Tests on mixed optical fiber accesses (GPON and XGS-PON)

Selective level measurement, ONT simulation and subsequent performance evaluation

As in life, so in telecommunications: some forge ahead while others hang back. Or in other words: some want as much bandwidth as they can get, while others are perfectly happy with the weak WiFi from the neighbour's access.

Europe's telecommunications network has never been so diverse, and thus as complex, as it is today. Most users still access the internet using ADSL or VDSL on copper lines, but optical fiber customers are increasing and demanding ever greater speeds, not least on account of the increasing digitalisation and the growing acceptance of working from home, as well as a new optical interface breakthrough: XGS-PON.

XGS-PON will elevate the entire telecommunications infrastructure to a new speed level, at least wherever optical fiber is installed. The target: 10 gigabit/s. What makes thi technology special is that it can use the same fiber infrastructure that has already been installed for GPON over wide areas. But this also entails new measuring challenges. This is because XGS-PON uses different optical wavelengths from GPON, which not only permits the same fibers to be used, but also the concurrent deployment of GPON and XGS-PON on one and the same optical fiber line. Naturally, the central office and terminal devices (ONTs) must support this, and thus may need to be upgraded.

Can one instrument with a simple integrated OPM handle all this, and what does the measurement tell us?

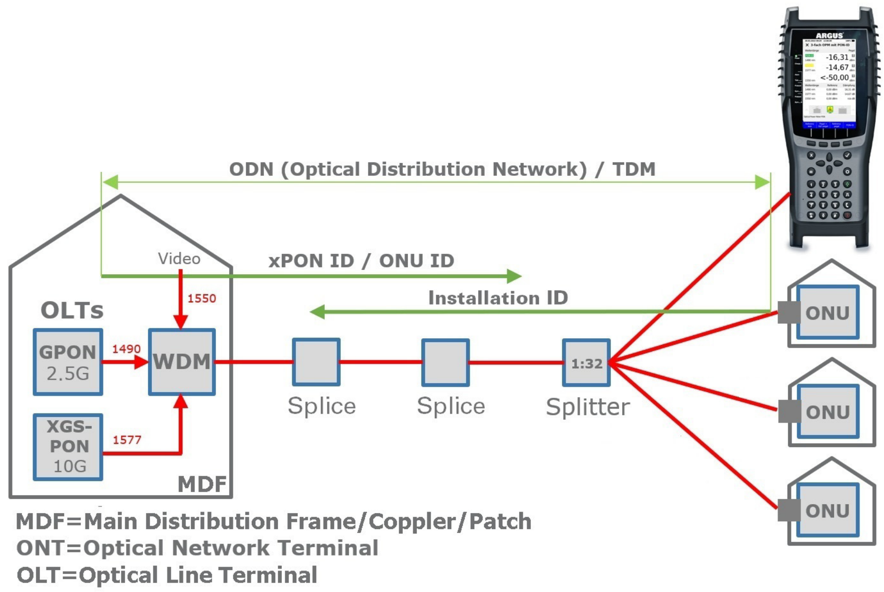

Figure 1:
Structure of a coexisting GPON and XGS-PON network.

Selective level measurement

First, we need to talk a little bit about how PONs are structured. A PON is a point-to-multipoint topology (see Fig. 1) in which optical splitters provide the datastream delivered via the optical fibers to all subscribers – passively, i.e. no power supply along the entire line. All users connected to such a splitter share the existing bandwidth that the central office (OLT) provides.

According to the GPON standard (ITU-T G.984.3), that is a maximum of 2.5 Gbit/s in down- and 1.25 Gbit/s in upstream. The total bandwidth is distributed among the individual users by means of a time division multiplex (TDM) process. In single mode, data are downstreamed at a wavelength of 1490 nm and upstreamed at 1310 nm concurrently on a single fiber.

GESELLSCHAFT FÜR INFORMATIONSTECHNIK mbH

Using XGS-PON (ITU-T G.9807.1), it is possible to simultaneously transmit 10 gigabits/s in both directions using a wavelength division multiplexing (WDM) process, in addition to GPON. This standard specifies the download wavelength as 1577 nm and the upload wavelength as 1270 nm.

It is additionally possible to continuously broadcast a video overlay at 1550 nm and thus provide TV content via the same optical fiber. A convoluted mess?

Another factor that should not be underestimated is that a lot of technicians still need to gain experience with optical networks. They are often unaware that the power that an OLT delivers at one of its ports is extremely high (up to +15 dBm for XGS-PON, +5 dBm for GPON), as the light must overcome kilometre-long line lengths, splitters, splices and connectors, and connecting an ONT or sensitive instruments directly to the OLT will inevitably cause their immediate destruction. Thus, to protect your investment, make sure that your instruments are protected and be sure to warn the users.

