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KINGBROTHER
NVIDIA Jetson AGX Xavier Evaluation Board
Embarking on a New Era of AI-Powered Autonomous Machines

Background

Based on NVIDIA’s Jetson AGX Xaiver SoC module, KINGBROTHER (KB) has developed a high-performance Jetson AGX Xaiver evaluation board. Unlike other common computing platforms, this evaluation board presents a number of unique designs and manufacturing challenges, which we will detail below.

Designing Principles

The Jetson AGX Xavier stands out as the world's first computer designed explicitly for autonomous machines, offering an impressive 32 TOPS of peak computing power and a staggering 750 Gbps high-speed I/O performance. This cutting-edge device is not only capable of handling highly complex modern AI computations but also addresses a wide range of challenges across various sectors, including manufacturing, logistics, retail, services, agriculture, smart cities, and healthcare. Its heterogeneous accelerated computing architecture is a unique feature that enhances its advanced edge computing capabilities, making it a powerhouse for AI-driven applications.

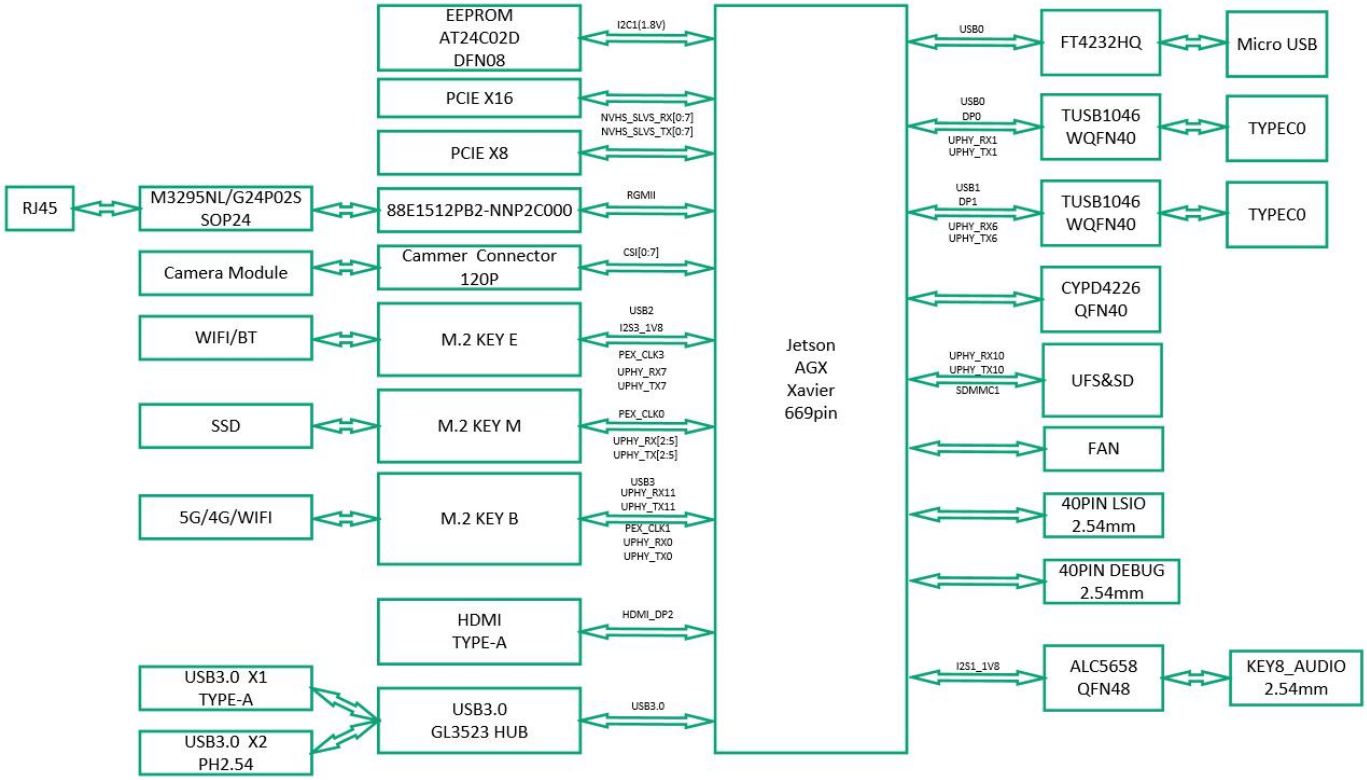
Our engineering team has strived to create an evaluation board that is highly affordable while maintaining NVIDIA's unmatched performance standards. To achieve this balance, we employed some unique designs, test and validate the board to not only its ensures superior performance but also facilitates efficient and accurate signal transmission between the NVIDIA GPU and the high bandwidth memory, which is crucial for high memory bandwidth access. The board's design is a testament to overcoming significant challenges in the printed circuit board (PCB) realm, showcasing our commitment to pushing the boundaries of what's possible in autonomous machine technology.

