mechanical Specification

The dimensions and the weight of NIC adapters, including NIC Adapter-1G and NIC Adapter-10G, are described in Figure A-7 and Table A-9.

Figure A-7. NIC Adapter Dimensions

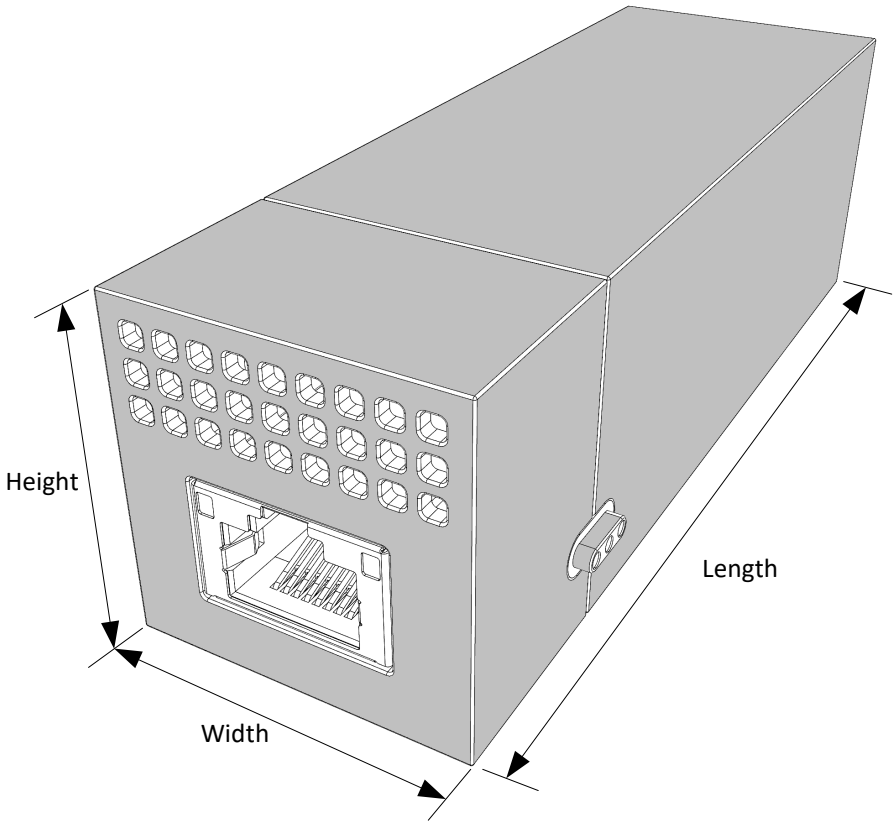


Table A-9. Dimensions and Weight

Dimensions (mm)	
Length	97.4
Width	32
Height	32
Weight (g)	
Weight	119 ± 3%

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