White Paper

FUJITSU

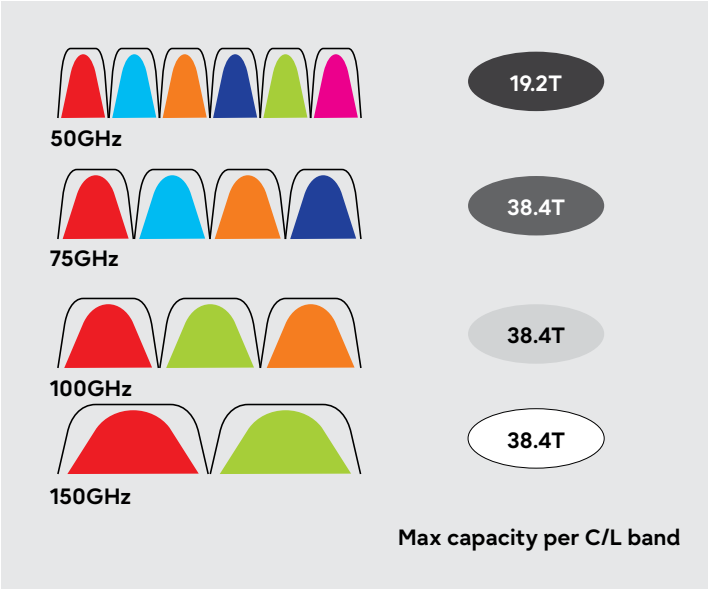
The coherent DSP evolution: Enabling 800G waves everywhere

Next-generation Digital Signal Processors (DSPs) help network operators maximize performance while driving sustainability

DSPs in modern optical networks

The workhorse for the majority of today's optical network applications is 400G 16QAM transmission. The DSPs used in these modules are based on 7nm CMOS technology and operated at baud rates of up to 70 GBaud. They represent a significant increase in flexibility and performance when compared with older ~30Gbaud devices. New shaping and modulation techniques, such as probabilistic constellation shaping and exotic modulation schemes, enabled them to address the needs of DCI, metro, and core networks. This generation offered flexible line rates (100G-600G, supported by multiple modulation types (QPSK-64QAM) and FEC options. Most importantly, these DSPs achieved maximum spectral efficiency (38.4T in C- or L-band) that can be used practically in optical transmission.

In addition to performance enhancements, fundamental improvements to deployment flexibility came with these DSPs. The first generation of coherent DSPs that could interoperate across vendors based on OIF and OpenZR+ standards so operators are no longer tied to a single supplier for optical transport. These devices are available in both traditional embedded optics and pluggable DCO options, so operators can now choose to trade off performance for reduced power consumption and lower cost.



Maximum spectral efficiency at 38.4T in C- or L- bands

Increasing data demands are driving DSP upgrades

The benefits of 5nm DSPs

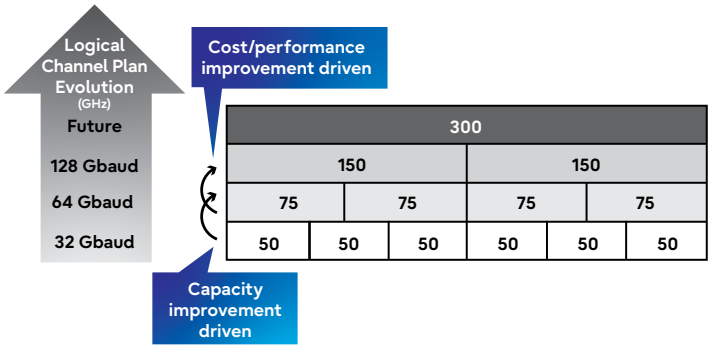
Despite these improvements, the continuous growth of Telco and CIP optical networks are already pressing operators to upgrade their networks to higher data rates as soon as the technology is available.

The next mainstream choice for optical DSPs based on the advanced 5nm-CMOS process (FinFET) are becoming available in transmission systems starting in 2023. The main benefits of 5nm optical DSPs to customers are doubling the line rates up to 1.2T that require 50% fewer coherent optics, lowering CAPEX and significantly lower power consumption per bit, reducing OPEX. The increase in data rate is primarily attributed to DSPs ability to operate at double the baud rate, compared to 7nm DSP, driven by significant CMOS process improvements as shown in the table.

7nm to 5nm process improvements (typical)	
Power	-30%
Performance	+15%
Transistor density	1.7x

Typical 7nm to 5nm process improvements

High performance DSPs of this generation can operate at up to 150GBaud in enhanced mode, by taking advantage of the advanced DSP optics packaging. Doubling the baud rate also simplifies network channel planning because the channel size also doubled from 75GHz to 150GHz. This helps to avoid spectral fragmentation in line systems that have existing traffic.



