Testing DOCSIS 3.1 OneExpert CATV

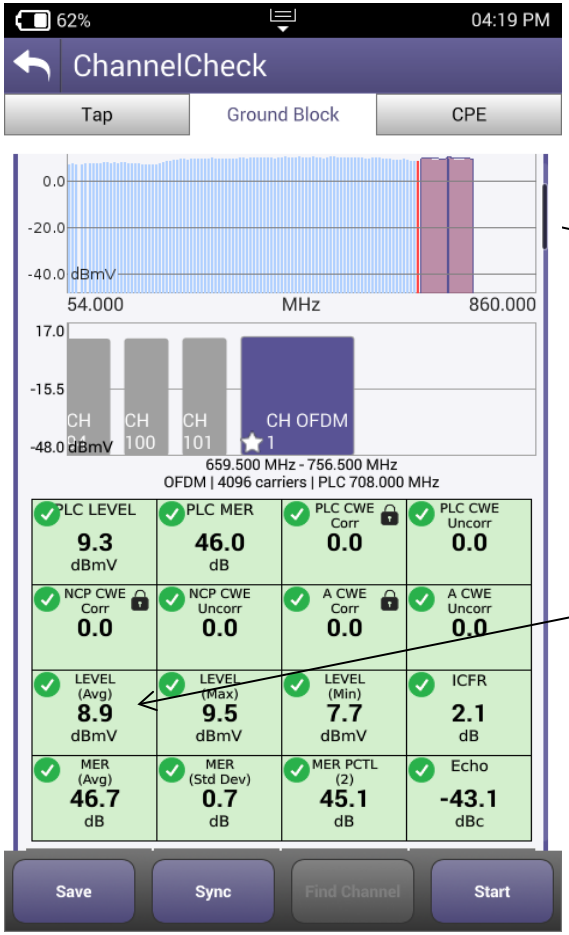
3.31.2016

Testing DOCSIS 3.1
What matters most

3.31.2016

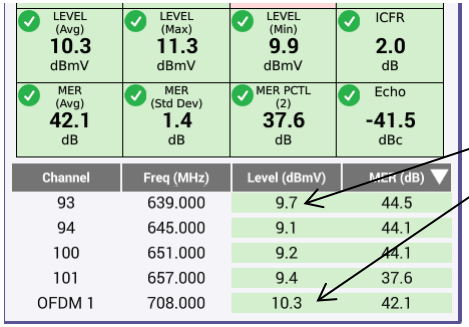
Measuring with ONX

- Using a OneExpert CATV (ONX-620) to set power levels



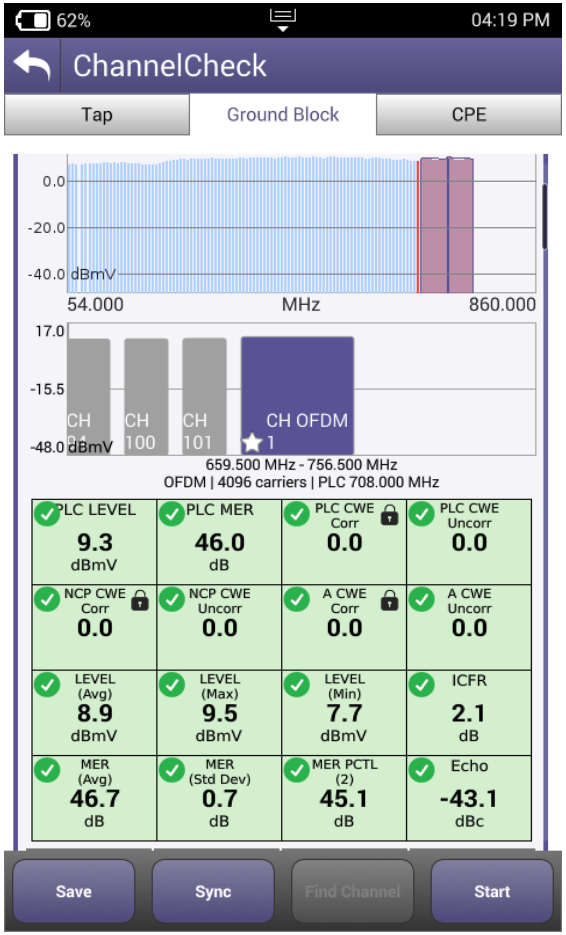
Select the OFDM carrier in the cover flow

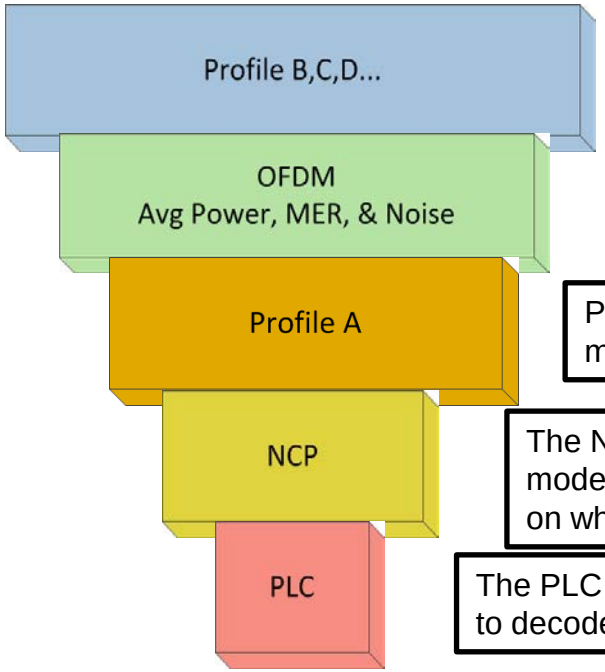
Look at the average Level of the OFDM Carrier



The Level should be set similar to the power of the 6MHz SC-QAM's
eg. All at 10dBmV

Testing the OFDM Building Blocks





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

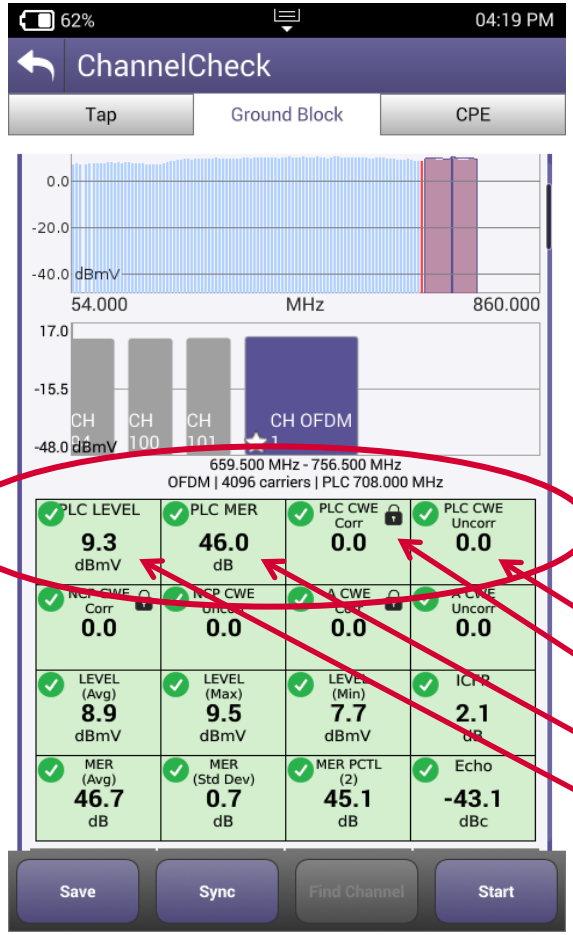
The OFDM avg. power needs to be within range. Good MER and lack of noise enable higher modulations

