What are the functions of linear direct-drive optical modules



Overview

Direct-Drive Electro-Optical Tech for 800G+ | Synopsys IPLearn how Direct-Drive Electro-Optical Interfaces are transforming datacenters, enabling efficient.

Key Takeaways

Linear direct-drive optical modules (LPOs) enable high-speed, low-latency optical interconnects by removing DSPs from the module and directly interfacing with host SerDes.

Overview

Linear direct-drive optical modules, also known as linear pluggable optics (LPOs), are designed to transmit and receive optical signals without the intermediate digital signal processing (DSP) typically used in conventional optical modules. Instead, the host ASIC's SerDes directly drives the optical transmitter and receives signals from the photodiode/TIA, creating a fully analog, linear signal path. This approach reduces module complexity, power consumption, and latency while maintaining a pluggable form factor compatible with existing network infrastructure.

Key Advantages



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Lower Power Consumption: By eliminating the DSP, module power can drop by approximately 40%, reducing from ~14W to under 8W per module. Reduced Latency: Direct analog transmission avoids the re-timing and equalization delays introduced by DSPs, which is particularly beneficial for AI/ML and high-performance computing applications. Cost Efficiency: Fewer components and simpler module design lower manufacturing costs while preserving compatibility with standard optical form factors like OSFP, QSFP-DD, and QSFP112.

High Bandwidth Support: LPOs can handle high data rates (e.g., 112–224 Gbps per lane) and are suitable for 800G network systems.

Technical Considerations

Signal Integrity (SI): Removing the DSP shifts the responsibility for signal conditioning to the host SerDes. Designers must carefully manage crosstalk, reflection, inter-symbol interference (ISI), and channel loss across the electrical and optical path. Linear Performance: Each component in the link, including the modulator driver, optical transmitter, photodiode, and TIA, must operate as linearly as possible to maintain signal fidelity.

Hybrid Approaches: At very high speeds (e.g., 224 Gbps), nonlinearity in the optical domain may require additional components like Automatic Gain Control (AGC) and Clock Data Recovery (CDR) to ensure reliable transmission. System Integration: LPOs are often used in conjunction with co-packaged optics (CPO), where optical components are integrated closely with the host ASIC to minimize electrical trace losses and improve performance.

Applications

Linear direct-drive optical modules are particularly suited for: Data Center Networks: High-speed interconnects for AI/ML clusters and HPC systems. Enterprise and Telecom Networks: Short- and long-reach optical links with reduced power and latency.

Next-

Generation Ethernet Switches and NICs: Supporting 800G and beyond with efficient, pluggable modules.

Summary

Linear direct-drive optical modules represent a shift from DSP-based optical modules to a simpler, lower-latency, and more power-efficient architecture. By leveraging the host SerDes for direct analog driving of optical components, LPOs reduce complexity and cost while enabling high-speed, high-performance optical interconnects. Challenges remain in signal integrity, linearity, and high-speed nonlinearity management, but ongoing developments in SerDes design and co-packaged optics are addressing these issues.

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Article Content

Direct-Drive Electro-Optical Tech for 800G+ | Synopsys IP

Learn how Direct-Drive Electro-Optical Interfaces are transforming datacenters, enabling efficient data transfer and processing for 800G and beyond.

What are linear pluggable optics?

Learn how linear pluggable optics (LPOs) reduce power use, cost and latency by eliminating the DSP and enabling efficient AI, ML and GPU intra-data-center links.

Linear Pluggable Optics – An Overview

Comparison to CPO g the need for a standalone module. Although CPO is becoming increasingly popular, LPO is seen as a natural evolutionary path for pluggables, offering lower risk compared to

How Linear-Drive Pluggable Optics (LPO) Is Revolutionizing 800G ...

Explore how Linear Pluggable Optics (LPO) transforms 800G transceivers in data centers, reducing power, latency, and costs while enabling high-speed, short-reach connectivity.

What is Linear-Drive Pluggable Optics & What Are Its Challenges?

It has a digital clock recovery function and a dispersion compensation function (removing the influence of noise, non-linear interference, and other factors), which can combat and compensate

Linear Drive Pluggable (LPO) Early Adoption: 800G Engineering

A deep-dive guide to Linear Drive Pluggable (LPO) early adoption. Learn about 800G signal integrity, SerDes tuning, RS-FEC limits, and TCO for AI data centers.

Introducing Linear Pluggable Optics (LPO)

The idea is simple: instead of a DSP (digital signal processor) inside the module – replacing it with transimpedance amplifier (TIA) and a driver chip with high linearity and EQ capability

LPO vs LRO vs CPO vs NPO Optics: Understanding The Difference

LPO (Linear-drive Pluggable Optics) is a pluggable optical transceiver solution based on a linear-drive architecture. Traditional high-speed optical modules usually use DSP (Digital Signal

Comparisons and Challenges Associated with Linear Interface

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Given that timeline of the db task force to D1.0 no later than March-2021 the focus should be developing optical PMDs instead of dabbling in technically very challenging direct drive linear optics.

Pluggables, Power, and Geopolitics: Mapping the 800G

3.2 Linear Pluggable Optics (LPO): The Low-Power Challenger LPO technology removes the DSP from the optical module entirely. Instead, it relies

LPO: Leading Low-Power 800G Optical Communication and

LPO (Linear-drive Pluggable Optics) refers to a pluggable optical module that uses only linear analog components in the data link, eliminating the need for DSP or CDR chips. It replaces

800G Linear Direct Drive Network System Design & Implementation

This DesignCon paper showcases high-speed design and testing schemes for LPO systems from a system perspective while also presenting the testing results, data, and product

Exploring LPO Linear-Drive Optical Modules: A Modern

LPO (Linear-Drive Pluggable Optics) optical modules utilize linear drive technology to enhance data transmission efficiency while lowering power

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800G Linear Direct Drive Network System Design & Implementation

Abstract In the data center network system, the application of LPO (Linear-direct-drive Pluggable Optics) modules has certain advantages in terms of cost, power consumption, and latency compared to

LPO webinar note

Non-retimed Linear Drive Pluggable Optics (LPO) was the hottest topic at OFC 2023 and it continued to draw a crowd at the most recent international optical networking show CIOE 2023. LightCounting

What a Linear Drive Module is?

DSP Function Block Diagram The following figure shows the power consumption breakdown of a 400G ZR optical module, with a similar scenario for an IMDD. As a response to the

The Evolution of Optical Modules: Powering the Future

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