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VIAVI Solutions 5G

# *Enabling Australia's Field Technicians to build, troubleshoot and maintain better communications networks.*

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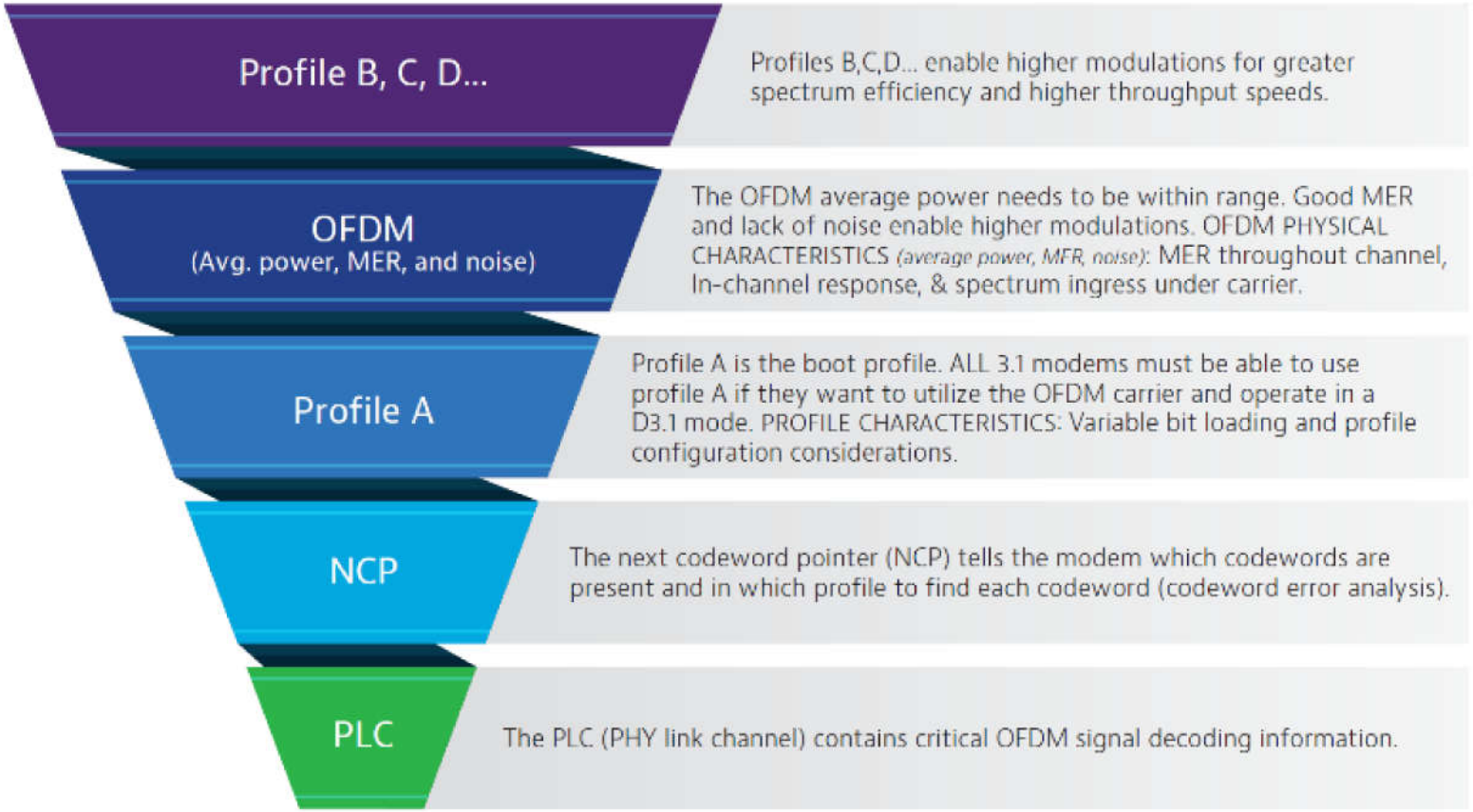
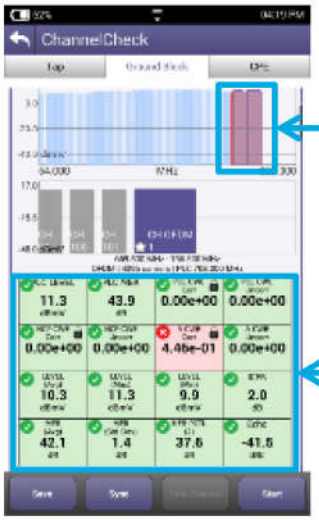
## FREECALL 1800 680 680

