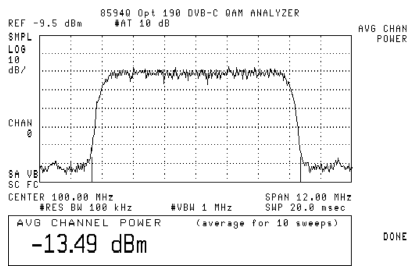
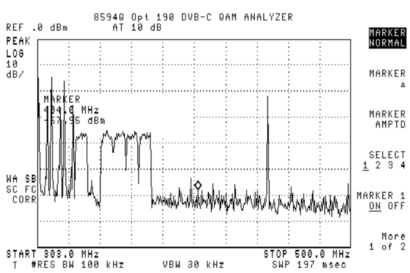
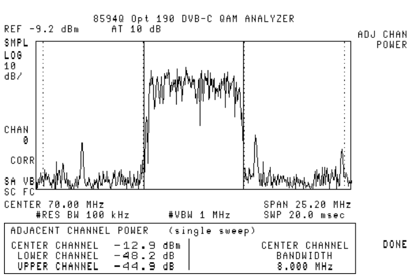
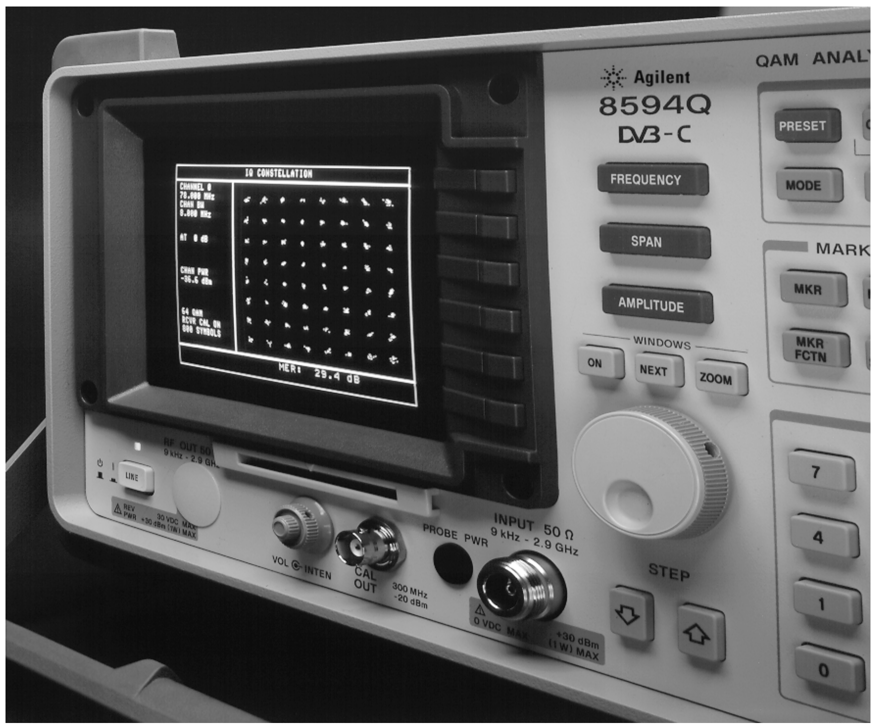
Agilent 8594Q QAM Analyzer
DVB-C Solutions

Product Note









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Introduction

All cable TV network operators planning the introduction of DVB-C (Digital Video Broadcast via Cable) services have increasing competitive pressure to install these new services quickly. With the added complication of migrating to a new technology, measuring new modulation types and learning how digital signals are affected through the system, it is important to be able to quickly measure system performance. The Agilent Technologies 8594Q QAM analyzer is a comprehensive and powerful test solution for installation and maintenance test on DVB-C systems. This product note describes the capabilities of the 8594Q QAM analyzer, where it can be used and why the measurements it performs are important.

Before describing the measurements in detail it is important to understand the flow of data through the system from transmitter to receiver.

