As signals travel through the coaxial cable network they are attenuated more at higher frequencies. This natural loss and slope is considered in the network design, as can be noted in that tap values decrease as distance from the last amplifier increases. While the amount of loss and slope at any point in the network can be calculated, this is a time-consuming step that can be eliminated with a patented measurement mode called SmartScan. By compensating for different signal types and levels and the tilt of the system, SmartScan enables the tech to see the frequency response and compare measured levels with prescribed limits.

When troubleshooting at a subscriber location a technician must be able to show that performance at the tap is not meeting specification before escalating a ticket to maintenance. These tests must show whether levels and the peak-to-valley (frequency response) are within range even with tilt at the tap. Power levels must be maintained with positive tilt to compensate for high frequency losses. SmartScan™ helps automatically find these channel levels which fall out of optimal operating range.

High Peak to Valley Limit Delta at Tap is required to allow for low frequency and high frequency channels to have tilt and still pass.

Analog Video = 24dB
64QAM = 35dB
256QAM = 25dB
System design factors make setting fixed level measurement limits a challenge. First, there can be various types of signals carried on the network, from analog signals, and pilot carriers to various QAM and OFDM signals. These signals may be set at different levels at the source, by design, depending on their type. It may be difficult for a technician to interpret measurement results, when these different levels are present in the network by design. They may not always know when adjacent channels should be the same, or a different level is expected.

Another challenge to setting level measurement limits is tilt/slope. Cable networks are designed with a tilt (higher frequency signals are at higher levels than lower frequency signals) to compensate for cable loss that attenuates higher frequencies more than lower frequencies, and for potential benefits related to distortion if amplifiers are cascaded. This naturally occurring tilt makes setting limits especially difficult, as setting them wide to accommodate levels at different ends of the frequency range, can make the limit ineffective in catching out of specification channels.

Network issues that impact customers include suck-outs, bad channels, and bad passives (tap plates, frequency limited splitters, etc.). The tech needs test capability that compensates for the different levels of various channel types, and eliminates tilt. A feasible limit can then be set for tilt and the compensated levels.

How SmartScan Works

- Compensating for tilt – SmartScan, considering all channels, automatically calculates a statistically significant best fit line for system tilt and compensates for it
- Compensating for different channel types – SmartScan automatically normalizes carriers based on channel type detected (256 QAM signals levels are typically set 6 dB lower than analog signals for example).

- Normalizing and providing tighter limit bands – SmartScan provides a normalized view so individual channel issues and system problems are easily identified. A perfect channel lineup would result in a flat 0 dB line.

SmartScan compensates for tilt and designed level variation, but still shows response issues, as seen in the standing wave example below.
**SmartScan Limit Setting Guidelines**

Recommended limits depend on the network design, but here are a few guidelines.

1. A well-balanced network should pass a “max deviation” limit of 3 dB. Cable operators may be able to tighten this to 2 dB if they run a very well-balanced network.

2. The minimum SmartScan tilt should probably be at least 0 for “TAP” and “Ground Block” limit sets.

3. +/- 12 dB is the default maximum/minimum tilt limit based on the DOCSIS 3.0 PHY specification, but these limits may be set much tighter depending on network equipment.

4. Limit definitions:
   a. Min SmartScan Slope Compensation – If the system has negative tilt that is lower than this value, the limit check will fail
   b. Max SmartScan Slope Compensation – If the system has a positive tilt that is greater than this value, the limit check will fail
   c. Max and min slope compensation settings are separately configured because they vary depending on the test location. For example, it may be undesirable to have a negative slope at the tap, but negative tilt could be expected at the CPE location.

**SmartScan Display Description**

System Tilt – overall tilt of the system based on an all-channel statistical best-fit line, considering measurement data over the frequency range.

Max Deviation – the highest deviation value of measured levels after all slope and channel type compensations are applied.

Limits – the orange horizontal markers represent the configured pass/fail limits, and any measurement deviating above or below these limit lines indicate a warning or failure.
Wide limits are needed to accommodate for forward tilt min/max values expected at the tap:

- Analog = Min 3dBmV to Max 27dBmV
- 64QAM = Min -5dBmV to Max 30dBmV
- 256QAM = Min 0dBmV to Max 25dBmV

Since SmartScan compensates for system tilt and channel type, the limits are simplified, for example to ±3dB

(Note in this example the limit was set to warn and not fail when exceeding the ±3dB limit)

**Suck-out or Filtered Channels**

**High End Roll-off**
SmartScan Application Examples continued

Negative Tilt

![Graph showing channel view with negative tilt](image1)

![Graph showing SmartScan with negative tilt](image2)

Standing Waves

![Graph showing channel view with standing waves](image3)

![Graph showing SmartScan with standing waves](image4)

SmartScan Benefits and Conclusion

SmartScan streamlines the “refer to maintenance” process for installation and service technicians. A failure at the tap that is substantiated with a SmartScan failure, shows that the levels and/or frequency response are out of limit. The test enables setting tight limits, regardless of tap value, and makes it easy for techs to see roll-off, suck-outs or standing waves in the RF plant. With StrataSync a maintenance technician can examine the tap test results prior to going on site, and can also use SmartScan to identify and fix issues at the site.

SmartScan tests improve on a full scan view by compensating for tilt, and for a variety of signal types with different levels. The tech’s task is simplified by eliminating mental math gymnastics. Effective limits can be set with an expectation for consistency throughout the plant and home, regardless of location. The test provides a helpful record to maintenance techs when the issue is escalated.