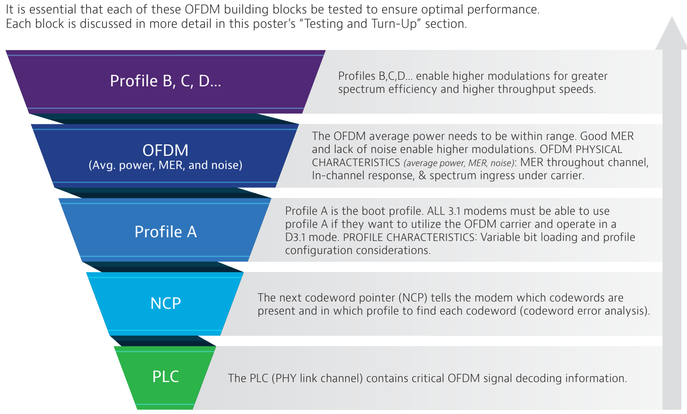
Optimizing DOCSIS 3.1 Performance for Gigabit Services

OFDM AND PROFILES

Testing OFDM Building Blocks and Results Analysis

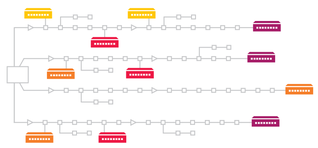
It is essential that each of these OFDM building blocks be tested to ensure optimal performance. Each block is discussed in more detail in this poster's "Testing and Turn-Up" section.



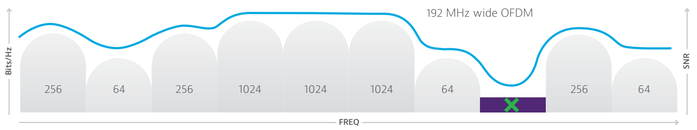
Network Conditions and Multiple Profiles

Not all parts of the network will be able to operate on the highest profile due to varying network conditions. Running multiple profiles and testing can improve plant performance and improve overall customer QoE.

Profile	Example Modulation Mix	Approximate # of Bitz/Hz
Profile A	Mixed 64 QAM & 1024 QAM	6.5
Profile B	Mixed 64, 1024 and 2048 QAM	8.0
Profile C	Mixed 64, 1024, 2048 and 4096 QAM	9.5
Profile D	Mixed 1024, 2048 and 4096 QAM	10.1



EXAMPLE PROFILE: Subcarrier Modulation Varies by Frequency



TESTING AND TURN-UP

DOCSIS 3.1 OFDM Carrier Level Measurements

Measuring with OneExpert™

QAM	DOCSIS 3.1 OFDM carrier	DOCSIS 3.1 OFDM carrier

- Measure and reference OFDM carriers in comparison to power in a 6 MHz bandwidth (the CableLabs® recommendation).
- In a flat system, the average power of an OFDM carrier, referenced to a 6 MHz carrier, should read the same power level as the adjacent 6 MHz QAM 256 carriers.
- The total OFDM carrier power is greatly different than average power in a 6 MHz bandwidth.
- Do not use the total OFDM power to adjust CMTS output power: this would be like using the total integrated power of 32 DOCSIS QAM carriers to set the level.

EXAMPLE:

Single 6 MHz channel power = 5 dBmV

- Total power (96 MHz channel) = 5 dBmV + $10\log_{10}(16)$ = 5 + 12.04 = 17.04 dBmV
- Some spectrum analyzers show the total power, instead of the average power in a 6 MHz bandwidth.

With 8 MHz SC-QAM (Europe): set the OFDM level (ref. 6 MHz) 1.2 dB below the 8 MHz SC-QAM 256 to maintain the same power/Hz.

Total power = total power per channel (6 MHz) + $10\log_{10}$ x (channel bandwidth)

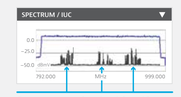
Where channel bandwidth is overall OFDM bandwidth/6 MHz, channel bandwidth = # of 6 MHz channels:

- For a 96 MHz wide OFDM carrier, the total power will be 12.04 dB higher.
- For a 192 MHz wide OFDM carrier, the total power will be 15.05 dB higher.

