Optimizing DOCSIS 3.1 Performance for Gigabit Services

VIAVI Solutions

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.

Profile B, C, D... — Profiles B,C,D... enable higher modulations for greater spectrum efficiency and higher throughput speeds.

OFDM (Avg. power, MER, and noise) — The OFDM average power needs to be within range. Good MER and lack of noise enable higher modulations

Profile A — Profile A is the boot profile. ALL 3.1 modems must be able to use profile A if they want to utilize the OFDM carrier and operate in a D3.1 mode.

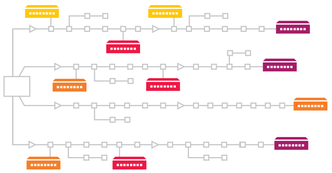
NCP — The next codeword pointer (NCP) tells the modem which codewords are present and in which profile to find each codeword (codeword error analysis).

PLC — The PLC (PHY link channel) contains critical OFDM signal decoding information.

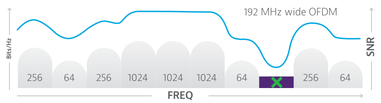
Network Conditions and Multiple Profiles

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

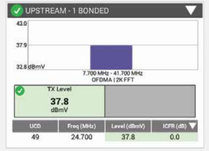
Select the OFDM carrier in the scan

Look at OFDM carrier average level

Level approximates 6 MHz SC QAM power, for example, all at 10 dBmV

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.

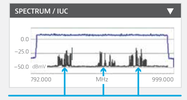


The upstream OFDMA signal level average power measurement is referenced to a 1.6 MHz channel band, so the measurement is comprised of 1.6 MHz sections of the OFDMA carrier. For example, the measurement of this 34 MHz wide carrier is made up of an average of the 1.6 MHz sections across the channel band

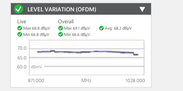
DOCSIS 3.1 Signal Testing & Troubleshooting

Signal Testing

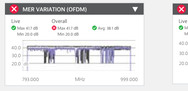
Measuring MER across the entire subcarrier list enables identifying potential impairments with impact on higher-level profiles.



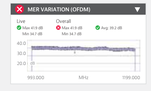
Spectrum and noise identify portions of a carrier where degradation may occur and require possible profile adjustment.



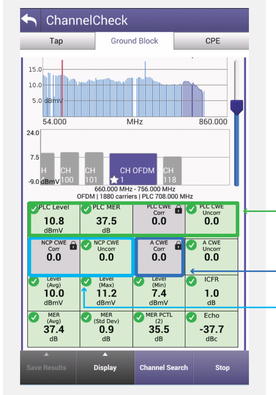
Level variation within the OFDM channel band provides insight into frequency-response related issues.



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



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.

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, many operators are migrating to running 256 QAM or 1024 QAM on profile A. It is expected and common that there will be Correctable Codeword Errors. This is OKAY since LDPC is so effective.

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.

THINGS TO CHECK

Avg level, variable: >–6dBmV recommended

ICFR (In Channel Frequency Response): < 2dB peak to peak

Avg MER, variable: >36dB recommended (all should run on profile A&B)

MER Std Deviation: < 2dB recommended

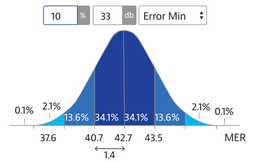
MER at 2 percentile: >35dB recommended to ensure 1024 in all conditions or 33 MER at 10th percentile as a predictor of network health

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.

