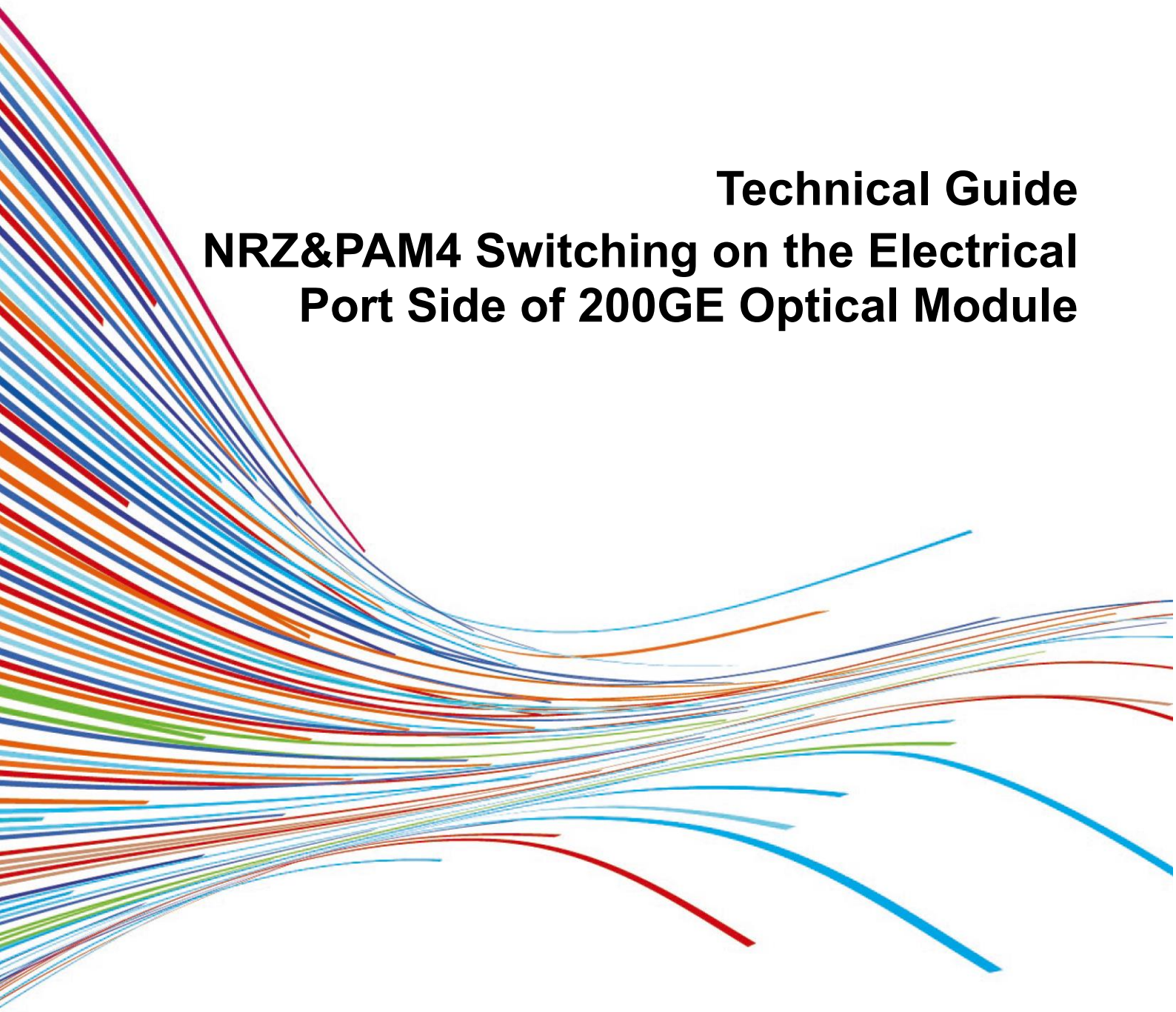
Technical Guide
NRZ&PAM4 Switching on the Electrical Port Side of 200GE Optical Module



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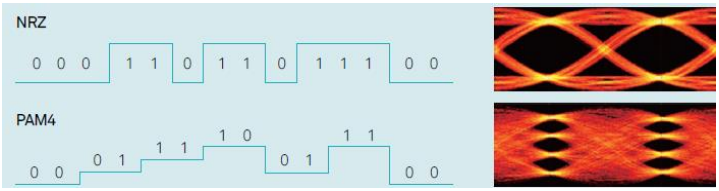
1. Development History of 200GE Standards and 200GE Optical Modules

The IEEE 802.3 Ethernet Working Group initiated a project in 2013 to formulate the 400GE standard after completing the project survey of Bandwidth Assessment I (BWA I). Because 200GE and 400GE specifications are correlated, 200GE single-mode specifications were eventually included in the 802.3bs project. The 200GE single-mode specifications were generally formulated as half of the 400GE single-mode specifications.

On December 6, 2017, IEEE 802 approved and officially released the IEEE 802.3bs 400GE Ethernet standards, including 400GE Ethernet and 200GE Ethernet single-mode standards. IEEE 802.3cd defined the 200GE Ethernet multi-mode standards, which were officially released in December 2018. With the maturity of 200GE standards, the R&D and productization of 200GE optical modules keep making progresses.