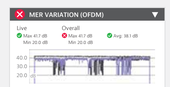
DOCSIS 3.1 Signal Testing & Troubleshooting

Signal Testing

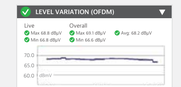
Measuring MER across the entire subcarrier list enables identifying potential impairments with impact on higher-level profiles.



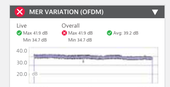
Spectrum and noise identify portions of a carrier where degradation may occur and require possible profile adjustment.



Unstable MER with drops below 30 means only lower profiles running 256 QAM or lower will work.

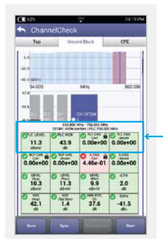


Level variation within the OFDM channel band provides insight into frequency-response related issues.



Stable MER better than 40 dB means QAM 2048 and 4096 will work.

Testing PLC — PHY Link Channel



PLC — PLC contains critical OFDM PLC signal decoding information.

THINGS TO CHECK
Level: >–15 dBmV (6 MHz)
MER: >15 dB (min)
Lock status: locked
Uncorrectable CWE: none
Other info: PLC center frequency

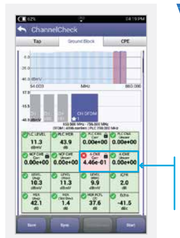
Testing Next Codeword Pointer (NCP)

NCP — The NCP tells the modem which codewords are present and in which profile to find each codeword (codeword error analysis); it is critical for proper data communication.

Don't disregard OFDM performance at the high end or low end. Roll off of either could impair a modem's ability to correctly receive NCP or codewords.

THINGS TO CHECK
Lock status: locked
Uncorrectable CWE: none

Testing Profile A



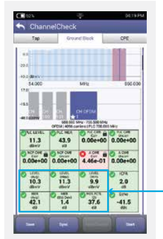
Profile A — Profile A is the boot profile; all 3.1 modems must be able to use profile A.

- Profile A is key to D3.1 modem communication via an OFDM carrier. This is where command and control, range, and registration occurs.
- In practice, profile A may be assigned lower mixed modulations, like QAM 64/16, so every D3.1 modem can communicate. Lower modulation profiles can operate at lower MER/CNR and power levels.

THINGS TO CHECK
Lock status: locked
Uncorrectable CWE: none

- If profile A isn't locked or has uncorrectable CWE, a modem may roll back and use only SC QAMs in 3.0 mode.

Physical Measurements (level, MER, noise)



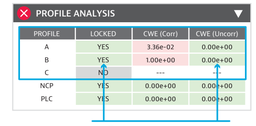
OFDM (Avg. power, MER, and noise) — OFDM average power must be within range. Good MER and low noise enable higher modulations.

MER 2 percentile shows how well 98% of the subcarriers are working and filters out underperforming ones that low density parity check (LDPC) error correction will likely clear up.

THINGS TO CHECK
Avg level, variable: >–6 dBmV recommended
Avg MER, variable: >36 dB recommended
MER at 2 percentile: >35 dB recommended
Level standard deviation: <2 dB recommended

CM Minimum CNR Performance in AWGN		
Channel Constellation	**Up to 1 GHz CNR (dB)**	**Min P_{64VC} dBmV**
4096	41.0	–6
2048	37.0	–9
1024	34.0	–12
512	30.5	–12
256	27.0	–15
128	24.0	–15
64	21.0	–15
16	15.0	–15

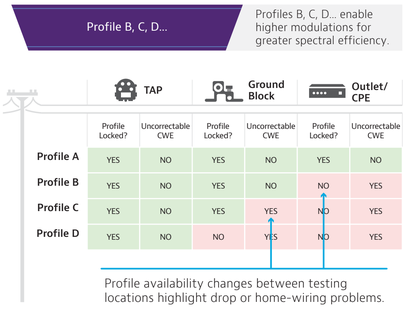
Testing Higher Profiles



PROFILE	LOCKED	CWE (Corr)	CWE (Uncorr)
A	YES	3.36e-02	0.00e+00
B	YES	1.00e+00	0.00e+00
C	NO	---	
NCP	YES	0.00e+00	0.00e+00
PLC	YES	0.00e+00	0.00e+00

THINGS TO CHECK
Lock status: locked
Uncorrectable CWE: none

Higher profiles improve network efficiency. Optimally, more modems run on higher profiles for overall network efficiency and improved customer QoE.