# ONX DOCSIS 3.1 Measurements

# Testing OFDM

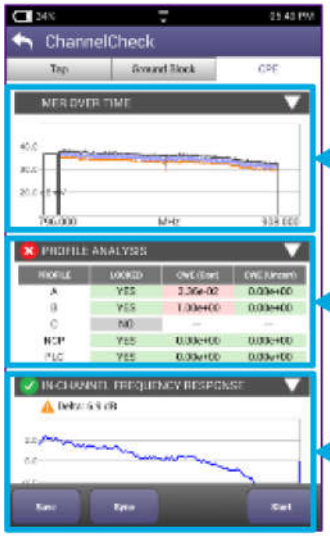


# OneExpert CATV DOCSIS 3.1 measurements




Identify OFDM carrier in the lineup: Downstream scan measurement requires no learning curve, same as D3.0 scan, but shows OFDM signal

Overall OFDM carrier performance metrics including best and worst case; simple pass/fail indications




MER over entire OFDM channel provides insight into why higher tier profiles are failing

Analysis of different profiles available and which profiles can be supported at test location

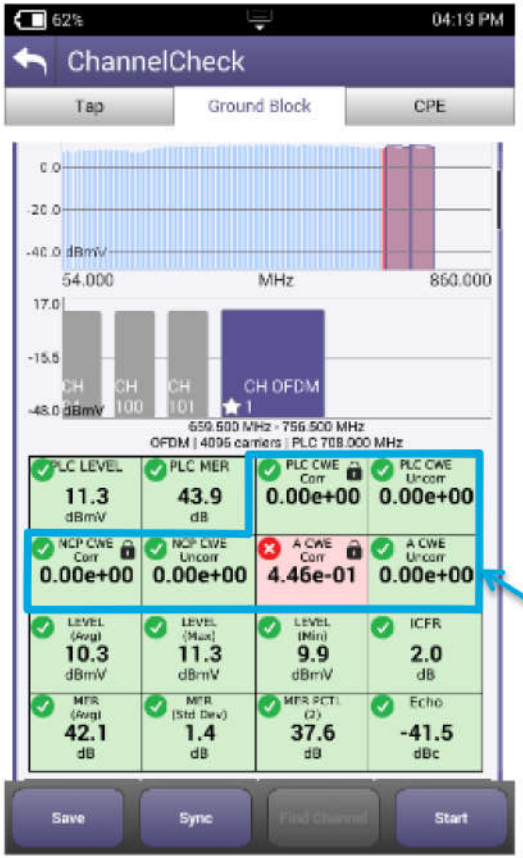
In-Channel Response identifies roll-off and excessive ripple

Spectrum and noise identify portions of carrier where degradation may occur

## OneExpert CATV with DOCSIS 3.1

- OFDM demodulation with D3.1 Profile Analysis
- **Full DOCSIS service testing including 32 Bonded + D3.1 OFDM carrier**
- Upstream **DOCSIS 3.1 OFDM-A capable**