Profile A is the Boot profile. ALL 3.1 modems must be able to use profile A

The NCP (Next Channel Pointer) tells the modem which Codewords (CW) are present on which profile to use on each CW

The PLC contains the critical information on how to decode the OFDM signal

Testing the OFDM Building Blocks
PLC – Phy Link Channel

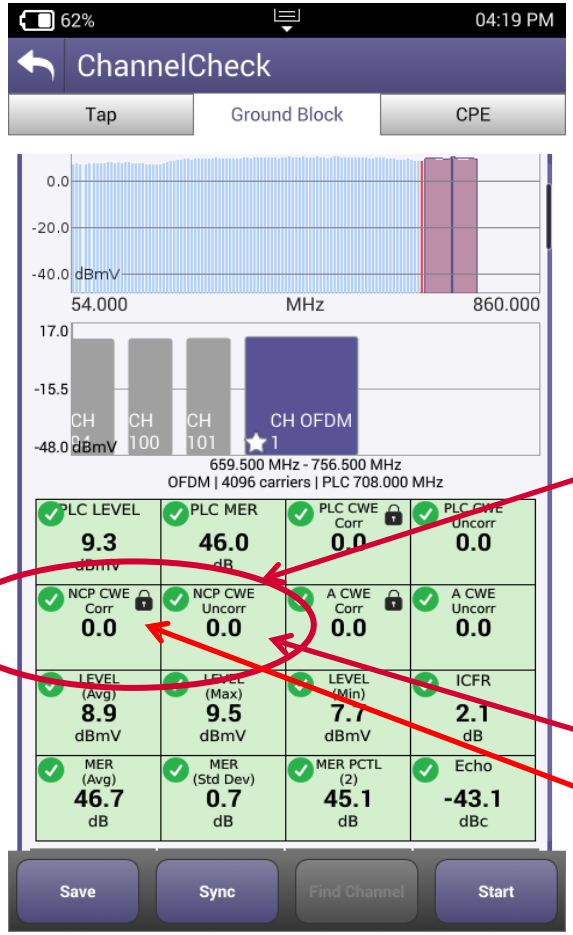


PLC

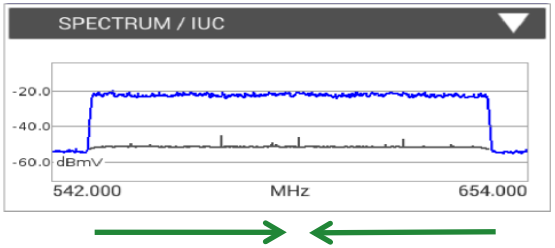
The PLC contains the CRITICAL information on how to decode the OFDM signal

Things to Check:
Uncorrectable CWE: NONE
Lock Status: Locked
MER: > 15dB (min)
Level: > -15dBmV (6MHz)
Other info: PLC Center Freq

Testing the OFDM Building Blocks
Next Channel Pointer



Don't disregard OFDM performance at the high end roll-off



CodeWords start at the LOW frequencies and populate UP

NCP's start at the HIGH frequencies and populate down

NCP

The NCP (Next Channel Pointer) tells the modem which Codewords (CW) are present on which profile to use on each CW

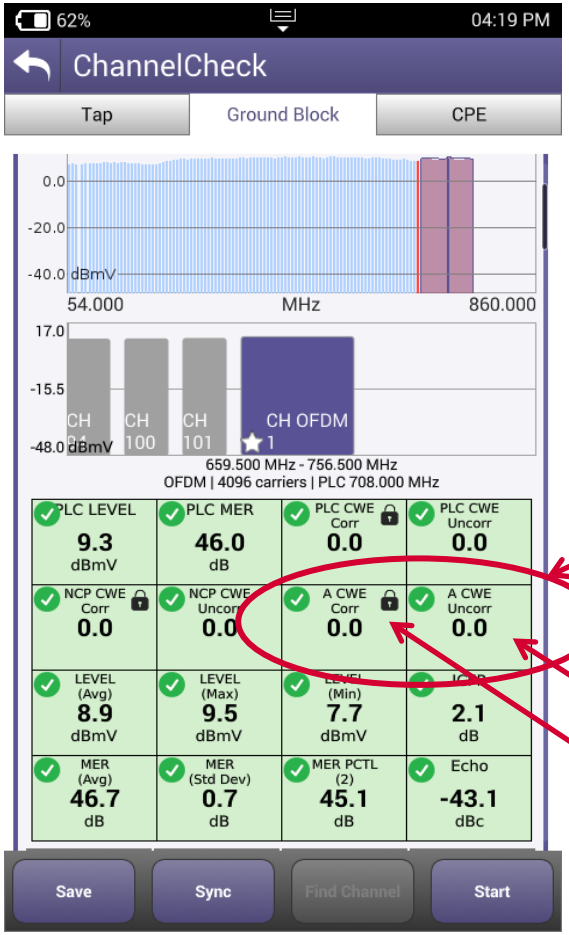
They are CRITICAL for proper data communication

Things to Check:
Uncorrectable CWE: NONE
Lock Status: Locked

Testing the OFDM Building Blocks
Profile A

Profile is the cornerstone for a D3.1 modem to actually operate on the OFDM carrier. This is where the command and control, range and registration occurs.

In practice Profile A may be assigned lower mixed modulations like QAM 64/16 so every 3.1 modem can communicate. Lower modulation profiles can operate at lower MER/CNR and power levels.



