FTTB technology as a fully-fledged replacement for the passive optical gigabit network (GPON)

Bringing fiber to the building in a cost-effective way

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When Comtech first announced a turnkey solution for FTTB technology (FTTB="Fibre to the Building") as a real alternative to the Gigabit Passive Optical Network (GPON), skepticism among experts was high. However, the Hungarian provider was able to prove based on a number of experiments that a similarly high, if not higher, throughput can be achieved with their solution approach if the optical and RF network parameters are set as described in this article.

But for first, why to choose FTTB from the available possibilities? Future proofness of GPON is undoubted, but present economical unsteadiness is not conductive to such rebuilding investments. The pandemic situation also rises questions in case of indoor installation works at subscribers. In contrast FTTB keeps the most expensive components of existing infrastructure and doesn't need any action in subscribers' homes. The structure is based on the old HFC network. The node is replaced with a multi-diode receiver (MDR), house amplifiers are replaced with FTTB nodes and the coaxial section up to the building is changed to single fiber optical links, warranting the migration to a later, fully passive solution.

Attractive user experience starting from a segment size of 300 HP

Since FTTB is based on analog optics, a limiting factor will be for the realization, that the maximal order of modulation is 4096-QAM in DS and 1024-QAM in US to accommodate to the available SNR value. The DOCSIS 3.1 system defines a DS throughput of 1.89 Gbit/s with 4096-QAM and 25 kHz subcarrier spacing per 192 MHz OFDM channels, furthermore a US throughput of 0.94 Gbit/s per 96 MHz OFDMA channels, the theoretical throughput of the network is 9.45/1.88 Gbit/s in case of a system with only data channels, 1.2 GHz bandwidth and 204/258 MHz diplexer. This capacity provides attractive user experience from a segment size of 300 HP or less at general overbooking rates. Assuming a service area with apartment houses, a node serves 20 households, a segment contains about 16 nodes. Our OHA MDR is optimized for this or smaller segment sizes.

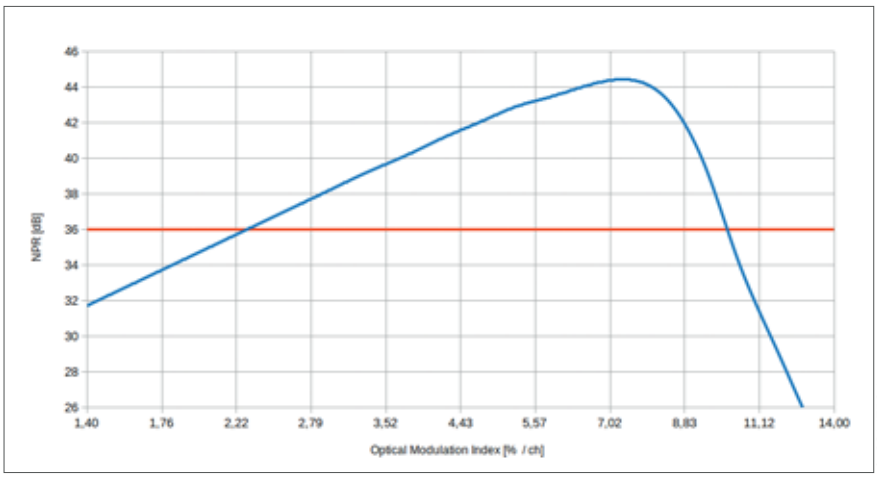
Check mesh element setting precisely

To achieve 42 dB Downstream (DS) and 36 dB Upstream (US) SNR required for the mentioned high order modulations, the settings of each network element must be precisely controlled. We made measurements to find these optimal settings. Our test network was built up with the OHA MDR, which can serve 4 segments, each with 16 single-fiber nodes. The optical connection with the host also needs a single fiber – using 4 DWDM channels for DS and 4 CWDM channels for US communication. These channels were handled by our FOT-E optical transmitter and QROR-H optical receiver.

We focused on the situation, where the host-MDR distance is ~10 km, but the nodes are near to the MDR. One segment was built up with a coaxial section simulated by attenuation and inverse tilt. This was followed by a modem for measuring data speed. The load of the system consisted of mixed DOCSIS 3.0 and 3.1 signals as in real networks.