# DOCSIS 3.1 Codeword Errors (CWE)

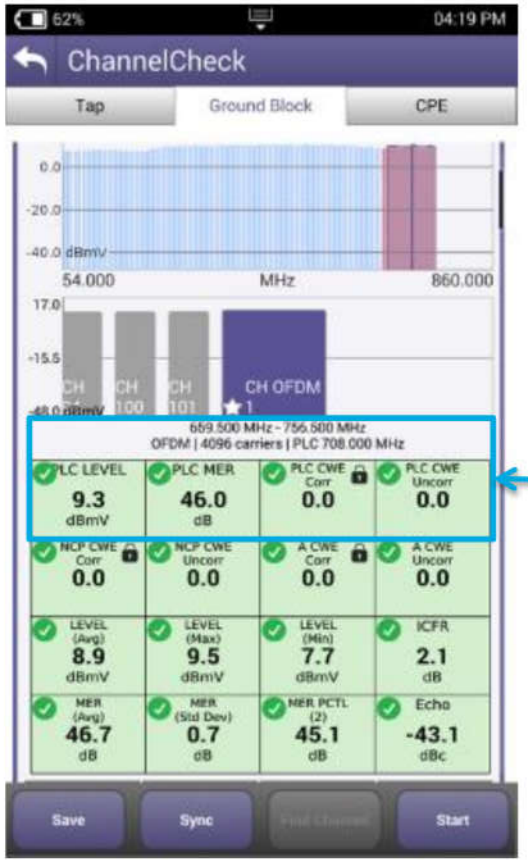



- **Codeword (CW):** a data bucket within a DOCSIS packet
- **CW Error (CWE)**: a byte-level data packet corruption resulting from QAM symbol displacement across constellation decision boundaries
- Correctable vs. Uncorrectable determined by number of corrupted symbols relative to CMTS forward error correction level settings
- If you are having CWEs, you may be losing data
- **Uncorrectable CWEs** indicate dropped packets (think post-FEC BER)
- Retransmit is required for recovery
- There is no recovery from dropped packets for real-time apps like VoIP!
- **Correctable CWEs** are an early warning that the uncorrectable threshold may be near! (think pre-FEC BER)

**THINGS TO CHECK:**

To make sure there are **no uncorrectable CWE**

# Testing PLC – PHY Link Channel



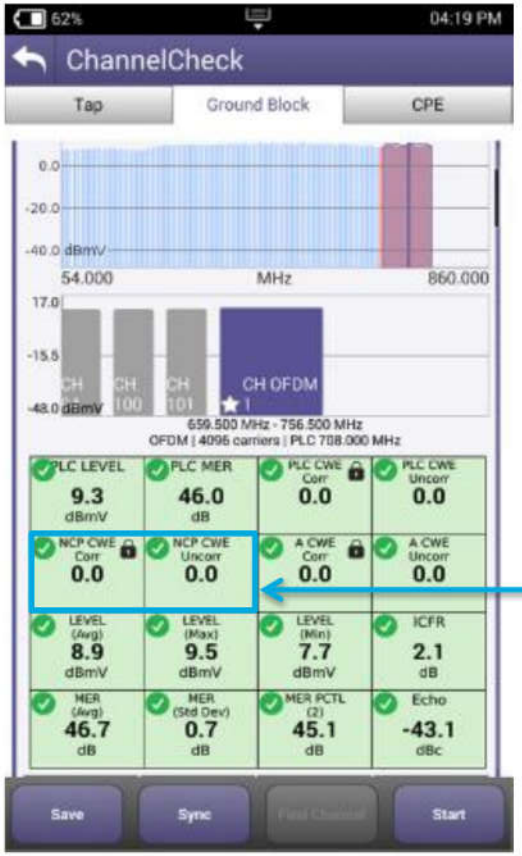

PLC

**PLC** contains CRITICAL OFDM 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)



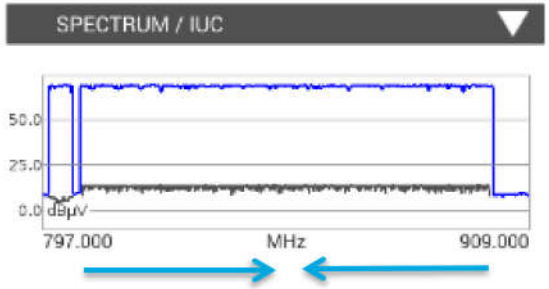

NCP

The **NCP** tells the modem which CW are present and in which profile to find each CW (CWE analysis), it is CRITICAL for proper data communication