Profile A

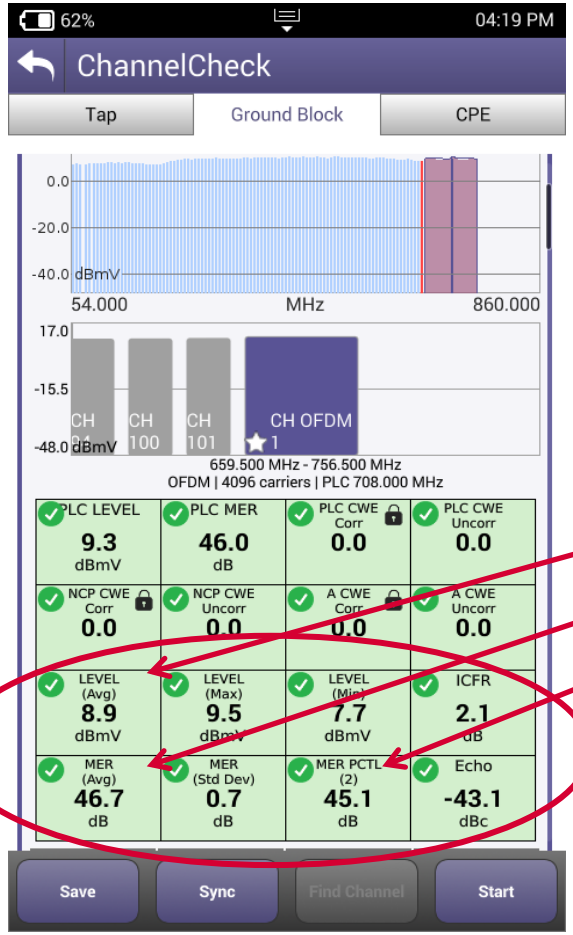
Profile A is the Boot profile. ALL 3.1 modems must be able to use profile A

Things to Check:
Uncorrectable CWE: NONE
Lock Status: Locked

If Profile A isn't locked or has Uncorrectable. CWE the modem may roll back and use only SC-QAM's in 3.0 mode

Testing the OFDM Building Blocks
Overall OFDM physical measurements (Level, MER)

CM Minimum CNR Performance in AWGN		
Channel Constellation	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



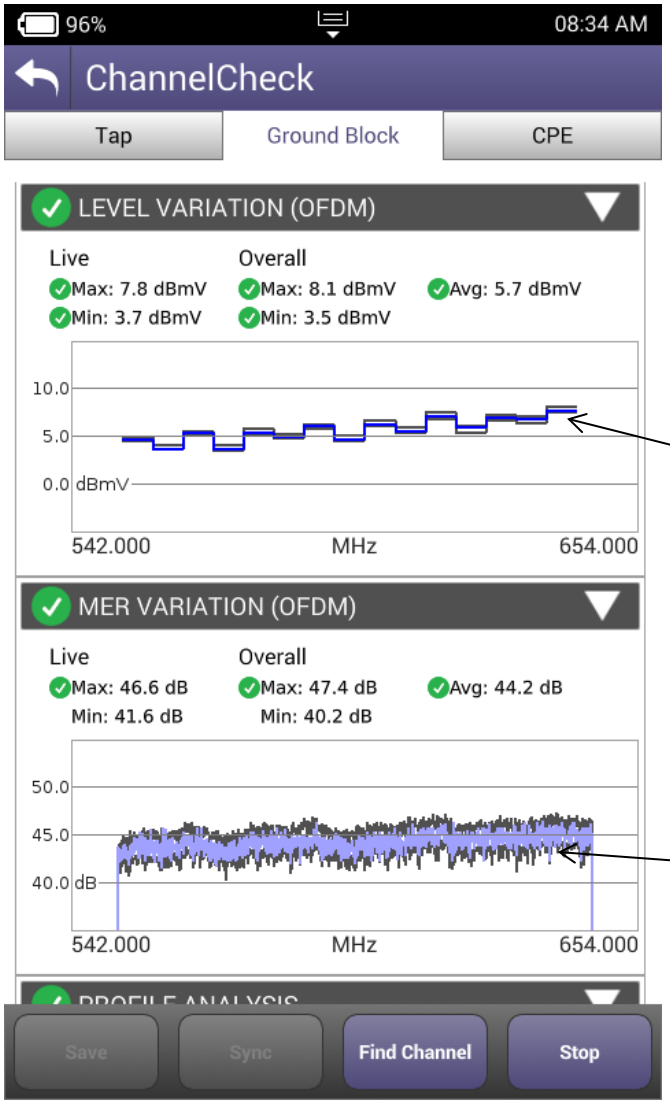
OFDM
Avg Power, MER, & Noise

The OFDM avg. power needs to be within range. Good MER and lack of noise enable higher modulations

Things to Check:
Avg LEVEL: Variable: >-6 dBmV recommended
Avg MER: Variable: > 36dB recommended
MER @ 2 Percentile: > 35dB recommended
Level Std Deviation: < 2dB recommended

Looking at the 2 Percentile shows how good 98% of the subcarriers are working and weeds out a couple underperforming ones since LDPC will likely clear it up

Testing the OFDM Building Blocks
Overall OFDM physical measurements (Level, MER)

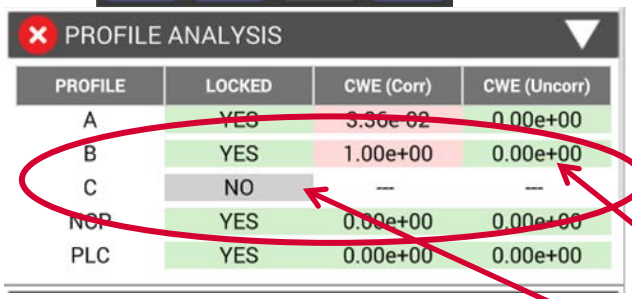


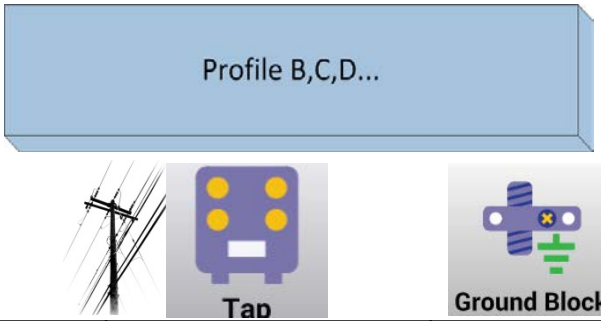
DOCSIS 3.1 OFDM carrier power levels should be measured and referenced in comparison to the power in a 6MHz carrier.

The ONX shows the power level across the OFDM carrier in 6MHz wide steps.

The ONX shows the MER details of each subcarrier. This helps identify underperforming portions of the spectrum.

