WHITE PAPER

400GE Data Center Transceiver Test: Overcoming Three Key Challenges

Emerging technologies such as fifth generation wireless (5G), artificial intelligence (AI), Virtual Reality (VR), Internet of Things (IoT), and autonomous vehicles will generate explosive amounts of data in the network, creating new computing, storage and performance demands in the data center. Data center operators need to embrace new technologies to support the response times and high bandwidth that these technologies will require.

With the expectation of billions of devices to be connected to the internet, and the data intensive real time applications they will run, 100 gigabit Ethernet (GE) speeds which are common in data centers today will not be fast enough. In addition to planning the size and location of data centers, as well as considering a shift to virtualized network architectures, data center operators are looking to evolve the speed of their networks from 100GE to 400GE.

The Basics

The speed of networking inside every data center is driven by the connection speed of transceivers that use advanced modulation and coding to increase data throughput over the existing network infrastructure. An optical transceiver consists of both a transmitter and a receiver, which share common circuitry and packaging (form factor).

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Transition from 100GE to 400GE

In the span of less than 15 years, data center speeds have swiftly evolved from 10GE to 100GE, and soon 400GE. Each new speed class built off the previous generation, yet was limited early on by high-cost and constrained demands. For example, 100GE began deployment in the data center in 2014, yet full manufacturing build-out only became cost effective over the last couple of years with the introduction of more efficient optical transceiver modules. No sooner did data center operators move into rapid deployment of 100GE than they needed to start planning to move to higher 400GE speeds.

Traditionally, service providers were the early adopters of new technology, and the first to test transceivers for the next speed class. However, applications such as VR and AI are driving the need for increased networking bandwidth within the data center. This need will be intensified with 5G substantially increasing the use of these applications. In addition, modern hyperscale data centers house more than 50,000 fibers with an optical transceiver at each end. Therefore, transceiver cost is another major factor driving data center operators to be the first to pioneer new technology. This means they no longer have the luxury of learning from the growing pains of service providers, so intensive testing of any new technology becomes an even higher priority. Consequently, the requirements and challenges associated with the data center are different than those faced by service providers in telecom. Ensuring data centers are capable to support the requirements of these applications requires finding solutions to three key challenges.

Three key challenges transitioning from 100GE to 400GE in the data center:

- Increase channel capacity
- Guarantee quality & interoperability
- Reduce test time, reduce cost

Challenge 1: Increase Channel Capacity

Traditionally, data centers operators tended to upgrade their network architecture every couple of years. However, many data centers are currently at maximum capacity, and data center operators need to find a way to increase channel bandwidth to reach 400GE speeds. Reducing the power per bit is equally important. Data center operators are turning to transceiver manufacturers to move to the next generation speed class.

Solution: Advanced Modulation and Coding

Ever-increasing demands for a connected world with instant data access continues to drive data center transceiver innovation. Development of 100GE data transmission is currently in production and will continue to evolve. The move from 100GE to 400GE is revolutionary, not evolutionary. Non-return-to-zero (NRZ) and four-level pulse amplitude modulation (PAM4) are two modulation technologies that can enable 400GE. Each comes with its own unique set of challenges.

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As speeds of NRZ designs increase above 28 Gb/s, channel loss of the transmission medium becomes a limiting factor. Therefore, new multilevel signal modulation techniques are needed. PAM4 modulation is the recommended method to reach 400GE speeds in the data center. However, PAM4 designs are far more susceptible to noise since four signal levels are packed into an amplitude swing of two. As a result, the signal to noise ratio (SNR) is lower, and analyzing noise in transceiver designs becomes a critical test factor. PAM4 will use forward error correction (FEC) to account for this. FEC is an advanced coding technique that sends the required information to correct errors through the link along with the payload data. FEC introduces new test challenges that must be considered in physical layer testing of PAM4 signals.

Challenge 2: Guarantee Quality & Interoperability

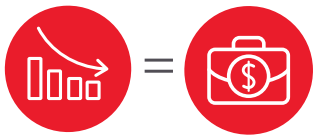
The nature of pluggable modules necessitates that any new transceiver technology must be thoroughly tested to comply with specifications to ensure seamless compatibility before it is inserted into the network. Optical transceiver manufacturers must test to ensure their transceivers have strict compliance with defined specifications and are interoperable with other network components and transceivers from different vendors. Network downtime due to faulty transceivers is not an option for data center operators which have guaranteed service level agreements (SLAs) with users.