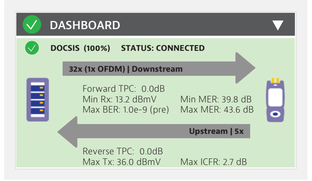


Codeword Errors

Component	Importance	Codeword Error Expectations/Impact
Profile B, C, D...	High	Uncorrectable CWE will affect throughput and overall QoE.
Profile A	Critical	Uncorrectable CWE causes poor QoE & make OFDM carriers unusable, forcing modems to use standard QAM carriers instead of OFDM.
NCP	Critical	Should have 0 uncorrectable CWE, otherwise OFDM may not work.
PLC	Critical	Should have 0 uncorrectable CWE, otherwise OFDM may not work.

OPTIMIZING SERVICE

Service Level Testing



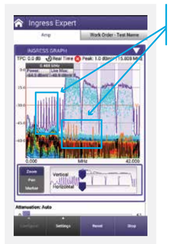
Since a D3.1 modem is backwards compatible, it can utilize just the 3.0 QAM carriers. Ensuring that the service is bonding with OFDM carriers or is using OFDM carriers validates that the high-tier data traffic is working on the more efficient OFDM carriers and is not impacting other customers.

Upstream Analysis

A clear picture of upstream RF performance is provided with in-channel response for DOCSIS signals

Upstream equalizer analysis enables identifying/correlating upstream impairments, and distance to faults

Troubleshooting Intermittent & Consistent Noise/Interference

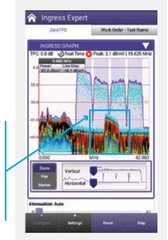


HyperSpectrum easily catches quick transient impulses, even within active upstream carriers

- The various traces make these impairments visible
- The Noise trace shows reoccurring impulse ingress under active carriers

Consistent ingress/noise sources have traditionally been easier to troubleshoot, however as vacant upstream spectrum becomes scarce finding and fixing noise under active QAM carriers is more important than ever

- Ingress Expert mode's persistence measurement catches and displays noise even under active upstream carriers

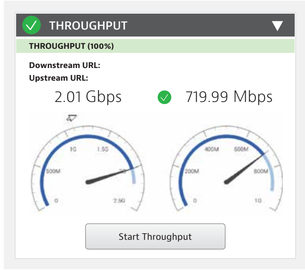


Throughput and Bandwidth Download Speeds

DOCSIS 3.1 systems can provide 1 Gbps throughput or greater.

Validating that the network and service can operate at subscribed rates is important to verify customer experience. Testing at the DOCSIS physical layer identifies RF impacts on overall service performance. Being able to test both DOCSIS service and Ethernet helps ensure top customer QoE.

Many consumer-grade PCs have hardware limitations that prevent them from testing up to 1 Gbps. Having a device that can test both the DOCSIS layer and Ethernet layer to 1 Gbps helps distinguish between service problems and equipment problems.



DOCSIS 3.1 testing, but much more...

Consider the breadth of test capability offered in optional software and components:

Fiber optic power meter and fiber scope	WiFi Testing	SIP VoIP	IP Video	StrataSync
USB optical power meter (OPM) to test fiber cable attenuation; optical fiber scope to test fiber connectors	BSSID, Spectral, and Channel View testing	Quickly place VoIP calls and verify QoS via mean opinion score (MOS) values	Test multiple standard and high-definition television streams regardless of compression format	Hosted solution manages assets, configurations, and test data

To learn more, visit www.viavisolutions.com/DOCSIS