Testing the OFDM Building Blocks





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

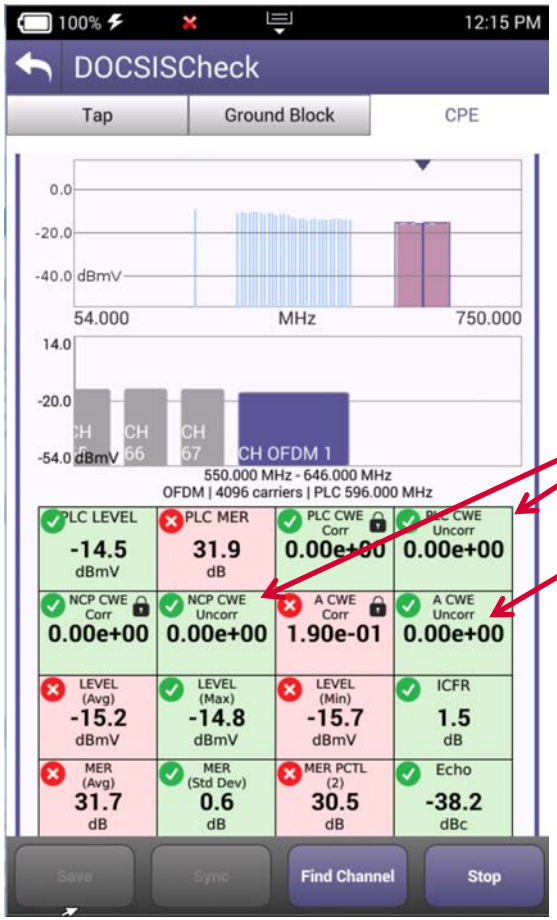
	TAP		Ground Block		Outlet/CPE	
	Profile Locked?	Uncorrectable CWE	Profile Locked?	Uncorrectable CWE	Profile Locked	Uncorrectable CWE
Profile A	YES	NO	YES	NO	YES	NO
Profile B	YES	NO	YES	NO	NO	YES
Profile C	YES	NO	YES	YES	NO	YES
Profile D	YES	NO	NO	YES	NO	YES

Profile changes highlight problems in drop and or home wiring:

Things to Check:
Uncorrectable CWE: NONE
Lock Status: Locked

Higher profiles makes the network more efficient. It is desirable to get as many modems running on higher profiles for overall network efficiency and customer quality of experience

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



PLC is working good
NCP is working good
Profile A: is working good with some correctables (in this case it is running 256 QAM)

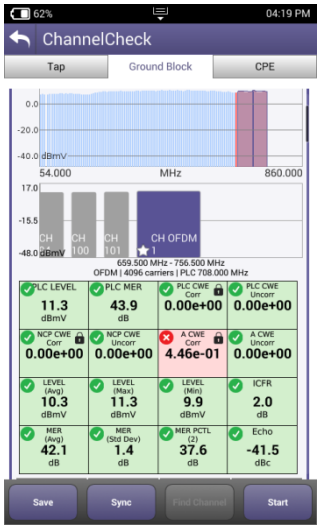
Profile B: (running 1024 QAM in this case) is on the edge: 100% correctable CWE but LDPC is correcting them all!

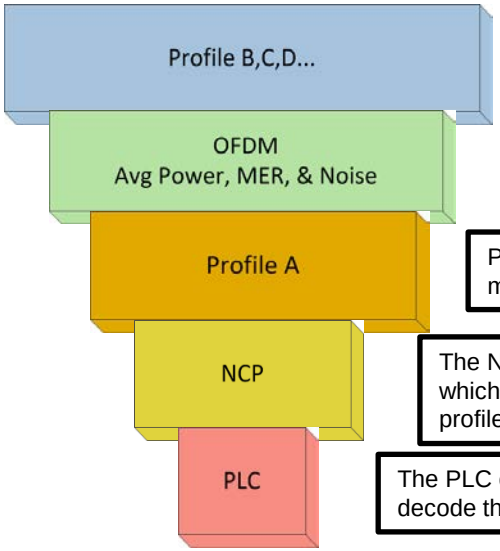
PROFILE ANALYSIS

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

This makes sense for 1024 QAM the level should be >-12dBmV and MER > 34 dB

Testing the OFDM Building Blocks
CodeWord Error Expectations and Impact





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

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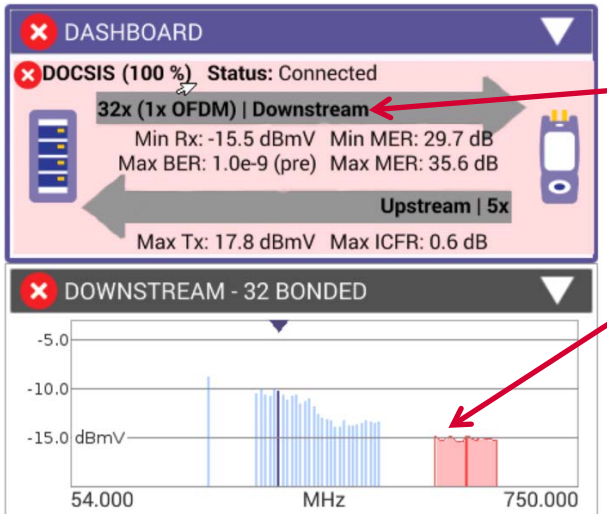
The PLC contains the critical information on how to decode the OFDM signal

Component	Importance	Code Word Error expectations and impact
PLC	**Critical**	Should have **0 Uncorrectable CWE** otherwise OFDM may not work
NCP	**Critical**	Should have **0 Uncorrectable CWE** otherwise OFDM may not work
Profile A	**Critical**	Uncorrectable CWE will cause poor QOE and possibly make the OFDM carrier unusable forcing data to regular QAM carriers instead of OFDM
Profile B,C,D	High	Uncorrectable CWE will affect bandwidth and overall QOE

Service Testing
DOCSIS 3.1 Range, Register and BONDING

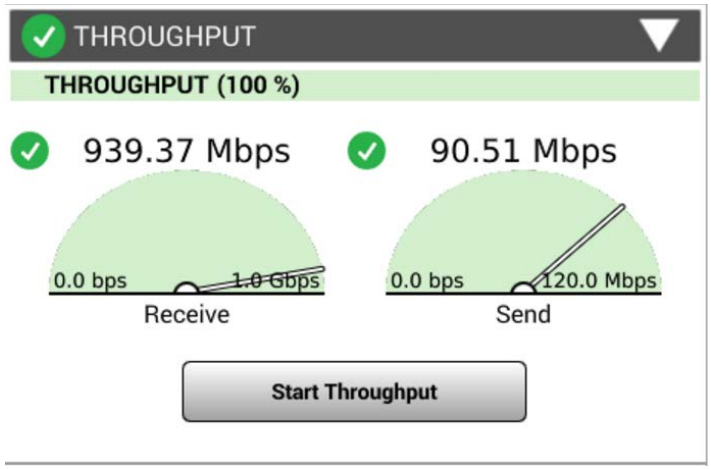


Things to Check:
Channel Bonding with OFDM
Upstream Bonding

Since a D3.1 modem is backward compatible, it can utilize just the 3.0 QAM carriers. By ensuring that the service is bonding with the OFDM carriers or using the OFDM carriers it validates that the high data customer will be working on the more efficient OFDM carriers and not impacting other customers.

Service Testing Throughput

Download Speeds



DOCSIS 3.1 systems can provide 1Gb/s or greater.

Validating that the network and service can operate at the subscribed rates is important to verify customer experience.

Testing at the DOCSIS service layer identifies RF impacts on the overall performance

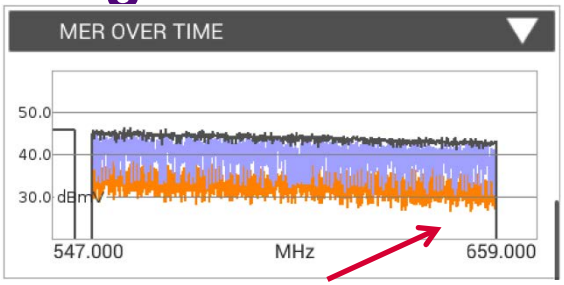
Being able to test both DOCSIS service and Ethernet helps ensure customers' QOE.

