Taking a close look at DOCSIS 3.1 cable networks

The DOCSIS 3.1 extended standard enables cable TV network operators to offer their customers complete multimedia packages with fast Internet, allowing them to compete with telecommunications and mobile phone service providers. The new R&S®DSA realtime DOCSIS analyzer provides comprehensive analysis of the complete transmission path.

DOCSIS 3.1: a quantum leap in performance

The Data Over Cable Service Interface Specification (DOCSIS®) was developed in the mid-1990s for transmission of Internet data over hybrid fiber coaxial (HFC) cable TV networks. Up to version 3.0, single-carrier signals with 6 MHz or 8 MHz bandwidth and modulation up to 256QAM were the norm, but DOCSIS 3.1 [1, 2] changed the game by introducing multicarrier signals with OFDM modulation. They can use bandwidths up to 192 MHz and constellations from 16QAM to 4096QAM. This catapulted the standard into a completely new performance class with downstream rates up to 10 Gbit/s, making it attractive for UHD TV and other data-intensive applications.

Another new feature of DOCSIS 3.1 is that different signal configurations can be assigned to individual areas of the network topology, depending on the quality of the transmission path between the modems and the cable modem termination system (CMTS).

This technological advance requires new T&M equipment for cable network operators and manufacturers of cable network components, because the high data rates in the DOCSIS 3.1 standard can only be achieved if all parts of the transmission path work together with proven high quality.

Fig. 1: The R&S®DSA realtime DOCSIS analyzer enables fast, accurate analysis of DOCSIS 3.0, EuroDOCSIS 3.0 and DOCSIS 3.1 signals.

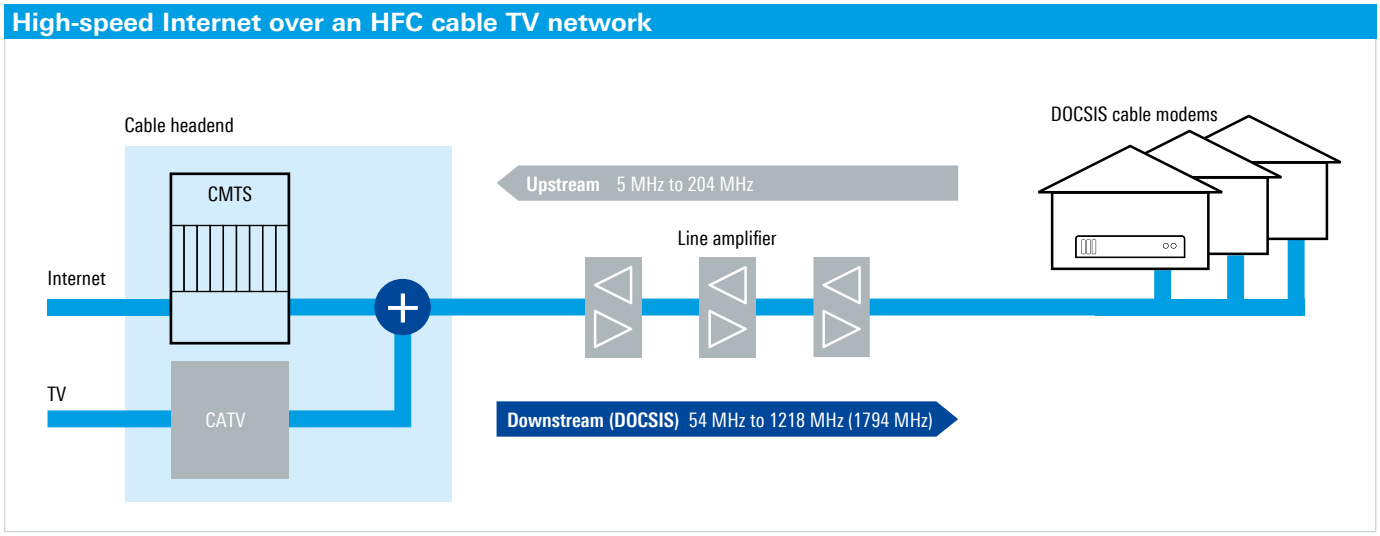


Fig. 2: DOCSIS 3.1 supports bidirectional transmission between the cable headend and the cable modems.

That's where the new R&S®DSA realtime DOCSIS signal analyzer (Fig. 1) comes into play. It is available in two versions – with or without an upstream receiver.