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

**THINGS TO CHECK:**

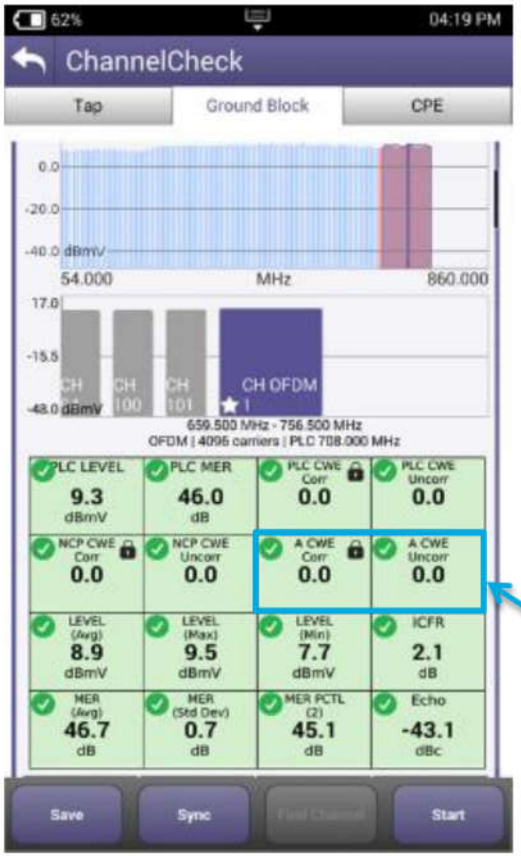
***Lock status:*** locked
***Uncorrectable CWE:*** none




Codewords start at LOW frequencies and populate UP

NCP's start at HIGH frequencies and populate down

# Testing Profile A




Profile A

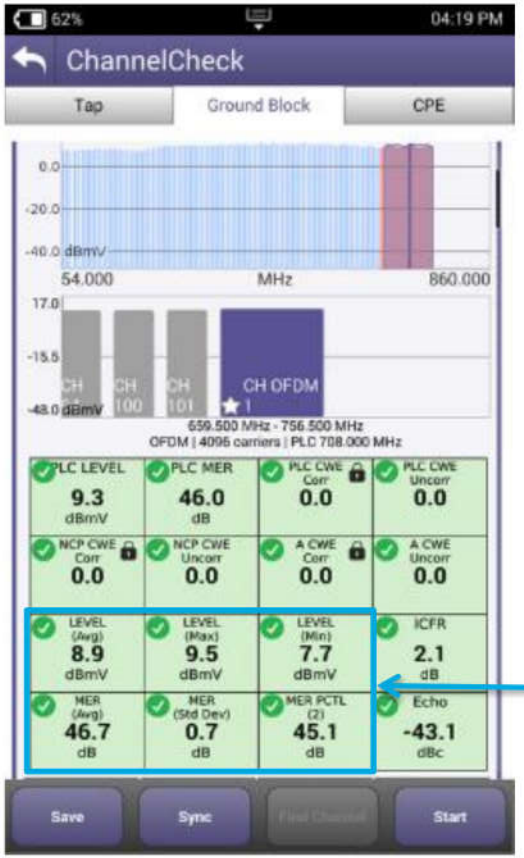
**Profile A** is boot profile; ALL 3.1 modems must be able to use profile A

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

**THINGS TO CHECK:**

***Lock status:*** locked
***Uncorrectable CWE:*** none

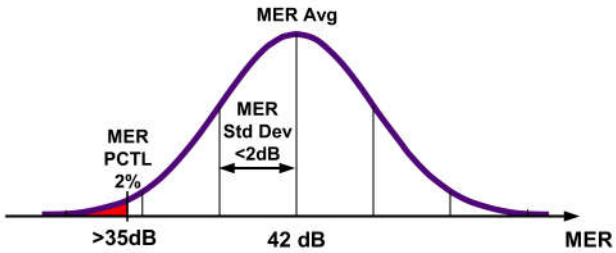
# Physical Measurements (Level, MER)