Many consumer grade PC's have hardware limitations that prevent them from testing up to 1Gb/s. Having a test device that can test both the DOCSIS layer and Ethernet Layer to 1Gb/s helps distinguish between service problems or equipment problems.

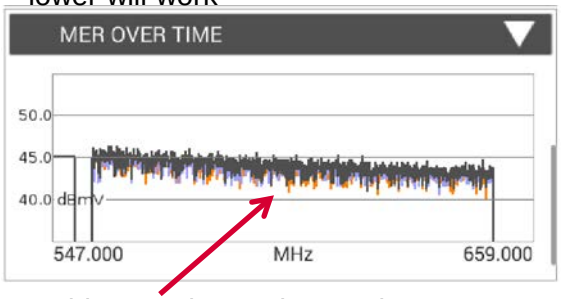
DOCSIS 3.1 Testing
Signal Testing and Troubleshooting

Signal Testing

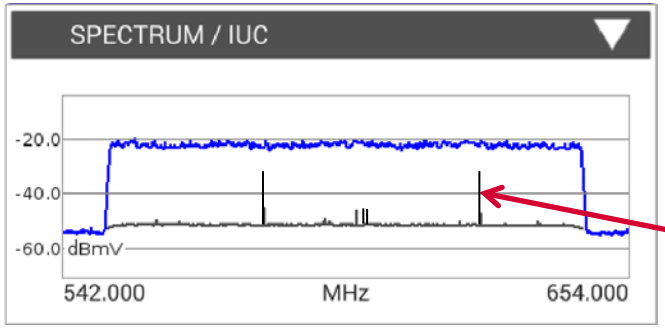
Looking a the MER across the entire list of subcarriers is important in order to identify potential impairments that affect the ability to carry higher level profiles



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

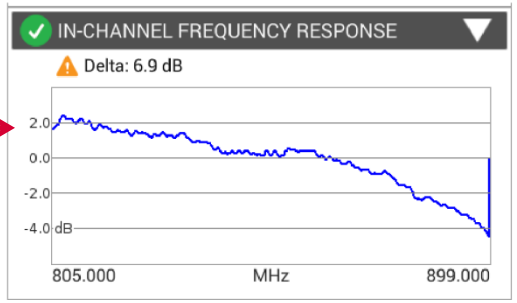


Stable MER better than 40dB means QAM 2048 and 4096 will work



Spectrum and Noise identify portions of the carrier where degradation may occur
Profiles may need to adjust for this

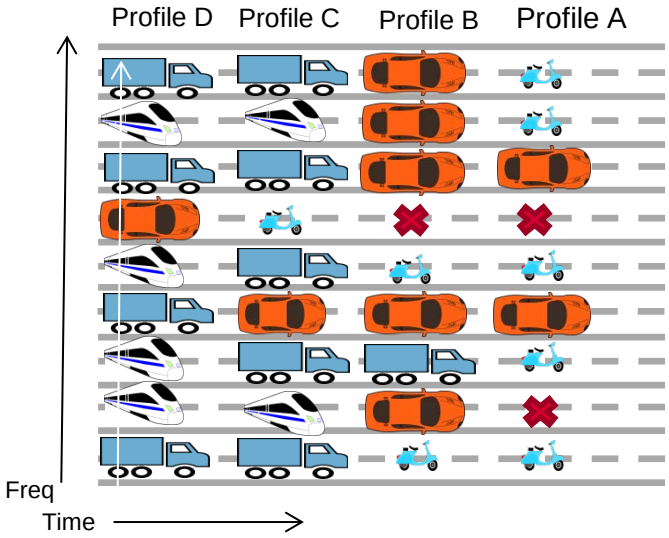
In-Channel Response identifies roll-off and excessive ripple

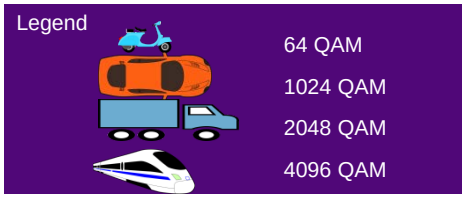


Profiles in a real network

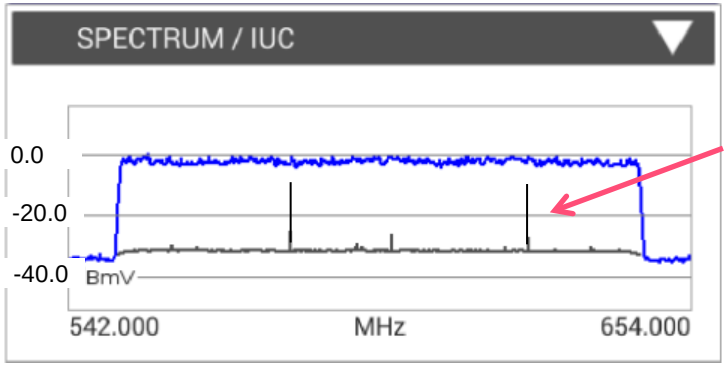
Profiles and Variable Bit Loading

Advanced Profile Concept:
Carrier Modulation Varies by Frequency



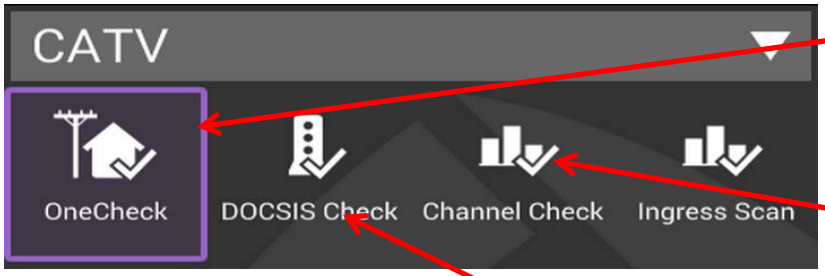


Variable Bit Loading of OFDM subcarriers allows each profile to adapt to varying network conditions, like LTE interference, by excluding subcarriers or changing its modulation in order to maximize the overall network efficiency. Each profile can have mixed modulation types across the different subcarriers.