Below are some information about the board, and a key description of some of the major challenges in designing the PCB to achieve this superior level of performance.

Specifications

Processor	
CPU	NVIDIA Carmel Arm® v8.2 64-bit CPU, up to 2.2G
VPU	Video Decoding: 2x 8K30 (H.265); Video Encoding: 8x 4K30 (H.265).
GPU	512-core NVIDIA Volta architecture GPU with 64 Tensor Cores
Storage	
RAM	32GB LPDDR4x
eMMC	32GB eMMC
Others	M.2 SSD
Communication Control Interface	
USB 3.0	3x USB 3.0 Host
Ethernet	1x Gigabit
5G	1x 5G M.2
4G	1x 4G Mini PCIE
TF	1x TF
UART	5x UART
CAN	2x CAN
SDIO	1x SDIO 4 Bit
SPI	1x SPI
GPIO	40
KEY	1x USER KEY,1x POWER KEY
RTC	1x RTC Battery Interface 2PIN 1.25mm
Debug	1x JTAG, 1x USB to TTL
Multimedia Interface	
HDMI OUT	1x HDMI 1.4 ,supports 1080p@60fps
MIPI CSI	4x 4 Lane MIPI CSI-2
Audio	1x Phone 3.5mm
Mechanical and Electrical Characteristics	
Product Structural Form	Core Board (with BTB connectors) + Carrier Board
Operating Ambient Temperature	Industrial Grade: -40°C to +85°C
Operating Ambient Humidity	5% to 95% relative humidity, non-condensing

Block Diagram



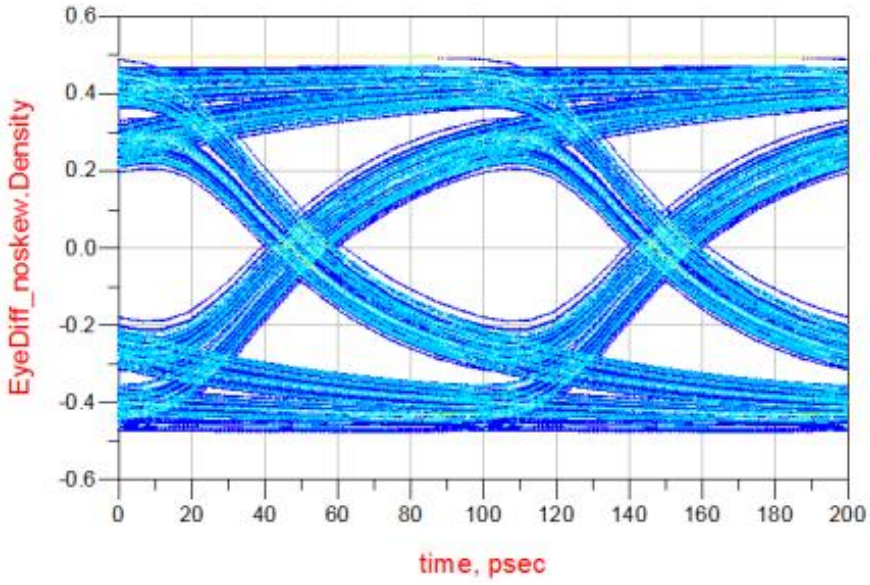
Challenges and Solutions

During the development of the evaluation board, we encountered performance-related challenges and addressed them with optimized design and layout. Here are the key aspects:

1. Impedance Control and Stack-up Structure

Challenges: The Jetson AGX Xavier supports high-speed I/O up to 750Gbps, up to 6 cameras (up to 36 through virtual channels), 16-channel MIPI CSI-2, D-PHY 1.2 (up to 40 Gbps), C-PHY 1.1 (up to 62 Gbps), and multiple USB 3.1 ports. These features are crucial for the integrity and real-time processing of camera data. Ensuring signal integrity requires careful PCB stack-up structure and impedance control.

