What's New Inside a 100G ZR Module?

In the optical access networks, the 400ZR pluggables that have become mainstream in datacom applications are too expensive and power-hungry. Therefore, operators are strongly interested in 100G pluggables that can house coherent optics in compact form factors, just like 400ZR pluggables do. The industry is labeling these pluggables as **100ZR.**

A recently released Heavy Reading survey revealed that over 75% of operators surveyed believe that 100G coherent pluggable optics will be used extensively in their edge and access evolution strategy. However, this interest had yet to materialize into a 100ZR market because no affordable or power-efficient products were available. The most the industry could offer was 400ZR pluggables that were "powered-down" for 100G capacity.

By embracing smaller and more customizable light sources, new optimized DSP designs, and high-volume manufacturing capabilities, we can develop native 100ZR solutions with lower costs that better fit edge and access networks.

Smaller Tunable Lasers

Since the telecom and datacom industries want to pack more and more transceivers on a single router faceplate, integrable tunable laser assemblies (ITLAs) must maintain performance while moving to smaller footprints and lower power consumption and cost.

Fortunately, such ambitious specifications became possible thanks to improved photonic integration technology. The original 2011 ITLA standard from the Optical Internetworking Forum (OIF) was 74mm long by 30.5mm wide. By 2015, most tunable lasers shipped in a OIF form factor that cut the original ITLA footprint in half. In 2021, the nano-ITLA form factor designed for QSFP-DD and OSFP modules had once again cut the micro-ITLA footprint almost in half.

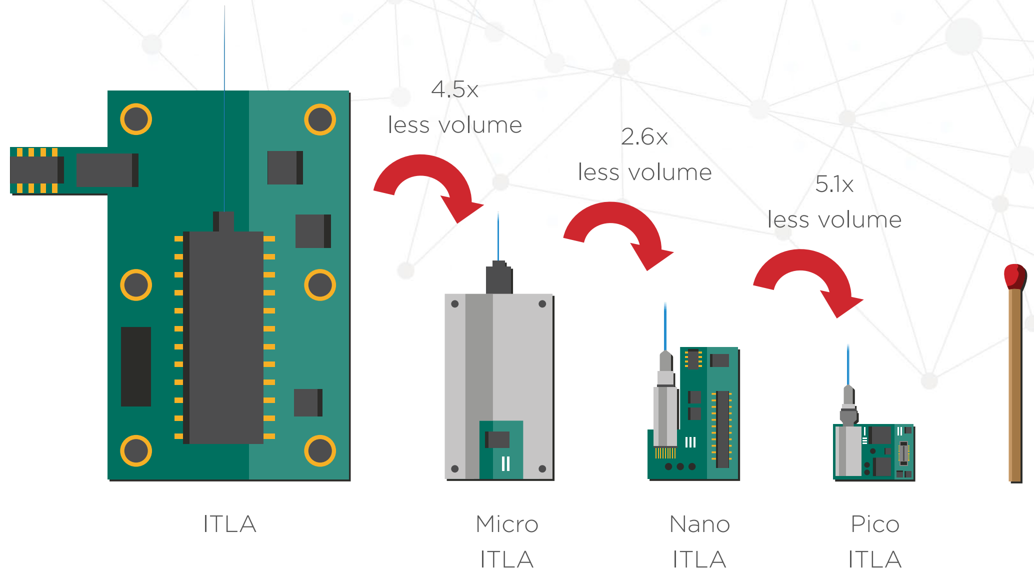

Figure 1: Volume reduction of ITLA form factors for coherent optics (2011-2023). A match of roughly 4cm in length is included for scale.

There are still plenty of discussions over the future of ITLA packaging to fit the QSFP28 form factors of these new 100ZR transceivers. EFFECT Photonics has developed a solution that monolithically integrates all tunable laser functions (including the wavelength locker) into a novel pico-ITLA (pITLA) module that will become the world's smallest ITLA for coherent applications. The pITLA is the next step in tunable laser integration, including all laser functions in a package with just 20% of the volume of a nano-ITLA module. The figure below shows that even a standard matchstick dwarves the pITLA in size.

More Efficient DSPs

The 5 Watt-power requirement of 100ZR in a QSFP28 form factor is significantly reduced compared to the 15-Watt specification of 400ZR transceivers in a QSFP-DD form factor. Achieving this reduction requires a digital signal processor (DSP) specifically optimized for the 100G transceiver.

Current DSPs are designed to be agnostic to the material platform of the photonic integrated circuit (PIC) they are connected to, which can be Indium Phosphide (InP) or Silicon. Thus, they do not exploit the intrinsic advantages of these material platforms. Co-designing the DSP chip alongside the PIC can lead to a much better fit between these components.