Identifying noise sources under the OFDM carrier can help plan for frequency exclusions or modulation changes for the subcarriers

DOCSIS 3.1 testing on the OneExpert CATV



OneCheck

- Comprehensive and automated testing of Ingress, Downstream & DOCSIS with Session Expert™ to help resolve problems

ChannelCheck

- Real-time analysis and powerful troubleshooting of downstream carriers
- Analyze OFDM carriers including analysis of multiple DS profiles
- Use ChannelCheck to quickly check levels and signal performance

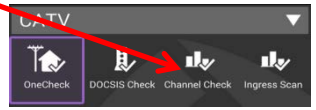
DOCSIS Check

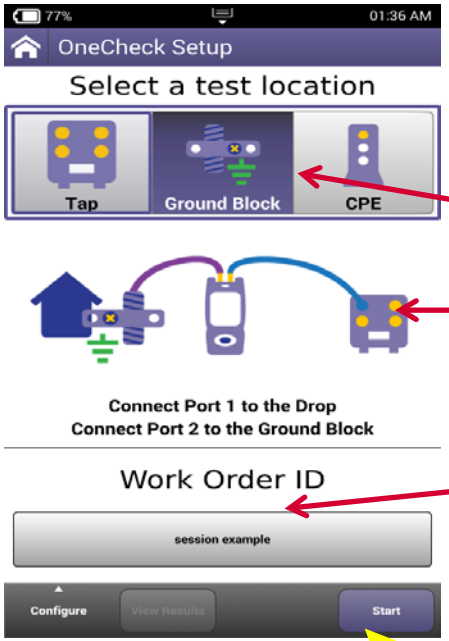
- Real-time analysis of DOCSIS services
- Only shows the DOCSIS carriers to allow you to focus on HSD services
- Troubleshoot and analyze Downstream and Upstream DOCSIS carriers including OFDM and channel bonding

Testing Flow with the OneExpert CATV

Test Flow

Choose your test to run:
Each test asks for basic information prior to running





Choose current test location

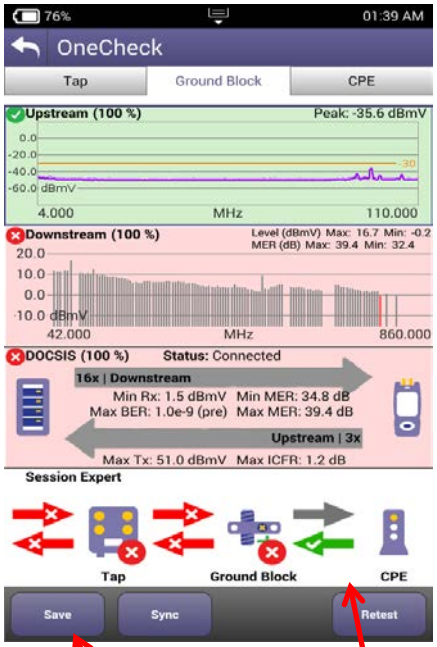
Connect the meter properly

Input a unique Work order/job identifier for each household (This is important since ONX uses test data at each location for data analysis)

Important!

Test Results

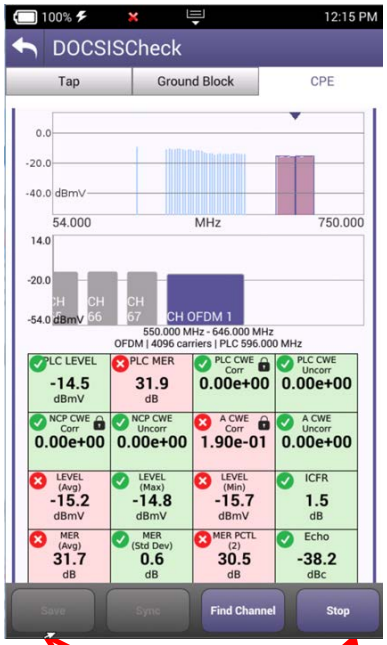
OneCheck
Provides dashboard with drill down results



OneCheck will automatically save the last run test. Hit Save and give a new name if you want to capture a specific result prior to Retesting

Tap on a panel to drill down to detailed results

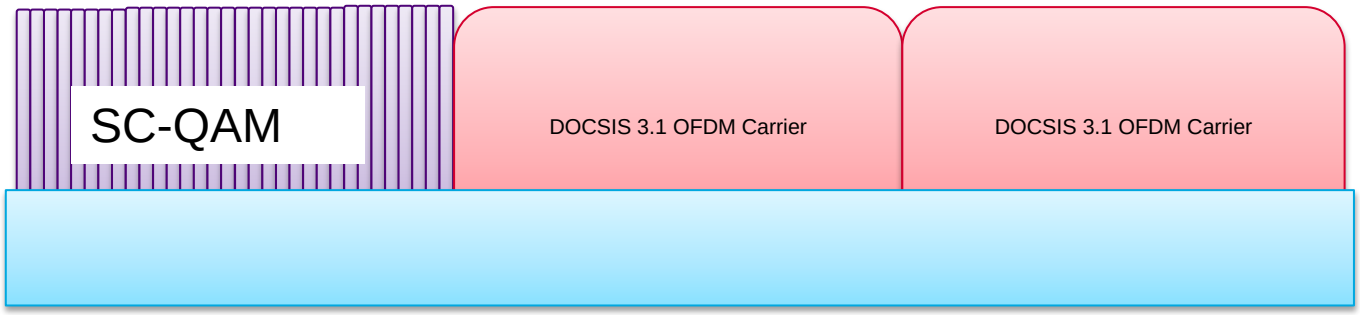
ChannelCheck & DOCSIS Check
Provides live analysis



Hit Stop and then Save if you want to capture live data results

Measuring OFDM power

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 QAM 256 carriers.

NOTE: The TOTAL power of the OFDM carrier is greatly different than the average power in a 6MHz bandwidth.

Total Power = Total Power PER Channel (6MHz) + 10log10(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)

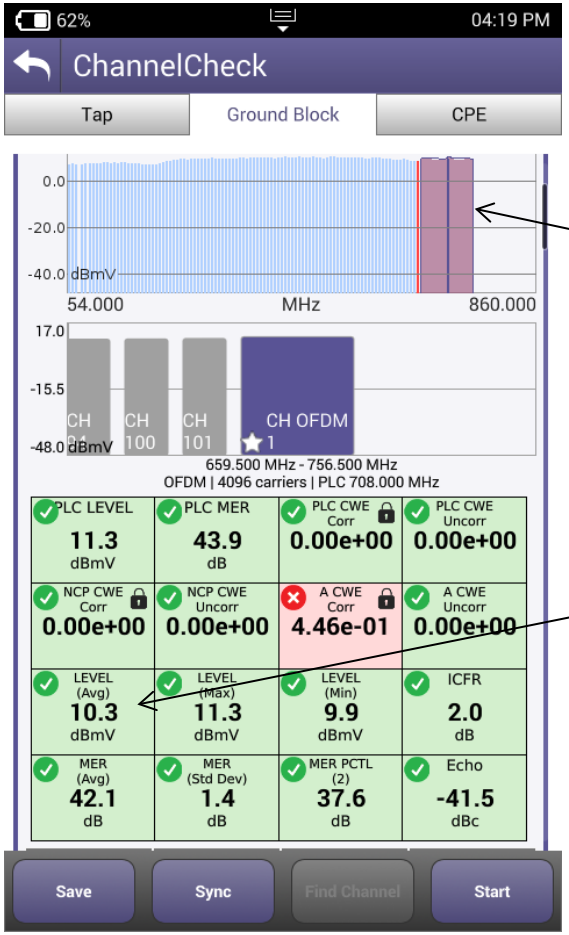
Single 6MHz channel power = 5 dBmV
Total Power(96MHz channel) = 5dBmV + 10log10(16) = 5 + 12.04 = 17.04dBmV
This is what some spectrum analyzers (like R&S FSW) show –
total power of 96MHz wide carrier: This is not referenced to a 6MHz carrier

