Industrial Hardening: Coherent Goes Outdoors

The global optical transceiver market is expected to double in size by 2026, and coherent pluggables will play a significant role in this growth as they will constitute roughly a third of those sales. While coherent is now an established solution in data center interconnects and long haul networks, it is also expected to start gaining ground in the access networks that connect mobile base stations and their controllers to the rest of the Internet. LightCounting forecasts that by 2025, coherent modules will generate 19% of all sales revenue, in an estimated market of $827 million, for transceivers in back-, mid-, and front-haul network segments. This is an increase in market share from 6% in 2021, as operators are expected to replace some of their direct detect modules with coherent ones in the coming years.

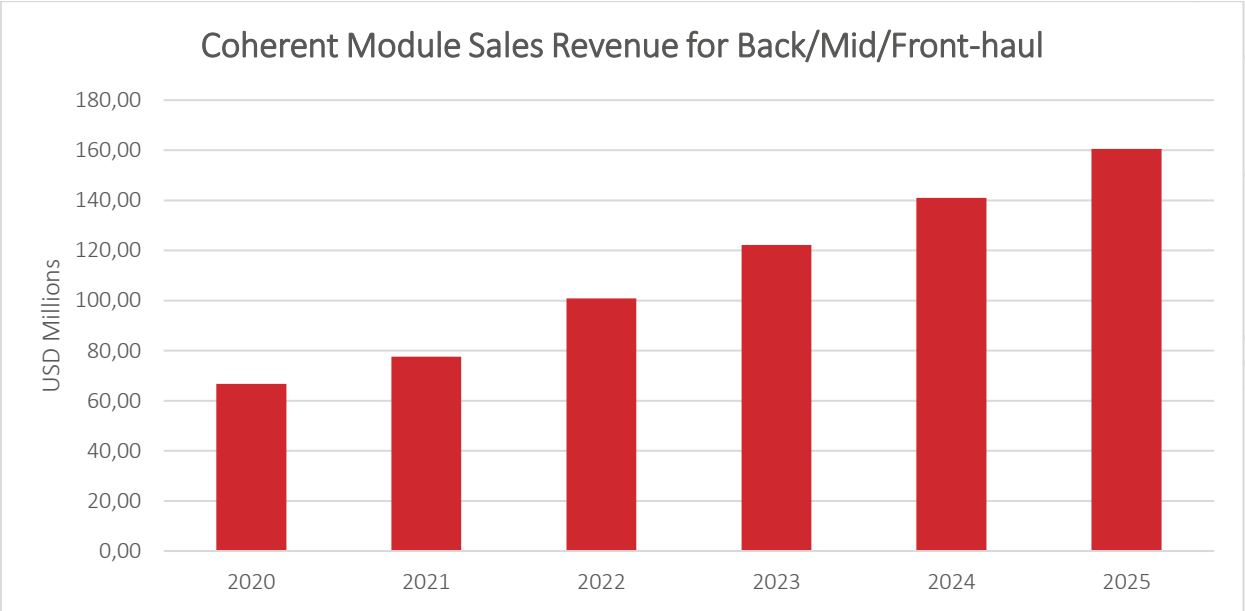

Figure 1: Transceiver sales revenue (in USD) forecast for coherent modules in back/mid/front-haul network segments. Source: LightCounting Access Optics Market Forecast – November 2020.

The numbers for coherent sales will only increase in the coming decade for two main reasons. First, electronic and photonic integration are making coherent pluggables economically viable and smaller (see our previous article on the subject). Second, the increasing data demands require access networks to increase their capacity beyond what direct detect can deliver. However, for coherent devices to become established in access networks, they must learn to live outdoors.

Controlled vs. uncontrolled environments

Coherent devices have traditionally lived in the *controlled* environments of data center machine rooms or network provider equipment rooms. These rooms have active temperature control, cooling systems, filters for dust and other particulates, airlocks, and humidity control. In these rooms, pluggable transceivers operate at a relatively stable temperature of around 50ºC, and they only need to survive in ambient temperatures within the *commercial* temperature range (C-temp) of 0 to 70ºC.

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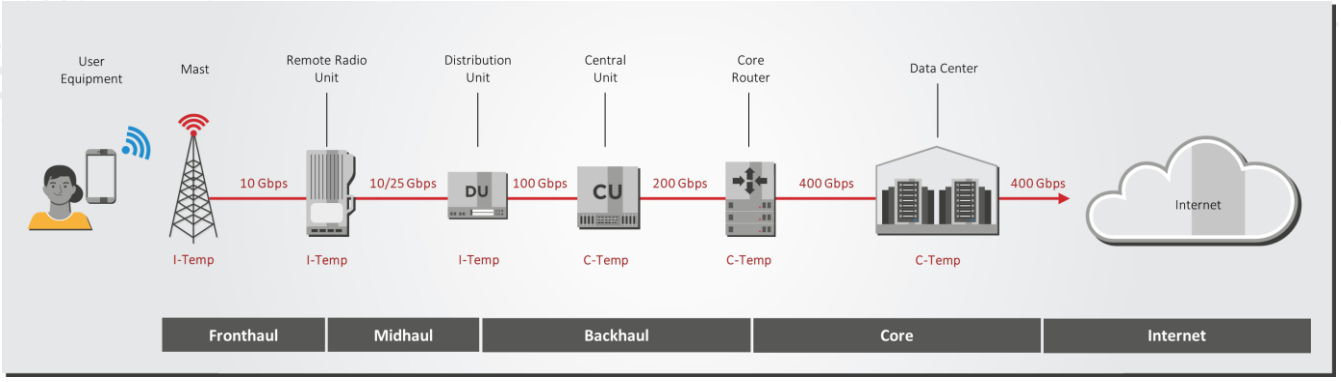