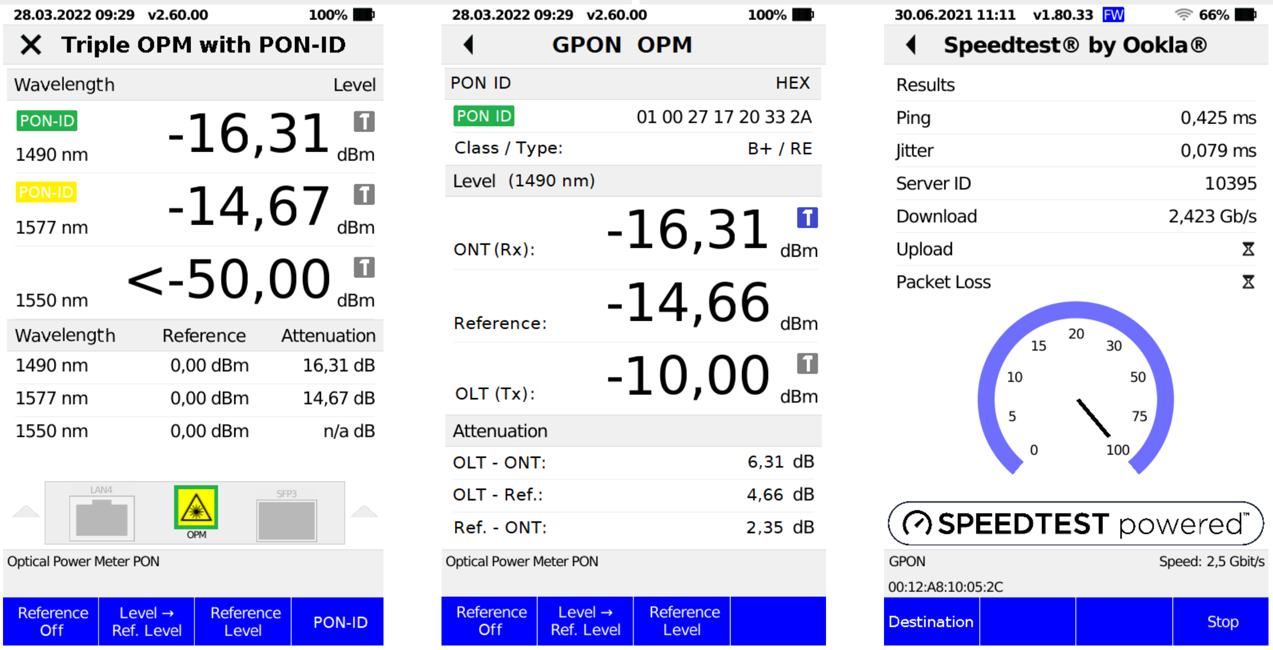

Figure 2: OPM measuring sequence performed on mixed PON accesses: level measurement, xPON-ID, Speedtest® by Ookla®.

Five wavelengths at once on a single fiber - that's more than any normal off-the-shelf power meter can handle. Thus, service technicians need a meter that can selectively measure individual wavelengths on such an access. If the optical modem (ONT) is separated from the PON branch for measuring, the two upstream wavelengths are lost - and while this might simplify the process, it certainly does not make it any easier.

The solution for such measuring tasks is known as a “selective” or “3x” optical power meter (OPM). The OPM must be able to initially filter out the expected downstream wavelengths and their effects in order to reliably measure. To date, very few manufacturers have been able to offer instruments that can perform dependably here. If the instrument is equipped with intelligent software, it can tell the technician what technologies are used on the access – which enormously simplifies and accelerates further testing (see Fig. 2 for examples of this type of measurement). However, it is essential that the selective power meter be able to measure the available power budget extremely precisely and loss-free (±0.25 dB).

Despite filtering, the technician must also be able to identify any other wavelengths that may be present on the line (alien ?) without having to switch plug connectors. That is possible for the optical window from 850 to 1625 nm typical of standard OPMs, which also covers the two upstream wavelengths of 1310 and 1270 nm. This is the only way to ensure that all power budgets are adhered to and no unwanted sources are present.

The right PON branch

Up to 32 ONTs, also called optical network units (ONUs), are connected to the central office side (OLT) via various splitters (see Fig. 1); however, the number is often lower, depending on the bandwidth requirements and local and structural features. Network operators often specify specific power budgets for each individual topology, and these can be verified using a selective OPM. A few select instrument manufacturers provide intelligent wizards that are able to query precisely which individual topology is being used (e.g. according to ZTV43/PON-FMT) and support assessments of the remaining power budget. This makes commissioning entire PON infrastructures child’s play: all details are logged, stored on the device and output in PDF format for further processing. But is that enough?

In order to correctly allocate the data streams for each subscriber, the OLT at the central office end assigns each OLT a PON ID, the xPON ID. This is unique for the PON branch to which the ONTs are connected (see Fig. 1) and constitutes the port ID of the OLT. The OLT then assigns the connected ONTs a fixed ONU ID that serves as an identifier in the further data exchange.

If, in addition to intelligent optics and a wizard that enable targeted measurement of the optical power for different wavelengths, the instrument is equipped with a fully enabled GPON chip, it can then be used to read and display the PON ID for GPON from the PLOAM message via the ONT management and control interface (OMCI), and directly from the frame in the case of the XGS-PON ID for XGS-PON (see Fig. 2, 2nd image). The receiver diodes integrated in the optics must be suited specifically for the rapid data package sequence.