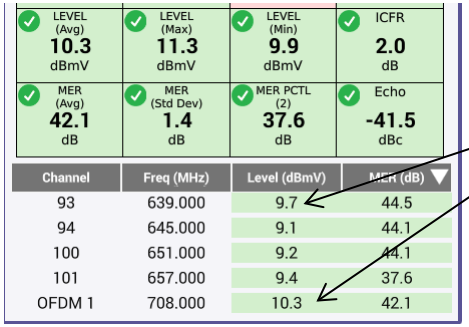
Other OFDM behaviors to take note:

- The level of the first and last 6MHz of an OFDM will be approximately 0.8 dB less than the other carriers due to guard band roll-off.
  - This is important if using a standard meter (e.g DSAM) or when looking at the power within individual 6MHz blocks of the OFDM
  - The average power of the PLC carrier will be approximately 0.8dB higher than the other carriers due to the additional pilots and data patterns.
  - The overall Max-Min (flatness) related to a 6MHz carrier in a OFDM will show 1.6dB variation due to the low end/ high end roll off and PLC variations.

Measuring with ONX

- Using a OneExpert CATV (ONX-620) to set power levels



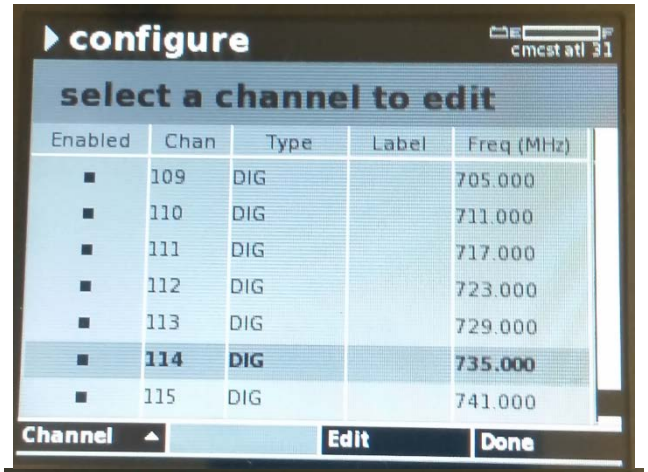


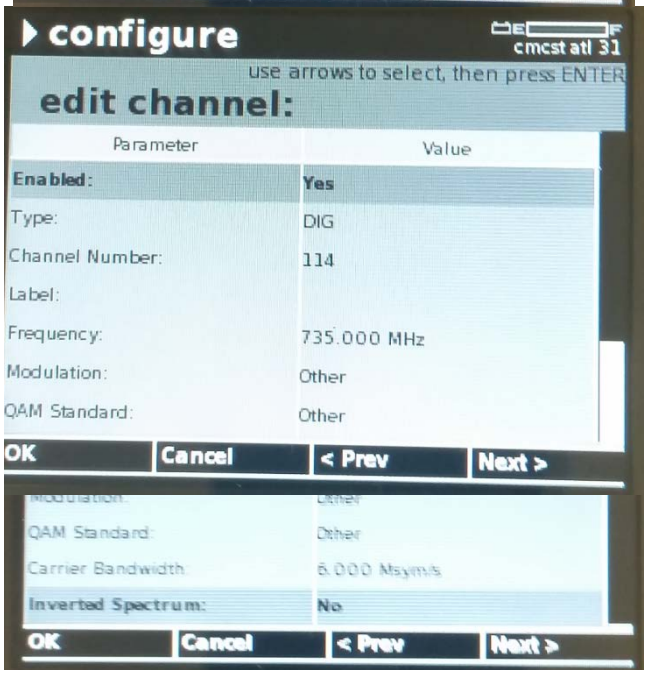
Select the OFDM carrier in the cover flow

Look at the average Level of the OFDM Carrier

The Level should be set similar to the power of the 6MHz SC-QAM's
eg. All at 10dBmV

Measuring OFDM with the DSAM

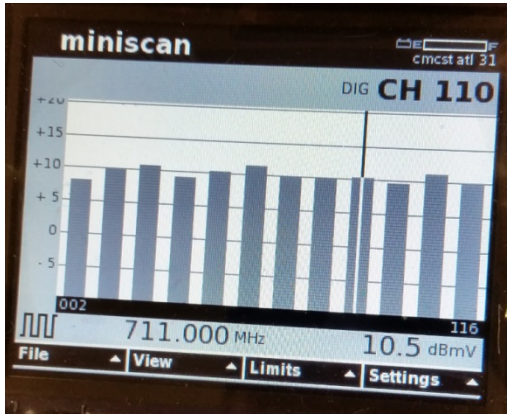


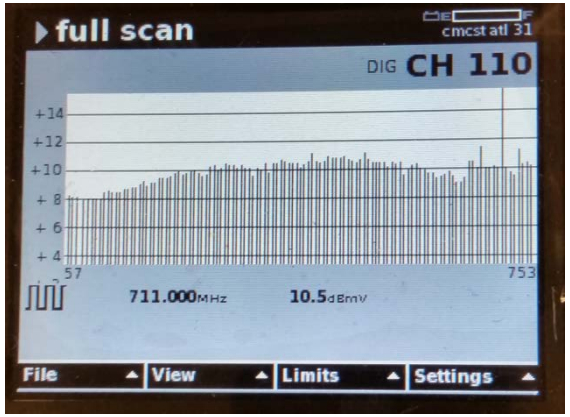


- Select the starting carrier of the OFDM in 6MHz channel blocks
- Set the channel type to DIG
- Set the Modulation to OTHER
- Set the QAM Standard to OTHER
- Set the Carrier Bandwidth to 6.000 Msym/s

- Repeat for the remaining 6MHz channels within the OFDM

- Use Full Scan, Level, or Mini-Scan to view the power levels relative to 6MHz in individual steps
- Level Mode provides the most accurate reading since it uses DigiCheck scan and summation method