Determine required input power at the diode

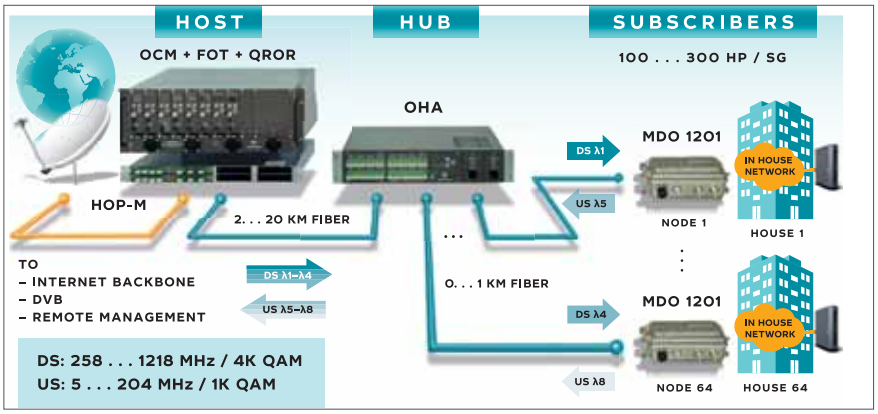
The US communication seems to be more vulnerable and so more critical. At the planning phase the first step is to choose the applied wavelengths. In case of the OHA MDR 4 arbitrary but different wavelength can arrive at a receiver diode. Based on this, using 4 wavelength a network of any size can be created. It is recommended to use a combination,



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US NPR to Optical Modulation Index (standalone MDO1201 node)

for which the FWM products appear outside the used bands. E.g., the set of 1470, 1510, 1590 and 1610 nm fulfills this requirement, so they were used at our experiment both for the MDR's transmitters and for the nodes. Then the minimal required input optical power at the diode of MDR (after the passive combiner for 4 nodes) has to be determined. We found it at -6 dBm/node, this is the lowest value, where the peak of the NPR (thereby the SNR) isn't degraded. With this condition the US NPR after combining 4 optical signals can reach 42 dB on the node-MDR optical section. This value is ensured if the US OMI is set to 7% on this section.



The FTTB solution from Comtech

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Approximately equal optical input powers are a prerequisite

Because of the different MDR-node fiber lengths, it is not easy to ensure perfectly equal incoming optical powers for each node at all the receiver diodes. Nevertheless, a setting must be guaranteed, where none of the incoming optical signals drive the US optical transmitter of the MDR into the nonlinear range. Since the 4 CWDM US channels forwarded via the MDR-host section are demultiplexed in the host, a moderate SNR will be available even if the laser's operating point is shifted to left on the NPR curve. A decrease in OMI up to 5% seems to be reasonable – with this condition if the incoming optical powers of each node differ from the set target by not more than ±1 dB, the resulting SNR of an OFDMA channel on the whole transmission line exceeds the minimal required 36 dB by a safe margin. Checking the data rate of the modem using the above settings, the measured value varies between 914 and 935 Mbit/s, which is close to the theoretical throughput of a single DOCSIS 3.1 US channel.

Network operators disagree on DS OMI

DS parameters have to be set by similar logic, but the differing modulation order and bandwidth will involve other optimal and limit values. We found -2 dBm as a minimal required input DS optical power at each device in the network, which can be ensured by an optical transmitter of +10 dBm installed in the host. If an EDFA with the same output power is mounted into the MDR (as in case of OHA), the optical power at the nodes will be high enough after splitting and a fiber section of a few hundred meters too. There is no consensus on the DS OMI issue at the network operators. We measured the very best NPR peak of higher than 45 dB after a 10 km fiber (first optical section) at 2.5%, but the slope of the characteristic is low enough within the OMI range of 2...3.5% not to lose valuable decibels from the SNR.

Conclusion: Customer data rates of 1 Gbit/s are possible with an FTTB network

By setting an input RF level of 15 dBmV at the modem by the proper alignment of our MDO1201 node, the SNR will reach and exceed 42 dB for the OFDM channels. Data rate is now about 1 Gbit/s, which is a speed limited by the data interface of the modem. The most important conclusion is, that customer data rates of Gbit/s are achievable in both directions using an FTTB network based on the OHA MDR. The test setup realizes the worst case with the highest number of nodes. Smaller segments imply better SNR values, for which the targeted data rate can be achieved even more safely.
Our solution supports scalability too. Segment size can be decreased, while in DS even increasing is possible. Asymmetrical segmentation is possible as well as shown on the figure. The MDR is available in outdoor and indoor housing, with or without built-in optical combiners.
All the further FTTB devices are available in standard form at Comtech. Each active network element is delivered with local electronic alignment interface and with optional remote management module. ■

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