Figure 2: Temperature ratings required across different segments of a 5G network.

On the other hand, access networks feature uncontrolled outdoor environments at Mother Nature's mercy and whims. It could be at the top of an antenna, on mountain ranges, inside traffic tunnels, or in the harsh winters of Northern Europe. Deployments at higher altitudes present additional problems. The air becomes less dense, so networking equipment cooling mechanisms don't work as efficiently, so the device cannot tolerate case temperatures as high as it does at sea level. Transceivers should operate in the industrial temperature (I-temp) range of -40 to 85ºC degrees for these environments. Optics are also available in the extended temperature (e-temp) range, which can operate as hot as I-temp devices (85ºC) but cannot get any colder than -20ºC.

Temperature Standard	Temperature Range (ºC)	
	Min	Max
Commercial (C-temp)	0	70
Extended (E-temp)	-20	85
Industrial (I-temp)	-40	85
Automotive / Full Military	-40	125

Table 1: Comparing the temperature ranges of different temperature hardening standards, including industrial and automotive/full military applications.

The initial investment has a longer-term payoff

An expensive challenge for a network operator is having a product that cannot perform reliably in the uncontrolled environments of 5G deployments. With more bandwidth and computing power moving towards the network edges, coherent transceivers must endure potentially extreme conditions in outside environments. Since i-temp transceivers are more robust, they will survive for longer, and operators will ultimately buy fewer of them compared to c-temp modules. Therefore, the initial, somewhat more expensive investment in I-temp transceivers will pay off in the long run.

In addition, the growth of Internet-of-Things (IoT) applications makes reliability even more important. A network connection drop could be disastrous in many critical and business services, such as medical and self-driving car applications.

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The importance of standards

Making an I-temp transceiver means that every internal component—the integrated circuits, lasers, photodetectors—must also be I-temp compliant. EFFECT Photonics has already developed I-temp pluggable transceivers with direct detection, so we understand what standards must be followed to develop temperature-hardened coherent devices.

For example, our optical transceivers comply with the Telcordia GR-468 qualification, which describes how to test optoelectronic devices for reliability under extreme conditions. Our manufacturing facilities include capabilities for the temperature cycling and reliability testing needed to match Telcordia standards, such as temperature cycling ovens and chambers with humidity control.

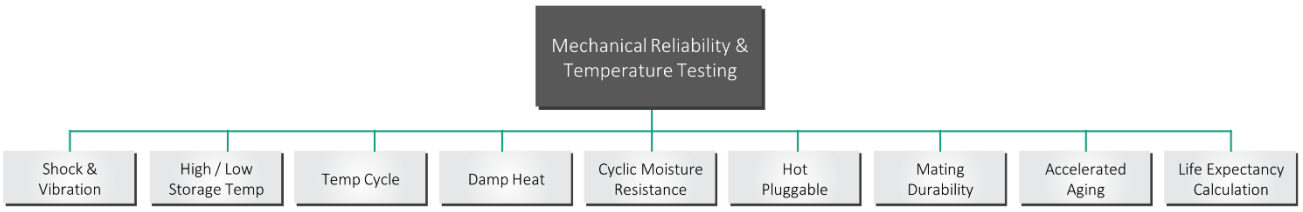

Figure 3: Examples of necessary verification tests for transceivers that will operate in harsh temperatures

EFFECT Photonics transceivers also comply with the SFF-8472 standard that describes the Digital Diagnostics Monitoring (DDM) required for temperature-hardened transceivers to compensate for temperature fluctuations. Our proprietary NarroWave technology even allows network operators to read such device diagnostics remotely, avoiding additional truck rolls to check the devices on the field. These remote diagnostics give operators a full view of the entire network's health from the central office.

Takeaways: going from Direct-Detect to Coherent I-temp

One of our central company objectives is to bring the highest-performing optical technologies, such as coherent detection, all the way to the network edge. However, achieving this goal doesn't just require us to focus on the optical or electronic side but also on meeting the mechanical and temperature reliability standards required to operate coherent devices outdoors. Fortunately, EFFECT Photonics can take advantage of its previous experience and knowledge in I-temp qualification for direct-detect devices as it prepares its new coherent product line.

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