**OFDM**
(Avg. power, MER, and noise)

**OFDM** Avg 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 LDPC error correction will likely clear up.

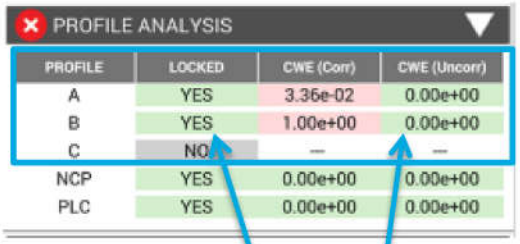



**THINGS TO CHECK:**

***Avg level, variable:*** >-6 dBmV recommended
***Avg MER, variable:*** >36 dB recommended
***MER at 2 percentile:*** >35 dB recommended
***MER standard deviation:*** <2 dB recommended

| CM Minimum CNR/MER Performance in AWGN | | |
|---|---|---|
| Channel Modulation | Up to 1 GHz CNR(dB) | Min $P_{6AVG}$ 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




**THINGS TO CHECK:**

***Lock status:*** locked

***Uncorrectable CWE:*** none

Profile B, C, D…

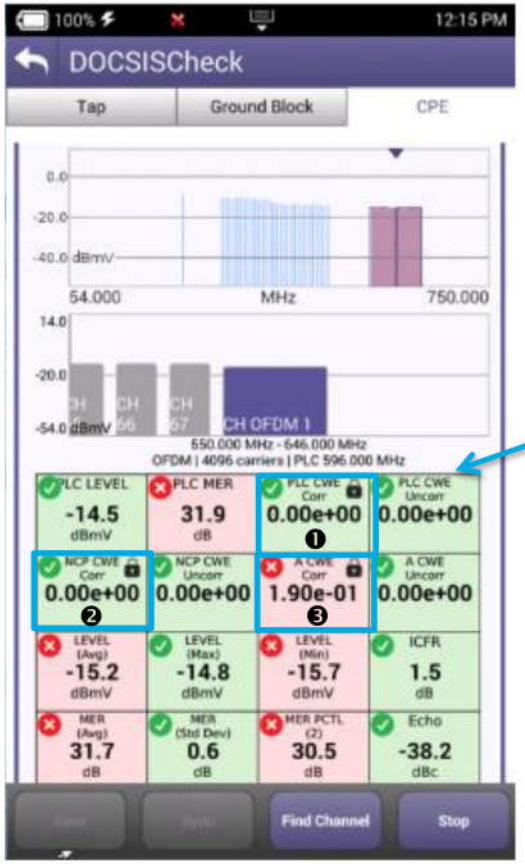
**Profiles B,C,D**… enable higher modulations for greater efficiency

- Higher profiles improve network efficiency. Optimally, more CM run on higher profiles for overall network efficiency and improved customer QoE.
- Profiles enable tiers of service, and allow best case service when consistent network constraints inhibit maximum performance
- Testing viability of all profiles provides quick assessment of network performance to any given test point (service outlet)
- Tech must be able to troubleshoot failing profiles and identify degradations
- Profile changes highlight drop or home wiring problems:

| | TAP | | Ground Block | | Outlet/CPE | |
|---|---|---|---|---|---|---|
| | Profile Locked? | Uncorrectable CWE | Profile Locked? | Uncorrectable CWE | Profile Locked | Uncorrectable CWE |
| Profile A | YES | NO | YES | NO | YES | NO |
| Profile B | YES | NO | YES | NO | NO | YES |
| Profile C | YES | NO | YES | YES | NO | YES |
| Profile D | YES | NO | NO | YES | NO | YES |