Top-class user interface concept to meet new requirements

A large screen is needed to clearly present the many signal parameters and extensive graphs resulting from DOCSIS 3.1 measurements. The R&S®DSA features a 10.1" touchscreen without mechanical controls. Large icons ensure convenient, ergonomic operation. Measurement results are presented in a clear, well-structured format.

Peak throughput requires top signal quality

The DOCSIS standard specifies bidirectional data transmission between the CMTS and the modems. Downstream signals (toward the modems) and upstream signals (toward the CMTS) are transmitted simultaneously in different frequency bands (Fig. 2). For comprehensive testing of downstream and upstream, the R&S®DSA (version .03) is equipped with two separate RF receivers that can analyze signals with an MER of ≥ 50 dB. Only a few years ago, signals of this quality and analysis of such signals were practically inconceivable. But high signal quality at the CMTS output is essential to provide sufficient margin for unavoidable losses arising from cascaded line amplifiers in the transmission path. With their low inherent noise, both RF receivers can also analyze low-level signals without significant inherent error.

R&S®DSA key features

- 10.1" color TFT LCD touchscreen
- RF frequency range for downstream: 47 MHz to 1794 MHz
- RF frequency range for upstream: 5 MHz to 204 MHz
- Maximum input level: 67 dBmV
- Inherent MER with DOCSIS 3.1 up to 600 MHz: ≥ 50 dB
- Inherent MER with DOCSIS 3.0, J.83: 59 dB
- Weight: 7.5 kg

With realtime signal processing, nothing goes undetected

For maximum data rates in both transmission directions, all components – e.g. power output stages in the CMTS, line amplifiers, optoelectronic converters and cable modems – must be operated within tightly specified ranges. It is crucial to have sufficient signal-to-noise ratios at every point in the network without overdriving the components, while maintaining the smallest possible safety margins.

Safety margins mean additional costs for network operators. Nevertheless, they must be provided because large parts of the cable network are exposed to external interference. This interference includes radiated emissions from terrestrial broadcasters, wireless and mobile services, and household devices with insufficient RFI suppression.

External influences and components operated outside their specifications can lead to interference and degraded performance, which is often only brief and intermittent. Realtime signal processing in the analyzer is needed to reliably detect these types of interference.

DOCSIS 3.1 focuses on proactive network maintenance (PNM), a technique in which chipsets in the modems provide a set of measurement parameters for remote analysis. However, in practice it turns out that the transmitted measurement results have relatively large tolerances and limited in terms of performance.

Unlike many DOCSIS measuring instruments that use these cable modem chipsets, the R&S®DSA circumvents these shortcomings by using fast, high-performance FPGAs for demodulation and signal analysis. It supports the DOCSIS 3.1 standard and optionally the DOCSIS 3.0 standard (R&S®DSA-K1501), the EuroDOCSIS 3.0 standard, and the DVB-C and J.83/A/B/C digital TV standards.