Figure 3: ARGUS® 300 from intec, optical fiber multitester with all necessary measurement and test functions.

Fiber measurement technology at this level of sophistication also makes it possible to read out the transmission power of the OLT and calculate the insertion loss directly without any further action on the part of the technician, including the often contamination-prone replugging of the fiber optic cable. This approach thus delivers three key values: the filtered measurement of the optical power, the insertion loss of the line and the xPON ID. Further parameters read out by the chip, such as the ODN class and the presence of range extenders (optical repeaters), can be additionally evaluated along with a pass/fail assessment.
Determining the PON ID during commissioning is essential so as to ensure that the technician is measuring the correct PON branch. A normal OPM cannot do this, nor can a variety of “selective OPMs”.

If an ONT is connected to a PON branch and e.g. transmits uploads in a timeslot in a that was not allocated to it in GPON, this is regarded as a “rogue ONT”. If this ONT goes online, all other ONTs connected to the OLT via the same PON port are offline, or go on- and offline frequently. If the rogue ONT is not configured, the other ONTs, which are also not configured, are not automatically detected.

But is this enough to ensure that multiple gigabit/s can be delivered interference-free?

The ultimate challenge: protocol, services and performance tests directly on the optical fiber

If everything has been tested and commissioned with no problems, there is, in physical terms, nothing to contradict the conclusion that the access works. In order to completely test a GPON or XGS-PON access completely in the event of a fault or transition it to permanent operation after rollout, it is necessary to establish the protocol, execute the identification process, verify the function of services such as VoIP or IPTV and simulate high-performance speed tests via FTP/HTTP up- and download, iPerf or Ookla® – just as on all other accesses (see Fig. 2, 3rd image). However, this means that the PON tester must be capable of performing a complete ONT simulation. It is a great help here if the ONT simulation can be connected separately from the optics for level measurement. An SFP slot for integrating various “optics” for GPON, XGS-PON or other standards (EPON, XG-PON, NG-PON2) is thus ideal, and decouples level and performance measurements. This also enables direct testing of active FTTH technology, often used by smaller network operators or in company networks as a point-to-point (PtP) active Ethernet variant. When the socket shows signs of wear, simple transceivers can be replaced, extending the service life of the instrument.

Only the complete ONT simulation, offered by just a few manufacturers, permits transmission of the installation ID and the PPP protocol setup, which can also reveal its own problems, such as an incorrect password. This is the prerequisite for testing whether downloads are even possible and whether triple-play services actually work. A select few devices can additionally read out the telephone numbers via TR-069 and thus rapidly make a VoIP test call for verifying the speech quality.

This is the only way to rapidly rule out problems along the entire ONT-OLT configuration. In addition to downstream performance, it also permits measurement and assessment of upstream. A GPON trace additionally detects problems in the authentication process.

Conclusion

Once again, we find that multipurpose meters previously used to test DSL, ISDN and analogue concurrently are also the optimum solution for service technicians who need to measure optical networks. GPON and XGS-PON will clearly dominate the wide-area installation of optical networks in the coming years, along with active Ethernet lines (FTTx, PtP). When a device combines selective OPM, ONT simulation and performance measurement for precisely this range, it is an ideal match for the new challenges. A few select players in the market, including the German metrological instrument specialist with its ARGUS® brand instruments, also offer the possibility of supplementing the aforementioned tests with more in-depth fault-finding and advanced performance testing. For instance, the new top of the line ARGUS® 300 instrument additionally offers OTDR measurement and even true 10-GigE performance tests with evaluations according to RFC2544, Y.1564 and other standards (see Fig. 3). Some devices can also be expanded with the fiber inspection tool, which lets the technician test the fiber ends for soiling or damage each time they are plugged.

Customers with extremely heterogeneous customers can even equip their new, fully fledged PON testers with WiFi and Ethernet measuring technology, ADSL, VDSL, G.fast or other copper measurements to cover all their needs. No other product offers such a complete range of functionality.

	GPON	XGS-PON
ITU standard:	G.984.3	G.9807.1
Wavelength down:	1490 nm	1577 nm
Wavelength up:	1310 nm	1270 nm
Max. data rate:	2.5 Gbit/s/ 1.25 Gbit/s	10 Gbit/s symmetric

Table 1: Differences/comparisons GPON and XGS-PON

Outlook

The digitalisation urgently needed in many areas, such as public administration, energy supply and public transport, will demand many innovative and more efficient communication solutions and, together with the increased broadband demand for working from home, the requirements of new UHD streaming services and 5G, and is sure to generate ongoing change in the telecommunications industry with its optical and copper-based interfaces and networks. Whether XGS-PON, GPON, G.fast and VDSL will be able to meet this demand in the coming years remains to be seen, but 10 gigabit/s is still a lot of data!

Now is the time to invest in future-proof measurement technology to help pave the way for these new technologies.