# OFDM is DYNAMIC with varying subcarriers and LDPC MER and Level alone don't tell the whole story

- Profiles and CWE analysis are important




| Component | Tasks | Importance | CWE expectations and impact |
|---|---|---|---|
| PLC PHY Link Channel | Contains CRITICAL OFDM signal decoding information | Critical | Should have 0 Uncorrectable-CWE otherwise OFDM may not work |
| NCP Next CW Pointer | Tells modem which CW are present and in which profile to find each CW | Critical | Should have 0 U-CWE otherwise OFDM may not work |
| Profile A | Boot profile. ALL 3.1 modems must be able to use profile A | Critical | U-CWE will cause poor QOE and possibly make OFDM carrier unusable, forcing data to standard QAM carriers instead of OFDM |
| Profile B,C,D | Enable higher modulations for greater efficiency | High | U-CWE will affect bandwidth and overall QOE |

## THINGS TO CHECK:

❶ PLC is working well

❷ NCP is working well

❸ Profile A is working well with some correctible (in this case running 256 QAM)

❹ Profile B (running 1024 QAM in this case) is on the edge: 100% correctable CWE but LDPC is correcting them all!

❺ This makes sense, 1024 QAM level should be ≥12dBmV and MER > 34 dB

PROFILE ANALYSIS

| PROFILE | LOCKED | CWE (Corr) | CWE (Uncorr) |
|---|---|---|---|
| A | YES | 9.20e-01 | 0.00e+00 |
| B | YES | ❹ 1.00e+00 | 0.00e+00 |
| NCP | YES | 0.00e+00 | 0.00e+00 |
| PLC | YES | 0.00e+00 | 0.00e+00 |

| CM Minimum CNR/MER Performance in AWGN | | |
|---|---|---|
| QAM Modulation | Up to 1 GHz CNR(dB) | Min $P_{6AVG}$ dBmV |
| 4096 | 41.0 | -6 |
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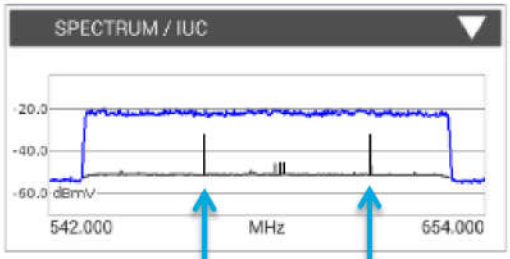
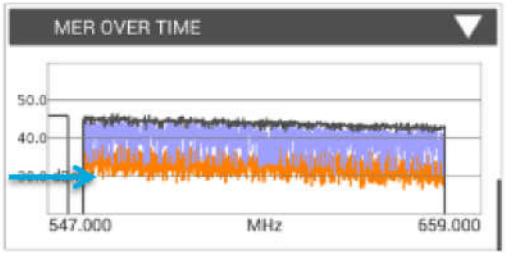
| 128 | 24.0 | -15 |
| 64 | 21.0 | -15 |
| 16 | 15.0 | -15 |

# DOCSIS 3.1 Signal Testing and Troubleshooting

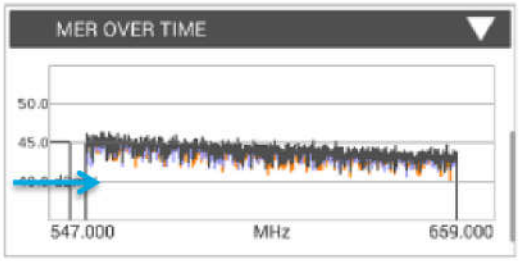
**Measuring MER across entire subcarrier list enables identifying potential impairments with impact on higher level profiles**



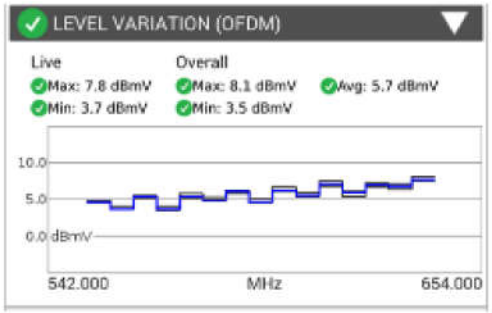

**Spectrum** and **noise** identify portions of a carrier where degradation may occur and require possible profile adjustment.