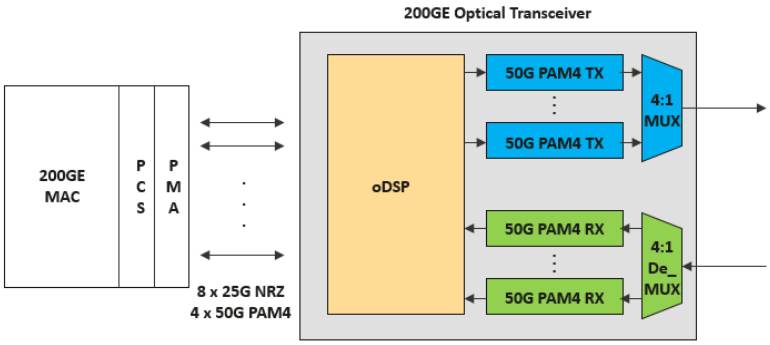
2. Electrical Port Technology Iteration of 200GE Optical Modules: NRZ->PAM4

PAM4 is a type of pulse amplitude modulation (PAM) technology. It is a mainstream signal transmission technology following non-return-to-zero (NRZ). As one of the multi-order modulation technologies, PAM is widely used in high-speed signal interconnection. The following figure shows the typical waveforms of NRZ and PAM4 signals. The right part of this figure compares the eye diagrams of NRZ and PAM4 signals, where an NRZ signal uses the single-pupil waveform and a PAM4 signal uses three-pupil waveform (three eye diagrams along the Y axis).



Therefore, under the same baud rate, the bit rate of a PAM4 signal is twice that of an NRZ signal, doubling transmission efficiency and reducing transmission costs. Due to its high transmission efficiency, 50Gbps/lane (50G for short) PAM4 is selected by IEEE 802.3 as the physical-layer encoding technology for 400GE, 200GE, and 50GE ports.

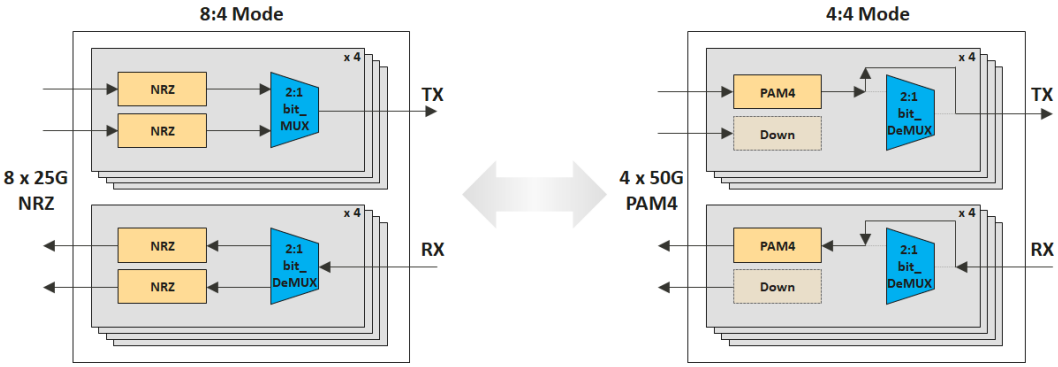
Take 200GE LR4 as an example. To achieve 10 km transmission, 4 x 50G is used on the optical port side. However, on the electrical port side, the service chips on some Ethernet boards support only NRZ ports due to the limitations of PAM4 application scenarios in the early stages. As the PAM4 technology matures, PAM4-based electrical ports are being applied to chips such as Ethernet service chips since 2019. To be compatible with 8 x 25G NRZ electrical ports, mainstream Ethernet service chips in the industry start to support both 8 x 25G NRZ and 4 x 50G PAM4 modes since 2019 H2.



3. PAM4/NRZ Switching on Electrical Port Side of 200GE Optical Modules

The 200GE LR4 optical modules of HiSilicon Optoelectronics use high-performance oDSP to implement high-performance O/E conversion. The modules support the transmission of 200GE optical signals with a transmission distance of 10 km on the optical port side, and PAM4 (53.125 Gbit/s) and NRZ (26.5625 Gbit/s) on the electrical port side through related functional blocks of oDSP, meeting different device-side requirements.

- The SerDes needs to support functions such as sampling and data recovery for two types of electrical signals of different rates.
- The bit_Mux enablement and bypass functions are supported so that the oDSP can switch between the 8:4 and 4:4 working modes.
- New chip techniques are used to meet challenges in integration, power consumption, and performance for more complex chip architectures.



Currently, optical modules such as 200GE LR4 and ER4 of HiSilicon Optoelectronics support PAM4/NRZ mode switching on the electrical port side to meet the requirements of different application scenarios.

No.	Product Model	Description	Specification on the Electrical Port Side	Specification on the Optical Port Side
1	OM9758LS100	10km 200GBASE-LR4 QSFP-DD Optical Transceiver Module	• 53.125 Gbit/s PAM4 Channel Electrical Serial Interface (200GAUI-4) • 26.5625 Gbit/s NRZ Channel Electrical Serial Interface	Compliant to IEEE 802.3cn 200GBASE-LR4
2	OM9758ES100	40km 200GBASE-ER4 QSFP-DD Optical Transceiver		Compliant to IEEE 802.3cn 200GBASE-ER4

No.	Product Model	Description	Specification on the Electrical Port Side	Specification on the Optical Port Side
		Module	(200GAUI-8)	