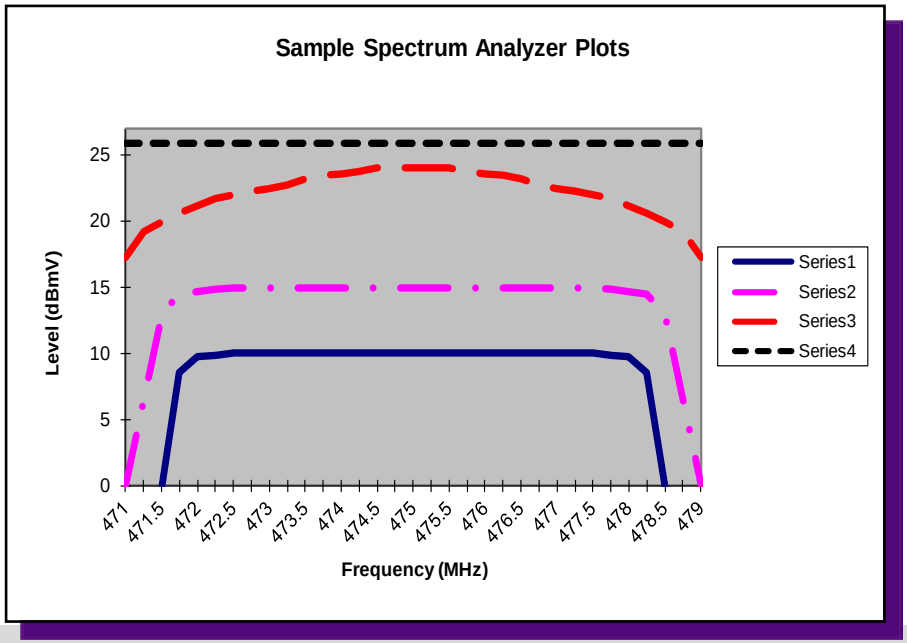




Using a Spectrum Analyzer
For measuring OFDM power Level relative to 6MHz Ch.

- Multiple settings to consider
  - RBW
  - VBW
  - Averaging
  - Dwell time

- If In the hands of an inexperienced user, the wrong settings may lead to improper interpretation and level setting. This can be confusing

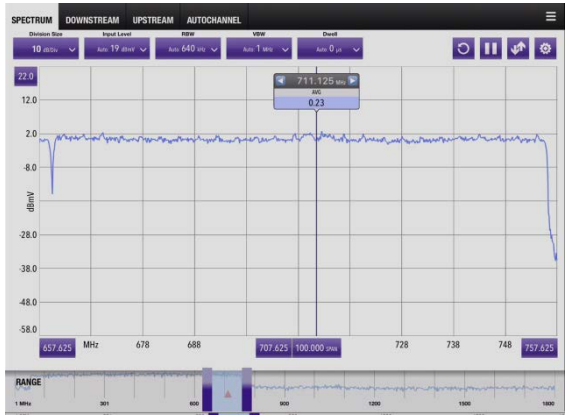


The spectrum analyzer's different resolution-bandwidth filter give different results for power level measurements.

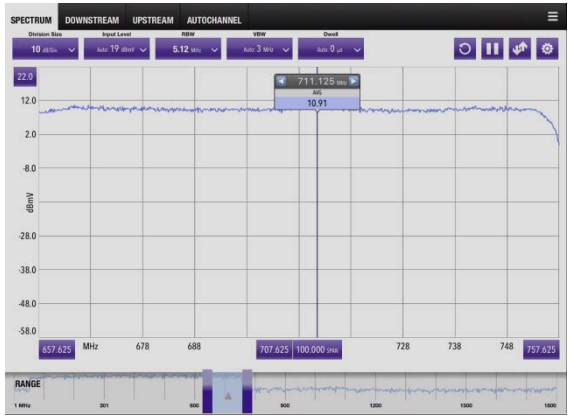
Using a Spectrum Analyzer

- Spectrum Analyzers measure the level within the RBW window
- Different RBW's have a big difference in the level

160kHz RBW
-5.49dBmV



640kHz RBW
0.23 dBmV



5120kHz RBW
10.91 dBmV

- If a technician simply uses a Spectrum Analyzer and looks at the level reported by the marker without compensating for bandwidth they could be radically mis-adjusting the power.

Remember total power?
Total Power = Power + 10*LOG (Bandwidth)
Using this to apply correction factors

= -5.49 + 10*LOG (6,000/160)
= -5.49 + 15.74
= 10.25 dBmV

= 0.23 + 10*LOG (6,000/640)
= 0.23 + 9.72
= 9.95 dBmV

= 10.91 + 10*LOG (6,000/5,120)
= 10.91+ 0.07
= 10.98 dBmV

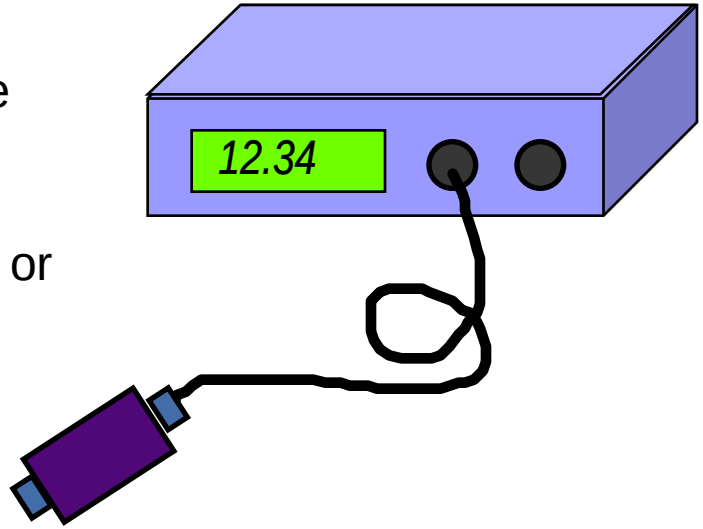
Using the 5.12MHz RBW on the VSE-1100 provides a measurement that is only 0.1dB off

Using A Spectrum Analyzer
Setting recommendations for t

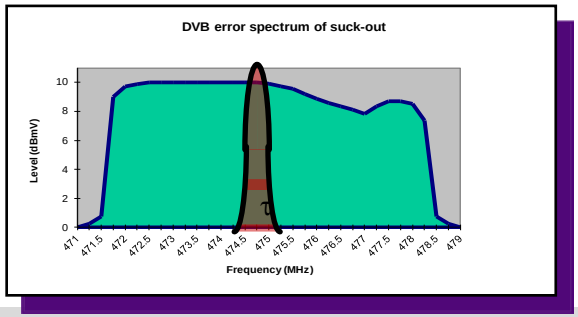
1. For measuring power you want to turn on Averaging. This provides a normalized measurement of the signal level.
   - On the VSE-1100 set the average to around 100 or more
2. Set dwell time to 0 microseconds or auto
3. If possible set the RBW to the same bandwidth as the desired carrier width
   - On the VSE-1100 choose the 5.120MHz RBW
   - If you use a smaller RBW, then remember to apply the proper correction factor.
4. Set the VBW to AUTO. The VBW will smooth out some of the noise.

What's the right way?
Use an instrument that is calibrated to a power meter

The most reliable method to measure the power of a Digital signal is to use an RF-power meter with a 75 Ohm thermal-sensor-measuring-head (crest factor is 5 or better).



- Use an instrument that uses the standard calculation of average power by summing the power measured across the bandwidth and not using just a single point. The instrument should be calibrated to an RF power meter.



backup