PCIe Expansion Compute Module Electrical and Signal Integrity Guide - Official Technical Overview & Hardware Datasheet

EXECUTIVE SUMMARY

The PCIe Expansion Compute Module (PECM) Electrical and Signal Integrity Guide serves as the definitive technical reference for system architects, hardware engineers, and integration specialists deploying high-performance compute expansion within carrier-grade and enterprise telecom infrastructure. This document details the electrical characteristics, signal integrity optimization methodologies, and physical layer design considerations essential for achieving deterministic, error-free PCI Express Gen4/Gen5 operation across multi-slot backplanes and extended cable topologies. The PECM platform is engineered to address the critical challenges of signal attenuation, inter-symbol interference (ISI), crosstalk, and power delivery integrity inherent in dense, high-bandwidth compute expansion environments. By adhering to the guidelines and specifications contained herein, integrators can ensure optimal link training, maximum effective throughput, and long-term operational reliability in the most demanding network edge and core routing applications.

ARCHITECTURE & CHASSIS DESIGN

The PECM hardware architecture is founded upon a modular, high-density compute expansion paradigm designed to augment host routing and switching engines with additional processing capacity. The core module integrates a PCIe switch complex, retimer/redriver stages, and a robust power delivery network (PDN) onto a compact mezzanine form factor. The chassis design accommodates multiple PECM units within a standard 1RU or 2RU shelf, interconnected via a high-integrity orthogonal backplane or over passive copper cable assemblies. Thermal management is achieved through a combination of directed airflow channels and integrated heatsink fins, ensuring that the electrical performance of the high-speed SerDes lanes remains stable under continuous full-load conditions. The physical layer layout prioritizes trace impedance control, minimized stub lengths, and strategic layer stack-up to

preserve signal fidelity from the host root complex to the endpoint device.

HARDWARE FEATURES

The PECM platform incorporates a comprehensive suite of hardware features designed to guarantee electrical and signal integrity excellence. Key features include support for PCI Express Base Specification revisions 4.0 and 5.0, providing 16 GT/s and 32 GT/s per lane respectively. The module employs advanced equalization techniques, including Tx FIR (Finite Impulse Response) and Rx CTLE/DFE (Continuous Time Linear Equalizer / Decision Feedback Equalizer), to compensate for channel losses up to 36 dB at Nyquist frequency. Integrated per-lane retimers restore signal eye height and width, enabling extended reach across backplanes and cables. A sophisticated power management IC (PMIC) delivers multi-phase, sequenced power rails with active voltage margining, ensuring stable operation during dynamic load transients. Furthermore, the module supports in-band and out-of-band diagnostics, including eye scan, PRBS pattern generation, and BER monitoring, facilitating rapid link health assessment and fault isolation.

COMPLIANCE & STANDARDS

The PCIe Expansion Compute Module is designed to meet or exceed the

following industry standards and specifications, ensuring interoperability and reliability across diverse telecom and enterprise environments. Compliance with PCI-SIG CEM (Card Electromechanical) specifications ensures mechanical and electrical compatibility with standard host connectors. The module is validated against PCIe Base Specification 4.0 and 5.0 electrical conformance test suites. Electromagnetic compatibility (EMC) is assured through adherence to FCC Part 15 Subpart B, EN 55032, and EN 55035 standards for Class A digital devices. Safety certifications include IEC 62368-1 and UL 62368-1 for audio/video, information and communication technology equipment. Additionally, the platform conforms to RoHS 2 (2011/65/EU) and REACH directives, supporting global deployment and environmental sustainability initiatives.

TECHNICAL SPECIFICATIONS

The following table summarizes the principal technical specifications of the PCIe Expansion Compute Module platform. These parameters define the operational envelope and performance characteristics essential for system-level integration and signal integrity budgeting.

Parameter	**Specification**
Form Factor	Mezzanine Card (Standard PCIe CEM Edge Connector)

PCIe Generation Support	Gen4 (16 GT/s) and Gen5 (32 GT/s)
Lane Configuration	x8, x16 (Hardware Configurable)
Channel Loss Budget	Up to 36 dB at Nyquist (with Retimers)
Equalization	Tx FIR, Rx CTLE/DFE, Per-Lane Retiming
Power Supply	12V and 3.3V from Host, On-board PMIC with Margining
Power Consumption	Typical 25W (x16 Gen5 Active), Max 40W
Diagnostics	In-band Eye Scan, PRBS, BER Monitoring
Operating Temperature	Standard: -5°C to +55°C / Extended: -40°C to +85°C
Compliance	PCI-SIG CEM, PCIe Base 4.0/5.0, FCC Part 15B, IEC 62368-1, RoHS 2

ORDERING OPTIONS

To facilitate precise configuration and procurement, the PECM platform is offered in multiple SKUs distinguished by lane count, retimer provisioning, and cooling profile. The PECM-16G4-8L provides an 8-lane Gen4 expansion path with a passive cooling solution, ideal for space-constrained edge nodes. The

PECM-32G5-16L-R offers 16 lanes of Gen5 connectivity with integrated retimers and a high-efficiency active heatsink, targeting high-density core routing line cards. The PECM-32G5-16L-C variant is optimized for cable-backed expansion, featuring enhanced Tx/Rx equalization for extended reach over 30 AWG twin-axial assemblies. All SKUs are available with either standard or extended temperature range options (-5°C to +55°C and -40°C to +85°C respectively) to suit diverse deployment environments.