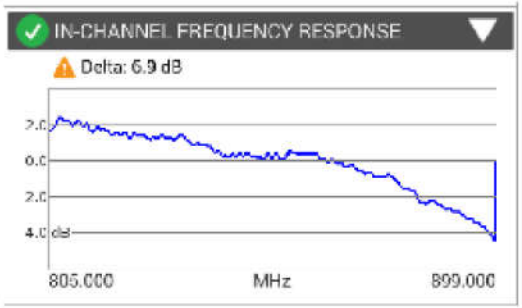

**Unstable MER with drops below 30dB** means only profiles running 256 QAM or lower will work.




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



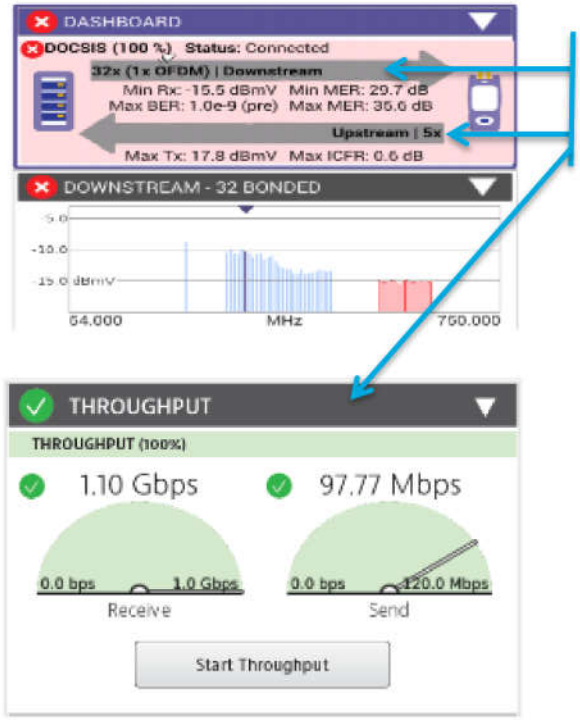

**Level variation** within the OFDM channel band provides insight into frequency-response related issues.




**In-Channel Response** identifies roll-off and excessive ripple

# DOCSIS Service Level Testing

**DOCSIS 3.1** is backwards compatible – can utilize just 3.0 QAM carriers. Verify bonding with OFDM carriers to ensure that high-tier data traffic is on more efficient OFDM carriers and is not impacting other customers.