Solution: Characterization and Compliance Test

Fortunately, several standards organizations, such as the Institute of Electrical and Electronics Engineers (IEEE), International Committee for Information Technology Standards (INCITS) and the Optical Internetworking Forum (OIF), govern optical transceiver specifications and define test procedures to ensure compliance to standards and interoperability with other vendors. Data center operators can ensure the quality and compatibility of their next generation transceivers by selecting one that has successfully passed all physical Layer 1 characterization and compliance tests defined by industry standards.

Standards organizations define specifications and provide compliance test procedures to ensure that a receiver will operate with a worst-case transmitter and vice versa. There are different sets of optical and electrical tests that need to be performed for transmitters and receivers, and the effects of the channel between them also need to be considered. The faster and more complex the system, the more difficult and time-consuming characterization and compliance test become.

Challenge 3: Reduce Test Time, Reduce Cost



Advanced modulation, such as PAM4, will enable data center operators to reach 400GE speeds. However, the cost of next generation optical transceivers then becomes the major contributor to the cost of data centers transitioning to 400GE. While the cost of transceivers is directly proportional to the complexity of the design and the number of optical components, test time is also significant and contributes to the overall cost of the transceiver. The need to measure complex specifications per defined standards complicates the design and validation process and requires a long learning curve for test engineers.

Solution: Test Efficiency

The number of communication standards and transceiver types has proliferated during the last decade, creating more complexity for R&D and manufacturing test. There are several techniques that can significantly reduce test time, and the overall cost of transceivers from design and simulation, to device characterization and compliance, and finally manufacturing.

Testing Starts in the Design Phase

Using innovative simulation technologies in the design phase ensures first pass success and high yields. Powerful software simulation tools simplify the design process and enable post-processing and data analysis without rerunning simulations. With software simulation, it is possible to pinpoint problems early in the design cycle and avoid costly manufacturing issues later.

Engineers are still struggling with how to efficiently test PAM4 modules in production. However, once 400GE transceivers reach the manufacturing phase, real time analysis and monitoring of process, test and equipment data can drive manufacturing improvements and efficiencies, mitigating risks of failure and down time. Real time containment of operational or product quality issues, increases productivity and asset utilization, reducing test time and cost.

Summary

100GE is widely deployed in data centers around the world today, but 400GE links will be the next step to increase network bandwidth for “5G capable” data centers. Data center operators can ensure the seamless transition from 100GE to 400GE by introducing next generation transceivers that increase channel capacity, guarantee quality and interoperability, and reduce test time and cost. If these challenges can be addressed, 400GE in data centers will soon become a reality and ready to support the new applications such as VR and AI.

With 400GE transceiver technology squarely on the horizon, data center operators are also looking for new ways to design and operate their networks to withstand the kind of traffic that billions of devices will generate. Many are shifting to virtualized networks using software-defined networking (SDN) and network functions virtualization (NFV). SDN is a network architecture that enables software programmable network control of a virtualized network infrastructure. Network functions virtualization is an architecture concept that automates entire classes of network node functions into building blocks that can be connected to create communication services. Once the shift to a virtualized network is achieved, data center operators need to make sure that data flows through it as they expected. This is where full network test of Layers 2-7, including SDN/NFV validation and traffic loading, becomes the next hurdle that they will need to overcome.

For information on how Keysight's solutions can help you address your 400GE data center implementation challenges, check the following links:

- For PAM4 simulation, transmit, interconnect and receiver test solutions, check out Pulse Amplitude Modulation (PAM4) Design and Test Solutions
- For data analytics tools to visualize and analyze measurement data, check out N8844A Data Analytics Web Service Software
- For optimizing manufacturing efficiencies and processes, check out PathWave Analytics

For additional information on overcoming the challenges of evolving your data center from 100GE to 400GE, go to www.keysight.com/find/400G

Learn more at: www.keysight.com

For more information on Keysight Technologies' products, applications or services, please contact your local Keysight office. The complete list is available at: www.keysight.com/find/contactus

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