Computing power requirements for optical modules

Overview

In modern data centers, the energy required to move data is becoming as significant as the energy required to process it.

Key Takeaways

Optical modules require computing power primarily for DSPs, CDRs, and gearbox functions, with power consumption and thermal limits dictating the necessary processing capabilities.Core Computing Requirements

Modern optical modules, including SFP+, QSFP-DD, and OSFP, rely on digital signal processors (DSPs) to handle high-speed data conversion, error correction, and signal conditioning. The computing power needed depends on the module's data rate:

• 100G to 400G modules typically require DSPs operating at core voltages between 0.5 V and 1.2 V, with load currents ranging from 1 A to 3 A depending on the design and modulation scheme .

• 800G and beyond modules, especially coherent optics, may consume 8 W to over 25 W per module, reflecting the higher computational demand for advanced modulation, forward error correction, and multi-lane processing .

• OSFP modules designed for 400G–1.6T data rates require larger thermal envelopes to support higher DSP power, emphasizing the need for efficient computing and thermal management .
Power Supply and Thermal Considerations

The computing power of optical modules is tightly coupled with power supply design:

• Miniature, high-efficiency DC/DC buck converters are used to supply multiple voltage rails to DSPs, CDRs, and biasing circuits within the module .

• Dynamic voltage scaling (DVS) allows DSPs to adjust core voltage in real time, reducing power consumption under favorable conditions (e.g., lower temperature or high-quality input signals), which can save hundreds of milliwatts per module .

• Compact power modules, such as Renesas RAA210040 and RAA210030, provide 3–4 A continuous current in a small footprint, suitable for space-constrained optical modules .

System-Level Implications

• High-speed optical modules contribute significantly to total switch power, sometimes exceeding the power of the switch ASIC itself in fully loaded 400G+ deployments .

• Efficient computing within the module reduces heat generation, enabling higher rack density and lower cooling requirements .

• Co-packaged optics (CPO) architectures integrate optical engines closer to the switch ASIC, minimizing electrical path lengths and improving energy efficiency, which reduces the required computing power per module for signal integrity management .

Practical Recommendations

• Match DSP capability to data rate: Higher data rates require DSPs with faster processing, more memory, and advanced error correction.

• Optimize voltage and current supply: Use high-efficiency, low-profile power modules with DVS support to balance performance and thermal limits.

• Consider thermal envelope: Ensure module design allows adequate heat dissipation for the DSP and associated electronics.

• Plan for system-level power: Account for cumulative power draw of all optical modules in a switch or rack to avoid exceeding power budgets.

• Leverage monitoring: Use DDM/DOM diagnostics to track module temperature, voltage, and current, enabling proactive adjustments to computing load and power settings . In summary, the recommended computing power for optical modules is determined by the DSP and data-path processing requirements, constrained by power supply, thermal limits, and module form factor. Efficient design, dynamic voltage scaling, and careful system-level planning are essential to meet high-speed data demands while maintaining reliability and energy efficiency.

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