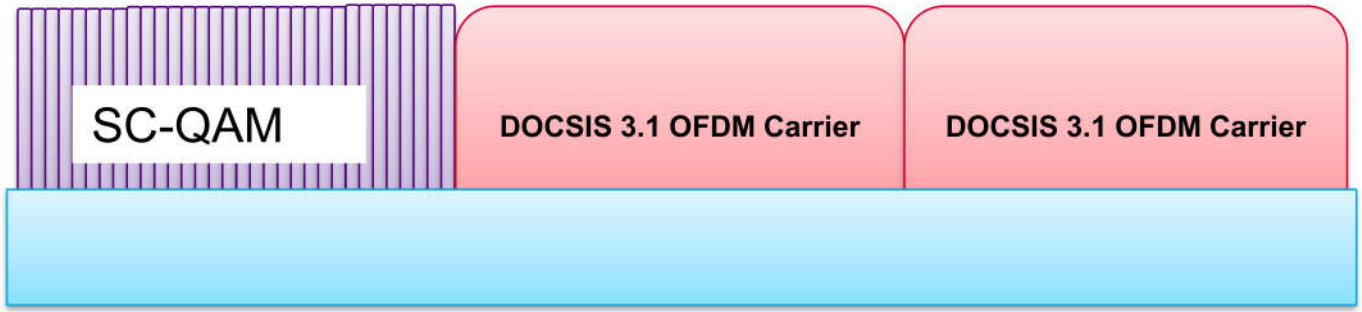



**THINGS TO CHECK:**

***Bonding with OFDM, Upstream bonding and Throughput***

- DOCSIS 3.1 systems can provide over 1 Gbps throughput
- Validating operation at subscribed rates is important to verify customer experience.
- Testing at DOCSIS physical layer identifies RF related impacts on overall service performance.
- Testing both DOCSIS service and Ethernet helps ensure top customer QoE.
- Consumer-grade PC HW limitations can prevent testing up to 1 Gbps.
  → Testing both DOCSIS and Ethernet layer to 1 Gbps helps distinguish
- between service problems and equipment problems.

# How to set the level of a D3.1 OFDM carrier




**DOCSIS 3.1 OFDM carrier power levels should be measured and referenced in comparison to the power in a 6MHz carrier.**

**In a flat system, the average power of the OFDM, referenced to a 6MHz carrier should be set to the same power level as the adjacent 6MHz QAM 256 carriers.**

NOTE: The TOTAL power of the 96 or 192 MHz OFDM carrier is greatly different than the average power in a 6MHz bandwidth.
Total power of 96/192MHz wide carrier: This is not referenced to a 6MHz carrier

**Total Power = Total Power PER Channel (6MHz) + $10\log_{10}$(Channel Bandwidth).**

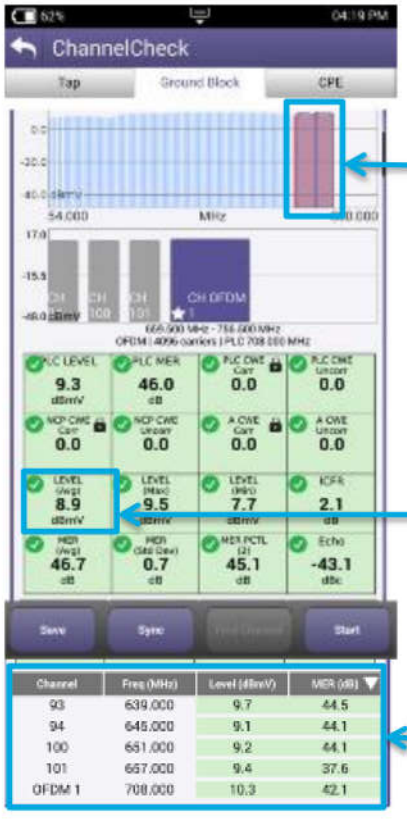
Where Channel Bandwidth would be overall OFDM Bandwidth/6MHz channel bandwidth = # of 6MHz Channels :

- ➔ for a 96MHz wide OFDM carrier the TOTAL power will be 12.04dB higher
- ➔ for a 192 MHz wide OFDM carrier the TOTAL power will be 15.05dB higher

*NOTE: DON'T 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 6MHz channel power = 5 dBmV*
➔ *Total Power(96MHz channel) = 5dBmV + $10\log_{10}(16)$ = 5 + 12.04 = 17.04dBmV* ➔ *This is what some spectrum analyzers (like R&S FSW) show*

# DOCSIS 3.1 OFDM Carrier Level Measurements




Select OFDM carrier in scan


Look at OFDM carrier average level

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


- Measure and reference OFDM carriers in comparison to power in a 6 MHz bandwidth (CableLabs® recommendation).
- With 8 MHz QAM in Europe → Set the OFDM level (ref. 6 MHz) **1.2 dB below the 8 MHz QAM 256** to maintain the same power/Hz.
- PLC carrier average power will be approximately 0.8dB higher than other carriers due to additional pilots and data patterns
- Total OFDM carrier (up to 192MHz) power is greatly different than average power in a 6 MHz bandwidth:
  - 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
- Do not use the total OFDM power to adjust CMTS output power: this would be like using total integrated power of 32 DOCSIS QAM carriers to set level.