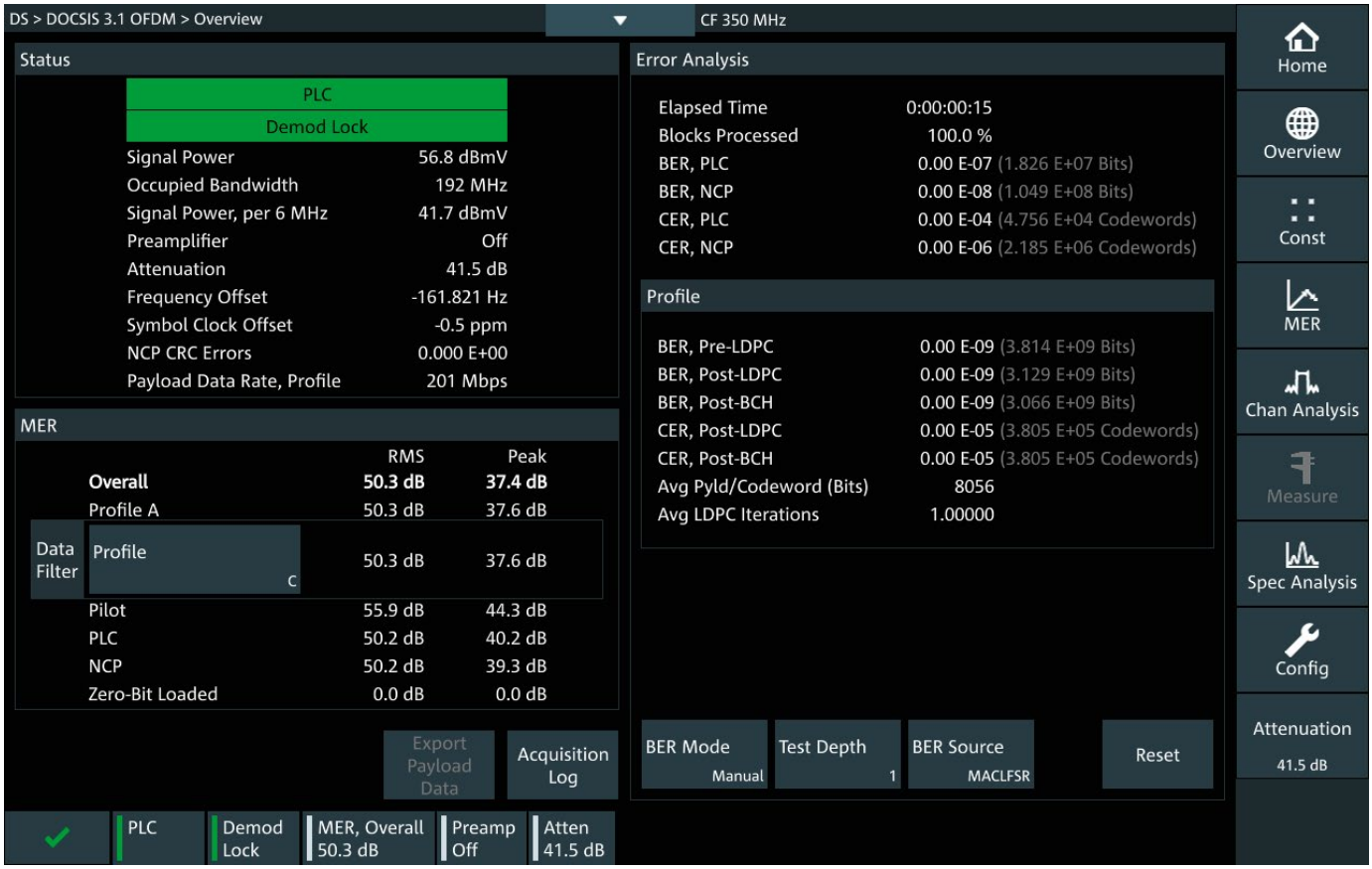
The high processing speed of the R&S®DSA ensures fast signal analysis and high update rates for measured values and traces. These properties are essential for reliable and detailed error analyses at the codeword and bit levels and for detecting brief intermittent errors. Here, the R&S®DSA has an advantage over chipset based instruments, which are limited to the codeword level because no analyses at the bit level are defined in the PNM specification.

Analysis of the physical transmission level

The quality of DOCSIS data transmission depends primarily on the condition of the cable TV network. Typical error sources include faulty connectors, oscillating or overdriven amplifiers and optoelectronic components, inadequate shielding and incorrect signal levels.

To detect such error sources, the R&S®DSA provides a set of measurements for downstream and upstream (R&S®DSA-K1500) that can be selected reliably with a clearly

Fig. 3: Overview window with key parameters of a DOCSIS 3.1 downstream.



structured menu based user interface. They provide conclusive information about the quality of a transmission path and its components.

The overview window (Fig. 3) presents key data on signal status and modulation quality, quantified in MER, and a section with detailed analyses of transmission errors. If any anomalies are visible there, further measurements (echo pattern, amplitude, group delay, phase and constellation) can provide useful clues. For DOCSIS 3.1 signals, the MER versus subcarrier measurement can be used to detect discrete interference signals within a channel (Fig. 4).

The operating modes also include FFT based spectrum analysis. Examination of the entire frequency spectrum is simplified by markers, masks, and frequency and level reference lines that can easily be displayed and modified with touch control.

Also welcome in the lab and in production

The RF characteristics and extensive analysis functions of the R&S®DSA also make it ideal for use in production and lab environments in situations where realtime capability makes the difference. It is already prepared for the optional extensions defined in DOCSIS 3.1. For example, its RF receiver covers downstream frequencies up to 1794 MHz and can already analyze constellations up to 16384QAM. In combination with the R&S®SFD DOCSIS signal generator, additional operating modes are planned for measuring return channel paths and checking the RF characteristics of cable modems.

All in all, the features of the R&S®DSA translate into a quick return on investment.

Werner Dürport

References

[1] DOCSIS 3.1 – the game changer for cable TV and Internet. NEWS (2015) No. 213, pp. 40–45.

[2] DOCSIS 3.1. Rohde & Schwarz Application Note (download search term: 7MH89).

Fig. 4: MER versus subcarrier measurement for detection of discrete interference signals (orange box).