Solutions: KINGBROTHER employs a 10-layer board, approximately 1.6mm thick. The stack-up structure is designed with impedance control and signal propagation speed in mind. Our design team meticulously calculates impedance, line width and spacing, with differential traces' characteristic impedance controlled at precisely 100 ohms (90 ohms for specific traces) to minimize signal reflection and loss. We also utilize micro-strip line structures for high-speed signal lines, modeling and controlling the propagation delay and impedance difference between inner and outer layers for optimal matching.



1 - Differential Traces' Signal Integrity Test

2. Stable High Power Supply Design

Challenges: The Jetson AGX Xavier module requires a stable power supply and effective ground plane design to mitigate the impact of power noise on signal integrity.

Solutions: In our 10-layer PCB design, four layers are dedicated to ground planes, providing a low-impedance return path and reducing loop area to decrease electromagnetic interference. Power planes are placed close to ground planes to enhance power stability. Additionally, a detection and management module monitors and balances the power supply in real-time, reducing power noise.

3. Thermal Management and Signal Integrity

Challenges: High loads generate significant heat in the Jetson AGX Xavier, potentially affecting signal integrity.

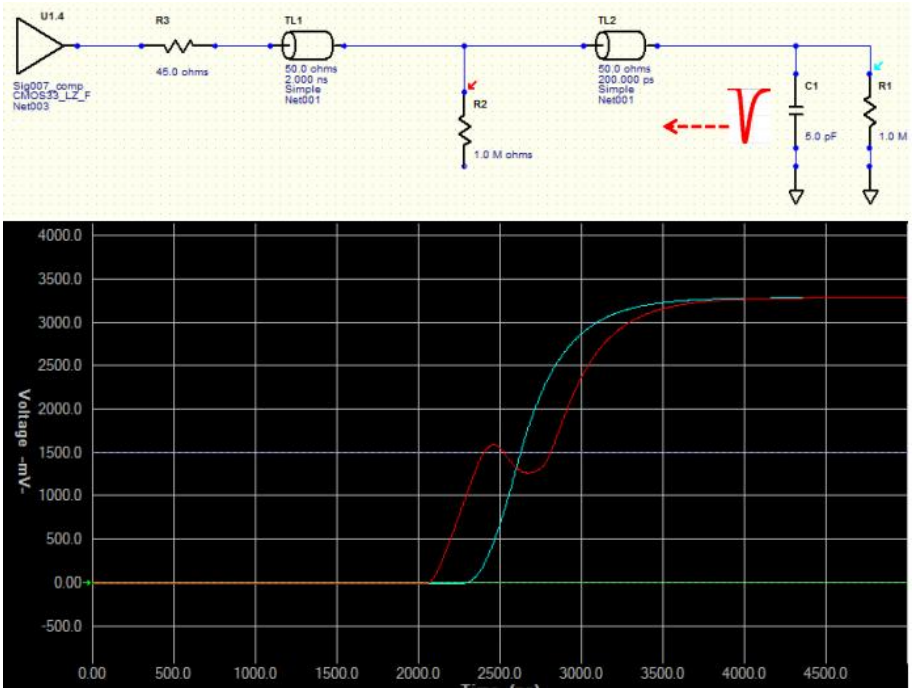
Solutions: We have incorporated thermal management solutions, including a thermal transfer plate (TTP) and special cooling methods, to dissipate heat effectively. With a power range of 10W/15W/30W and an operating temperature range of -25°C to 80°C, our PCB design team focus on the controller’s thermal design to ensure reliable performance.

4. Signal Integrity Analysis and Simulation prior to production

Challenges: Designed for Manufacturing (DFM) is crucial. We conduct numerous signal integrity simulations before production to minimize potential problem.

Solutions: We utilize high-speed PCB design signal integrity analysis tools, such as KBEDA SKILL, which is an in-house tool developed by KINGBROTHER based on the Cadence platform. This tool, equipped with over 400 application functions, enables us to simulate and predict issues like signal reflection, crosstalk, and delay,

allowing for more precise optimization during the design phase.



2 - Independence and Reflection Simulation Analysis