To illustrate the impact of co-designing PIC and DSP, let's look at an example. A PIC and a standard platform-agnostic DSP typically operate with signals of differing intensities, so they need some RF analog electronic components to "talk" to each other. This signal power conversion overhead constitutes roughly 2-3 Watts or about 10-15% of transceiver power consumption.

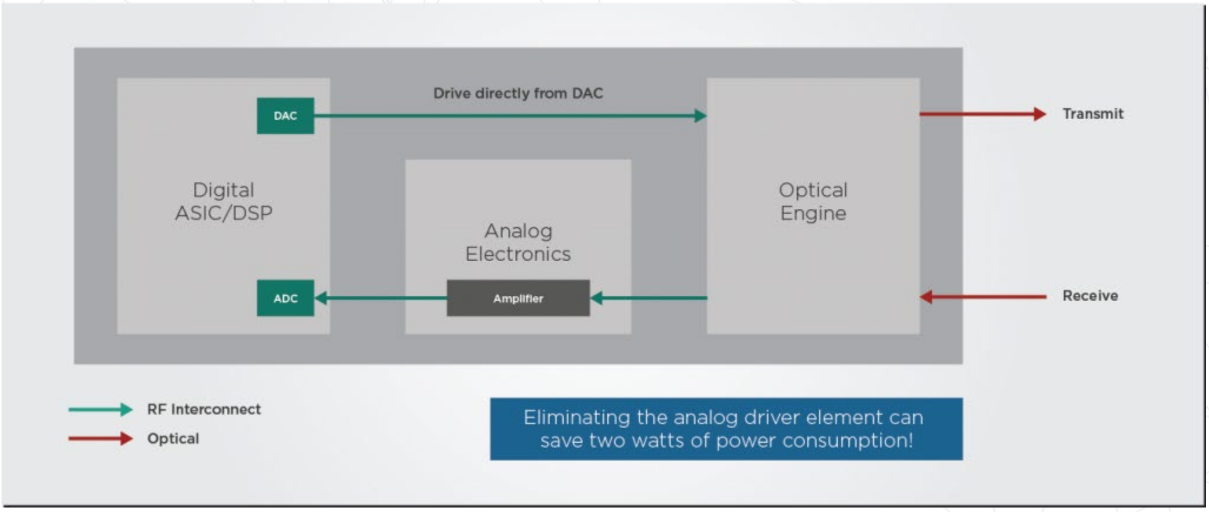

Figure 2: Simplified diagram of the building blocks of a coherent transceiver in which the DSP drives the optical engine directly from its digital-to-analog converter (DAC). This setup can minimize the power conversion overhead of optical transceivers.

If this InP PIC and the DSP are designed and optimized together instead of using a standard DSP, the PIC could be designed to run at a voltage compatible with the DSP's signal output. This way, the optimized DSP could drive the PIC directly without needing the RF analog driver, doing away with most of the power conversion overhead we discussed previously.

Industrial Temperature Ranges

Traditionally, coherent devices have resided in the controlled settings of data center machine rooms or network provider equipment rooms. These rooms have active temperature control, cooling systems, dust and particle filters, airlocks, and humidity control. In such a setting, pluggable transceivers must operate within the so-called commercial temperature range (c-temp) from 0 to 70ºC.

On the other hand, the network edge often involves uncontrolled settings outdoors at the whims of Mother Nature. It might be at the top of an antenna, on mountain ranges, within traffic tunnels, or in Northern Europe's severe winters. For these outdoor settings, transceivers should operate in the industrial temperature range (I-temp) from -40 to 85ºC. Higher altitude deployments provide additional challenges too. Because the air gets thinner, networking equipment cooling mechanisms become less effective, and the device cannot withstand casing temperatures as high as they can at sea level.

Making an I-temp transceiver means that every internal component—lasers, optical engine, DSP—must also be I-temp compliant. Thus, it's essential to specifically design laser sub-assemblies and DSPs that can reliably work within the I-temp range.

Takeaways

The advent of 100G ZR modules addresses the industry's need for more affordable and energy-efficient alternatives to implement coherent technologies in access networks. The drive towards miniaturization, exemplified by EFFECT Photonics' development of the world's smallest ITLA module, alongside DSP optimizations that minimize power conversion overhead, will help develop pluggables that meet the efficiency and footprint requirements of access networks. Furthermore, it's necessary for these modules to operate across an I-temp range that can handle a variety of challenging environments in which these networks must operate.

These developments will help operators lay the groundwork for a new generation of coherent optical access networks.

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