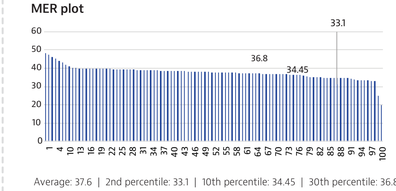
MER percentile is a better predictor of OFDM health than Average MER or CCWE's

- Recommended practice is setting the MER for the 10th percentile for the minimum profile you want everyone to run on. For more conservative approach adjust to lower percentile (eg. 5th or 2nd)
- Example: Set MER threshold to 33 at the 10th Percentile to provide health metric that 1024 QAM will work without Uncorrectable Codeword Errors (UCWE's)

Minimum OFDM MER Percentile



MER plot



Average: 37.6 | 2nd percentile: 33.1 | 10th percentile: 34.45 | 30th percentile: 36.8

NOTE: *90% of the carriers have MER better than 34.45 dB. This means that running 1024 QAM will be successful*

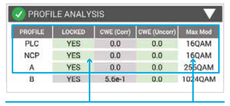
CM Minimum CNR Performance in AWGN

Channel Constellation	Up to 1 GHz CNR (dB)	Min P_{RXMER} 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 B, C, D...

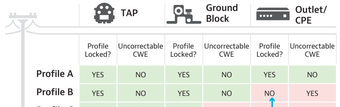
Profiles B, C, D... enable higher modulations for greater spectral efficiency.



THINGS TO CHECK

Lock status: locked ***Uncorrectable CWE:*** varies

Higher profiles improve network efficiency. Optimally, more modems run on higher profiles for overall network efficiency and improved customer QoE. Unlike SC-QAM's, you shouldn't use Correctable Codeword Errors as a predictor of performance. It is expected that all profiles will have CCWE's and often run at 100% CCWE's.



Profile availability changes between testing locations highlight drop or home-wiring problems.

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.

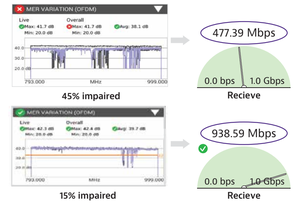
Validate Higher Profile Performance

Profile management can optimize plant and users for maximum efficiency. Balance profile promotion to higher modulations with UCWE's which cause retransmissions

Profile	Locked	CWE Correctable	CWE Uncorrectable
A	YES	0.0e+00	0.0e+00
B	YES	2.0e-01	0.0e+00
C	YES	01.6e-09	1.7e-05
D	NO	N/A	N/A

LDPC and Codeword Errors

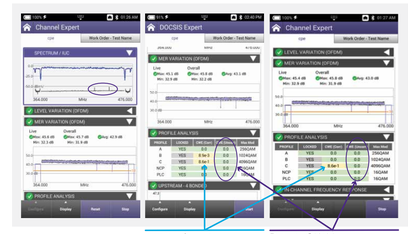
LDPC with Frequency Interleaving provides strong error correction. LDPC will correct many errors and still provide data even when impaired.



Avg MER is okay but data flow is being impacted when too many carriers are impacted. Using MER Percentile at 10% would provide adequate margin and warning. Using SpeedCheck validates overall functionality is okay

EXAMPLES:

- Noise causes slight MER deviations, may cause CCWE's but does NOT impact UCWE's

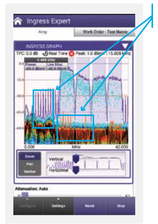


1 or 2 subcarriers impacted & causing CCWE's

Data is OKAY
No Uncorrectables!

OPTIMIZING SERVICE

Troubleshooting Intermittent & Consistent Noise/Interference

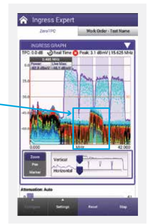


HyperSpectrum easily catches quick transient impulses, even within active upstream carriers

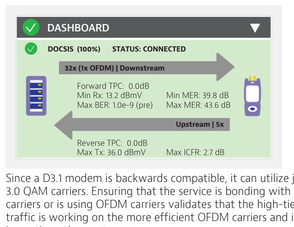
- The various traces make these impairments visible
- The Noise trace shows reoccurring impulse ingress under active carriers

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



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

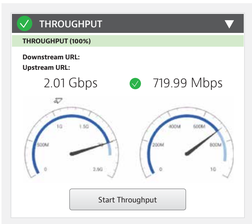
Upstream equalizer analysis enables identifying/correlating upstream impairments, and distance to faults

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 viavisolutions.com/DOCSIS