Full channel loading: simulation of cable networks with TV and DOCSIS 3.1

Once upon a time, cable television was a service used to deliver TV programs. Nowadays, however, the same cable can be used to provide telephone and Internet service to homes. The Internet in particular is demanding increasing amounts of bandwidth. More efficient transmission methods are needed since the frequency range cannot be extended without limitations. The new DOCSIS 3.1 standard supports unprecedented data rates in the downstream and upstream, placing new requirements on T&M equipment.

The last mile – meaning the cable run that connects to the user's home – is the most complex part of any network infrastructure. Changes here are complex and expensive, which is why network operators want to postpone them as long as possible. For cable TV, the last mile – which consists of optical fiber and coaxial cables, amplifiers and electrical/optical converters – is the bottleneck that prevents higher data rates.

Maximizing data throughput with existing HFC network infrastructure

This is where the new DOCSIS 3.1 standard comes in. It was created in order to maximize data throughput in the downstream and upstream without requiring any changes to the existing hybrid fiber coaxial (HFC) network infrastructure. To achieve this objective, DOCSIS 3.1 introduces fundamental innovations. The most significant advance involves usage of low density parity check (LDPC) forward error correction (already tried and tested with second-generation TV standards) in combination with robust OFDM modulation. LDPC error protection is so effective that even constellations such as 4096QAM can be used with DOCSIS 3.1 – something that was hardly conceivable in the past. DOCSIS 3.1 uses channel bandwidths of 192 MHz in the downstream and 96 MHz in the upstream; however, scaling is possible if necessary. This, in fact, is the benefit of OFDM modulation: It provides the flexibility to adapt the signal bandwidth to a given network's specific characteristics. However, since OFDM and LDPC together do not yet achieve the desired increase in data throughput, the frequency ranges have also been redefined in DOCSIS 3.1 (Fig. 1). The upper limit will be raised in two stages: first to 1218 MHz and then to 1794 MHz. In this case too, the error protection is expected to compensate for the cable's poor transmission characteristics at higher frequencies. The upstream will be extended to 5 MHz to 204 MHz. As a result of these measures, DOCSIS 3.1 is expected to support

Current and future channel loading

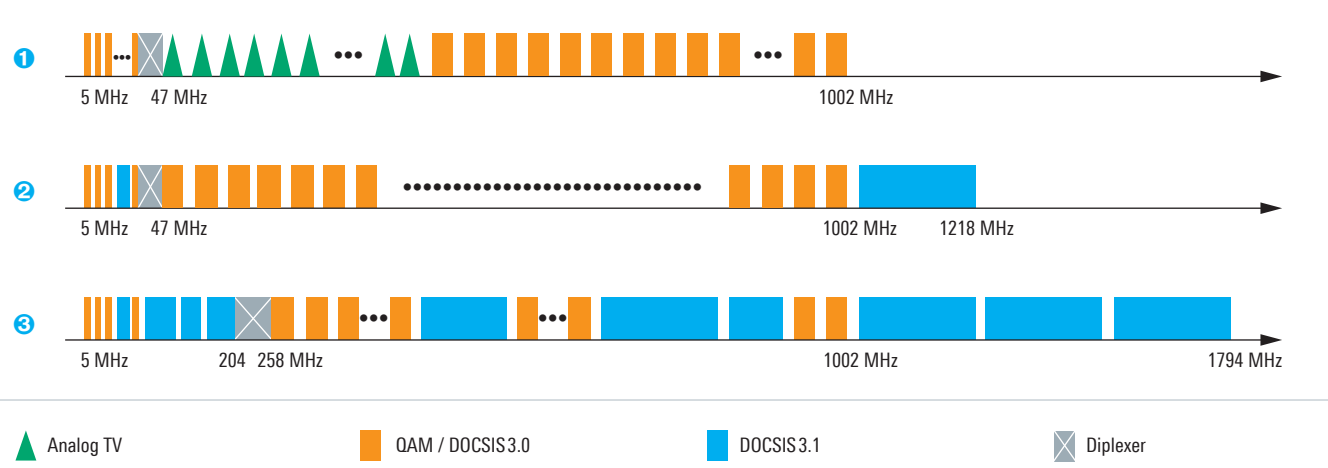


Fig. 1: ❶ Typical loading of cable TV networks with analog and digital channels up to 1002 MHz. ❷ Extension up to 1218 MHz with DOCSIS 3.1. ❸ Final expansion with upstream up to 204 MHz and downstream up to 1794 MHz.

