OVER-CLOCKED OPTICAL TRANSPORT NETWORK

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The increasing demand for 10 Gbit/s Ethernet LAN/WAN services is forcing service providers to consider new approaches for efficiently and cost-effectively transmitting various data types. Optical transport networks (OTNs) are quickly gaining popularity for their ability to transparently provision, transport and manage Ethernet services, among many other data packet services, over the common transport network.

Core IP routers are a prime example of this application where multiple 10 Gbit/s interfaces can be terminated in a particular location and transported long distances across the dense wavelength-division multiplexing (DWDM) core optical network. In addition, the integrated packet optical transport networks (POTs), built upon the ITU-T's optical transport network (OTN) standards, are efficiently provisioning, transporting and managing legacy TDM services and data-packet services over the same infrastructure.

Over-clocked OTN is a technology that enables the transportation of 10 GbE LAN signals transparently over OTN networks as per ITU-T series G supplement 43. Over-clocked OTN compensates for the rate mismatch between 10 GbE LAN and the OPU2 payload by raising the overall OTU2 data rate from the standard 10.709 Gbit/s to fit the 10 GbE LAN client signal. Obviously with this modification of the standard OTN line rate, interoperability issues will arise and the option for aggregating OTU2 signals into OTU3 is lost. On the positive side, over-clocked OTN offers real bit transparency of 10 GbE LAN signals–a necessity for the mass deployment of 10 G services.

Over-clocked OTN supports the following two optical line rates for mapping 10 Gig-E LAN signals (highlighted in the table below, among the other OTN standardized rates):

- OTU2e: 11.0957 Gbits/s ±100 ppm
- OTU1e: 11.0491 Gbits/s ±100 ppm

G.709 Interface	Line Rate	Corresponding SONET/SDH and Ethernet Rate	Line Rate
OTU-1	2.666 Gbit/s	STM-16/OC-48	2.488 Gbit/s
OTU-2	10.709 Gbit/s	STM-64/OC-192	9.953 Gbit/s
OTU-1e	11.0491 Gbit/s without stuffing bits	10 Gig-E LAN	10.3125
OTU-2e	11.0957 Gbit/s without stuffing bits	10 Gig-E LAN	10.3125
OTU-3	43.018 Gbit/s	STM-256/OC-768	39.813 Gbit/s

Table 1. OTN supported rates

The transparent transportation of 10 GigE LAN signals means that the full 10 Gigabit Ethernet data rate (10.3125 Gbit/s) is transported over OTN, including PCS 64B/66B coded information, inter-frame filler (IPG), MAC FCS, preamble, start-of-frame delimiter (SFD) and ordered sets (remote fault indication). The OTN clocking in this scenario is derived from the Ethernet customer signal (±100 ppm) rather than that of a standard OTU2 signal (±20 ppm). Therefore, standard methods for control of jitter and wander—according to G.8251—do not apply in this case, thereby limiting this application to point-to-point data paths.

OTU2e

The OTU2e (not to be confused with the OTU2, 10.709 Gbit/s signal standard) is a mapping mechanism that uses the mapping scheme of CBR 10 G signals into OPU2, defined in G.709 subclause 17.1.2. The 10GBase-R client signal with fixed stuff bytes is accommodated into an OPU-like signal, then further into an ODU-like signal, and then further into an OTU-like signal. These signals are denoted as OPU2e, ODU2e and OTU2e, respectively.

In the case where the original 10GBase-R input client signal has a different clock rate than the transport layer, a positive or negative bit stuffing would be required for adjustment. Typically, when the input client signal has a rate lower than the transport layer, positive stuffing occurs and when the input client signal has a higher rate, negative stuffing occurs. The location of the stuffing bits is communicated to the receiving end of the data link, where these extra bits are removed to return the bit streams to their original bit rates or form. In this case, the OTU2e signal must be clocked at nominal bit rate of 11.0957 Gbit/s.

OTU1e

The OTU1e (not to be confused with OTU1 which is a 2.7 Gbit/s signal) is a mechanism that maps CBR2G5 signals into OPU2, as previously described. However, the fixed stuff bytes of the CBR 10 G mapping are not left free in this mechanism, making the overall data rate somewhat less (11.0491 Gbit/s rather than 11.0957 Gbit/s). Again, the clock tolerance of the underlying Ethernet signal is ±100 ppm, rather than the ±20 ppm of a standard OTU2 signal. Therefore, standard methods for control of jitter and wander, according to G.8251, do not apply again in this case. Figure 1 below shows OTU2e framing with bit stuffing versus OTU1e.

