

Why use PAM4 for a 50G optical module

Article Overview

PAM4 is used for 50G optical modules because it doubles the data rate per symbol, enabling 50Gbps transmission over a single lane while optimizing bandwidth and reducing costs.

Higher Bandwidth Efficiency

PAM4 (Pulse Amplitude Modulation with 4 levels) encodes two bits per symbol using four distinct amplitude levels (00, 01, 10, 11), whereas traditional NRZ (Non-Return-to-Zero) encodes only one bit per symbol using two levels (0 and 1). This means that for a 50G data rate, PAM4 requires only 25 GBd symbol rate, compared to 50 GBd for NRZ, effectively halving the required bandwidth and reducing signal attenuation. This efficiency is crucial for high-speed optical links where bandwidth is limited.

Cost Reduction and Component Reuse

By using PAM4, a 25G optical component can achieve 50Gbps, allowing manufacturers to reuse existing 25G lasers and modulators, which reduces the cost of optical transceivers. This makes PAM4 particularly attractive for 50GE, 200GE, and 400GE interfaces, supporting scalable network upgrades without requiring entirely new hardware.

Scalability and Future-Proofing

PAM4 enables single-lane 50G transmission, which simplifies module design and allows for easy scaling to 100G and 200G using multi-lane configurations without redesigning port form factors. This makes PAM4 a future-proof solution for data centers and 5G networks, where high-density, high-speed connectivity is essential.

Trade-offs and Considerations

While PAM4 improves efficiency, it has smaller signal level spacing, making it more susceptible to noise and increasing the bit error rate (BER) compared to NRZ. To mitigate this, PAM4 transceivers rely on advanced digital signal processing (DSP) and error correction. Power consumption and design complexity are higher, but the benefits in bandwidth utilization and cost savings outweigh these challenges for high-speed applications.

Summary

PAM4 is chosen for 50G optical modules because it:



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- o Doubles data throughput per symbol, reducing required bandwidth.
- o Enables cost-effective use of existing 25G components.
- o Supports scalable, high-speed network architectures for 5G and data centers.
- o Provides a future-proof path for higher-speed Ethernet standards, despite increased complexity and noise sensitivity .

High-performance optical modules using PAM4 coding improve data transmission, converting NRZ to PAM4 signals.

Both the optical port side and the electrical port side use 50G PAM4 modulation, and the transmitting end uses DWDM

400G PAM4 Ethernet Transceivers - Introduction Pulse Amplitude Modulation 4-level or PAM4 has been

PAM4 in 400G/200G/100G/50G Networking Technology ... Note: Optical 400GBASE-SR16 at 25 GBd PAM2 NRZ not shown

PAM4: Unexpected Complexity Although PAM4 may have a longevity in Ethernet serdes design approaching that of NRZ, it would be

Enter PAM4 (4-level Pulse Amplitude Modulation), the critical modulation scheme enabling the next leap in speed for

This article examines 50G transceiver signaling technology, different types of 50G optical modules and why 50G is

Consequently, the industry has turned to PAM4 modulation to realize ultra-high-bandwidth network architectures.

Each standard applies to a particular purpose in a unique signal integrity environment. For example, Table 1 shows separate

Compare PAM4 and NRZ modulation in optical Ethernet. Learn how PAM4 doubles data rates with better bandwidth

PAM4-based Optical Transceiver Technologies The PAM4 (4 level Pulse Amplitude Modulation) encoding technology

PAM4 PAM4 only have 1/3 of the amplitude compared to NRZ In a more technical terms, we trade the

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transmitter's signal-to-noise

Why Does 400G Ethernet Need to Use PAM4 Technology? As the global bandwidth market grows, the transmission

The PAM4 (4 level Pulse Amplitude Modulation) encoding technology allows to double the current amount of

Explore QSFP28 PAM4 DWDM transceivers for high-speed 100G/400G networks. Learn how PAM4 modulation and

The single-lane 50GE PAM4 optical module design uses 25 Gbit/s optoelectronic components, lowering costs by leveraging existing

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