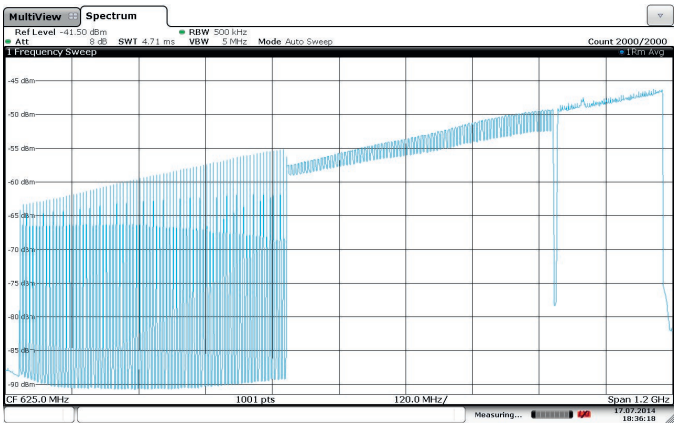
Fig. 2: The R&S®CLGD DOCSIS cable load generator provides DOCSIS 3.1 signals as well as digital and analog TV signals in the downstream along with DOCSIS 3.1 and DOCSIS 3.0 signals in the upstream.

data rates of more than 10 Gbit/s in the downstream and 1 Gbit/s in the upstream. Initial field trials are scheduled for 2014. Commercial deployment of DOCSIS 3.1 is planned starting in 2016.

New tests for cable tuners, modulators and amplifiers

Once the standard has been defined, the industry players need to get to work. A new generation of broadband modulators and tuners for cable modems and cable modem termination systems (CMTS) is required. Even if the network infrastructure is left untouched, it will still be necessary to test the amplifiers and converters with the new signals (Fig. 3). The large number of signals present on the cable is especially critical since distortion can easily occur due to intermodulation. Signal peaks can also occur which lead to laser clipping in electrical/optical converters, resulting in interference and loss of data. During a transition period, DOCSIS 3.1 will have to coexist in the cable with existing digital TV as well as analog TV and FM sound broadcasting to some extent. In the upstream, DOCSIS 3.1 and DOCSIS 3.0 will be used in parallel during the transition period. Here, it is important to determine whether the different systems interfere with one another and if so, how much.

Fig. 3: Test signal for a cable TV amplifier with analog TV, QAM and a 192 MHz DOCSIS 3.1 signal with a total of 15 dB uptilt. The DOCSIS 3.1 signal contains the bulk of the power.



Simulating cable TV networks with full channel loading

For analyzing this type of loading and coexistence scenarios, Rohde & Schwarz has launched a new signal generator: the R&S®CLGD DOCSIS cable load generator (Fig. 2), which has evolved from the R&S®CLG. The R&S®CLGD generates DOCSIS 3.1 signals as well as digital and analog TV signals in the downstream along with DOCSIS 3.1 and DOCSIS 3.0 signals in the upstream, allowing users to simulate any conceivable channel loading scenario. The R&S®CLGD makes such simulations realistic by adding different types of interference such as white noise, impulsive noise, microreflections, narrowband ingress and 50 Hz / 60 Hz AC hum. The new generator is an ideal tool for developing broadband tuners for the new generation of cable modems and CMTS. It is also well-suited to qualifying amplifiers and electrical/optical converters with DOCSIS 3.1 signals.

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