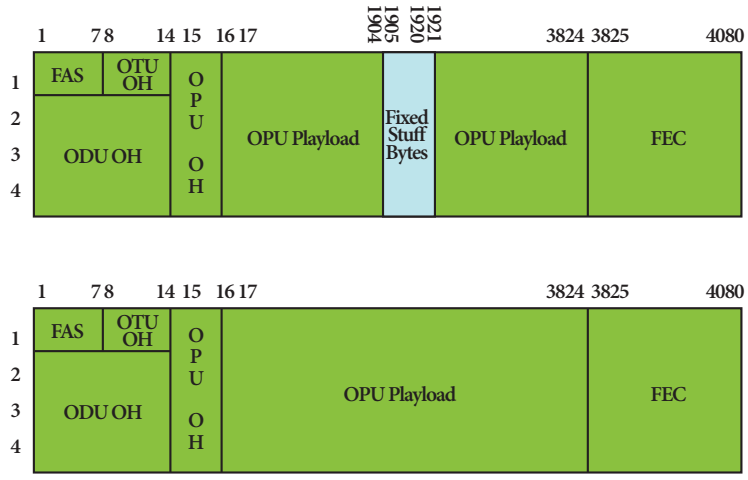

Figure 1. OTU2e versus OTU1e Framing

OTN Testing Beyond 10 Gbit/s

With the evolving responsibilities of telecom field-installation personnel–from testing traditional SONET/SDH networks to packet-aware networks–and with the growing need for integrated multiservice testing solutions to support the deployment, operation and maintenance of these services, EXFO continues to build momentum and market recognition with its Power Pack multiservice testing solution. The Power Pack is composed of an FTB-8120NGE (2.5 Gbit/s) or the FTB-8130NGE (10 Gbit/s) Power Blazer Next-Generation Multiservice Test Modules and is housed in the FTB-200 Compact Platform. It offers testing capabilities for both standard OTN line rates and over-clocked, in addition to testing DSn/PDH, SONET/SDH, Ethernet and Fibre Channel services up to 10 Gbit/s.

EXFO's Power Pack offers a complete set of testing requirements for turning-up wavelength services in reconfigurable optical add/drop multiplexer (ROADM)-based networks and for qualifying them end-to-end. The Power Pack OTN offering specifically includes connectivity testing of newly commissioned OTN lines, using SM and PM trace messages, frequency analysis, bit error-rate (BER) testing for validating error-free transmission, OTN Decoupled mode for testing newly deployed transponders, ODU multiplexing for testing 2.5 Gbit/s services multiplexed over 10 Gbit/s pipes and OTN tandem connection monitoring (TCM) for operators to monitor the performance of their networks at highly granular and global levels. In addition, EXFO complements its OTN offering with over-clocked BER testing with either pseudo-random bit sequence (PRBS) pattern or true 10 Gig-E LAN signal mapping into OTN payloads with complete traffic performance, throughput and statistics. EXFO is also extending its OTN testing capabilities to cover in-service troubleshooting and maintenance requirements of ROADM-based networks. The same FTB-8120NGE/8130NGE module housed in EXFO's newly launched FTB-500 Platform offers OTN overhead manipulation and analysis and OTN Through mode–both intrusive and non-intrusive in-service testing.

Taking advantage of the modular architecture of the FTB-500, EXFO is extending its multiservice testing capabilities with an integrated FTB-8140 40 Gbit/s and FTB-8130 10 Gbit/s solution, supporting DS0/E0 to OC-768/STM-256 testing with STS-1/AU3 granularity. This solution is compatible with a wide range of modulation schemes, including standard NRZ, duo-binary, DPSK and DQPSK. In addition, the integrated solution offers OTU1/OTU2/OTU3/OTU1e/OTU2e, 10M-to-10GigE and 1x/2x/4x/10x Fibre Channel software options, which can be enabled in the field via a software key. Finally, designed primarily for field testing, the FTB-500 platform supports simultaneous testing of 40 Gbit/s and 10 Gbit/s services for faster turn-up, battery operation up to 40 Gbit/s line rate and remote management capability–making it the industry leading integrated 40 Gbit/s field-testing solution.

Conclusion

With the wide deployment of POTs platforms today in the networks and their support of 40 Gbit/s line rates and multiservices–including SONET/SDH, Ethernet, 10 Gig-E LAN/WAN and Fibre Channel–EXFO's widely deployed Power Pack provides the ideal solution for 10 Gbit/s services turn-up in next-generation networks. Finally, combining the FTB-8130NGE and FTB-8140 in EXFO's newly launched FTB-500 Platform extends OTN testing capabilities beyond 10 Gbit/s to cover 40 Gbit/s / 43 Gbit/s networks.

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