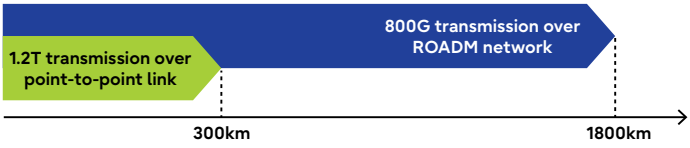
Doubling the baud rate simplifies network channel planning

As modulation rates higher than 64QAM offer diminishing returns, new DSPs maintain the same three main rates, while supporting numerous others for specific network conditions: QPSK for long haul, 16QAM for metro/regional applications, and 64QAM for DCI shorter links.

Reducing noise tolerance with higher baud rates

From an optical performance perspective, an increase in baud rate reduces the noise tolerance that can reduce reach significantly. However, this effect can be mitigated by increasing channel power to maintain power spectral density over wider channels and using a more noise tolerant modulation and improved FEC algorithms. New DSPs are also able to offer higher tolerance capabilities to optical degradations, like chromatic dispersion, PDL, and SOP change.

This DSP evolution, along with innovations in coherent technology, provides a significant increase in reach. For example, while the Fujitsu 1FINITY T900/950 transponder using NEL GAIA 5nm DSP offers 1.2T transmission up to 300km and lowering the rate to 800G enables the reach to address 90% of metro to core links in a typical optical network without requiring an electrical regeneration. This is possible because it can reach further than 1800km using backward Raman amplifier that are complemented with Fujitsu's latest and novel forward Raman amplification technology. Its flexible rates (400 – 1.2T at 50G granularity) allow operators to fine tune the capacity-reach metric on a link-by-link basis.



Flexible line rates allow operators to fine-tune the capacity-reach metric.

Reduce the cost/bit, improve network capacity, and lower power consumption

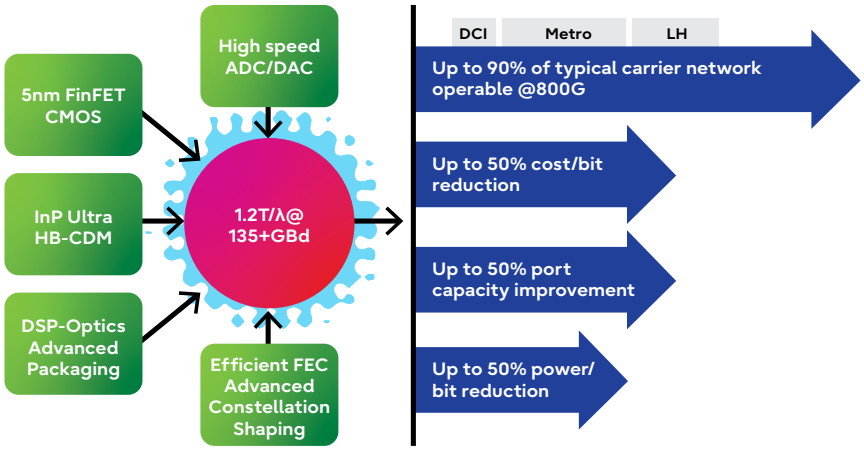
Utilizing Artificial Intelligence and Machine Learning with DSPs

135Gbaud generation DSPs also enable higher degrees of network automation by exposing pre-processed internal data that can be used to deeply analyze DSP and network conditions. This data can be consumed in real-time or offline through AI/ML processing to gain valuable insights, including predicting failures before they occur and optimizing performance for any given application.

Improved sustainability and power savings

5nm DSPs improve sustainability and offer a significant amount of power savings. This can be up to a 50% reduction when compared to the 7nm devices of the previous generation. A substantial portion of these savings comes from CMOS process improvement. However, additional savings can be achieved by functional optimizations in the DSP. For example, the power consumption of FEC algorithms typically increase linearly with the data rate. However, novel FEC techniques implemented in NEL's GAIA DSP maintain the same low power usage for all data rates and contribute to lowering overall DSP power consumption. Next-generation DSPs deliver better rates at lower costs.

In summary, 5nm 135GBaud DSPs with advancements in optics and packaging can deliver huge benefits for network operators. These include operating up to 90% of their links at 800G rates, reducing the cost/bit by 50% and improving network capacity by 50%, all while lowering power consumption by 50%.



5nm 135GBaud DSPs with advanced optics and packaging deliver huge benefits for network operators

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