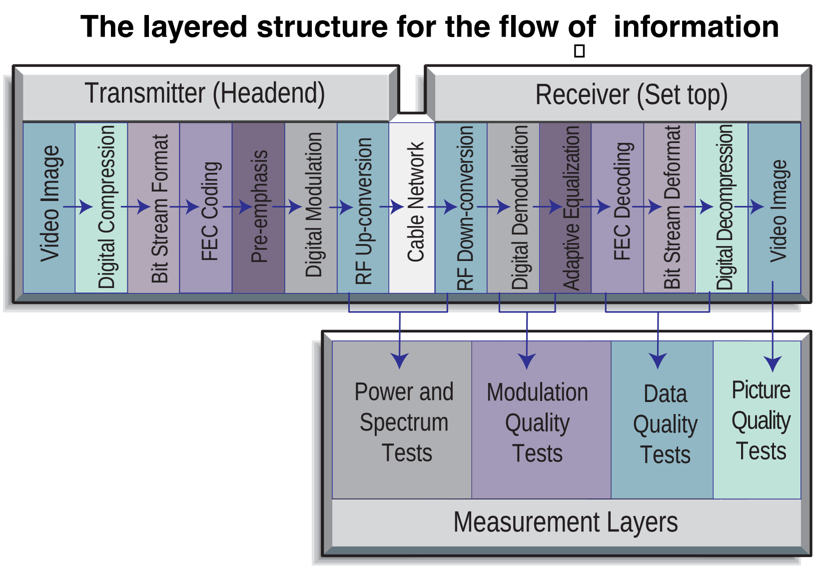

Figure 1: The layered structure for the flow of information

The video image is digitized, converting the analog signal to data bits. The data bit stream is compressed, using MPEG-2, into packet data. These packets are then organized into the transmission format called an MPEG-2 transport stream (TS). Forward error correction (FEC) coding is added to protect the MPEG-2 transport stream as it passes through the system. The digital video signal may be pre-emphasized to compensate for known problems in the transmission path. Finally, the data stream is digitally modulated and upconverted to the carrier frequency.

The digital video receiver, or set top box, reverses the signal processing layers performed in the transmitter. The key advantages of a digital receiver are the signal distortion compensation provided in the adaptive equalizer, and the bit error correction provided in the FEC decoder. These two signal processing blocks remove impairments from the received signal.

What measurements are important?

Digital video signals differ from traditional analog signals in that forward error correction and coding are designed to conceal transmission errors and linear transmission medium distortions. Therefore, different measurements are appropriate for different stages in the transmission process.

Power and spectrum tests are applied to the RF digital video signal. Modulation quality is assessed after digital demodulation, around the adaptive equalizer. Data quality tests examine the integrity of the bits recovered from the digital modulation, including the bit correction effect of the FEC.

- Power measurements are key to adjusting levels and minimizing inter-channel distortions throughout the cable distribution system.
- Spectrum measurements give a clear view of the RF channel quality.
- Direct measurements on the digital modulation are useful tools for troubleshooting the source of signal impairments.
- Data quality is the key product delivered to the subscriber. Data quality tests are overall, end-to-end checks on the integrity of the digital cable system.

Test from the headend through to the subscriber drop

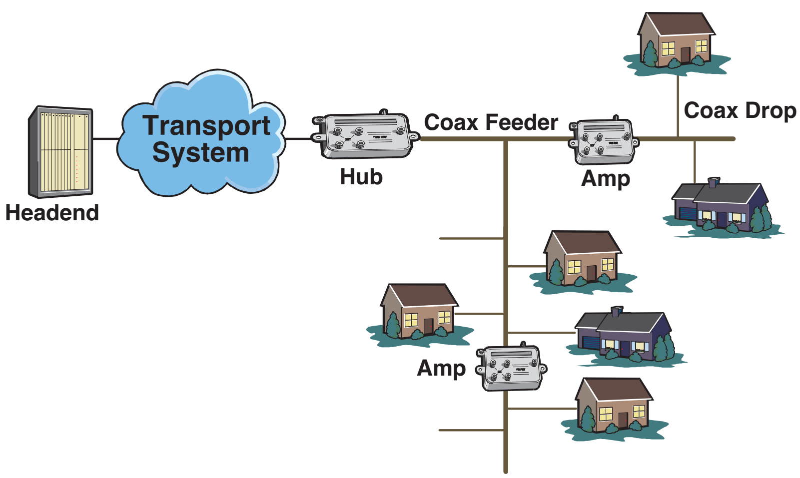

Figure 2: A simplified view of a cable TV system

The 8594Q QAM analyzer addresses the power, modulation and data quality measurement layers from the headend through to the subscriber drop. Whether measuring high-level signals at the output of a modulator or measuring low-level signals in a crowded spectrum at the subscriber drop, the 8594Q performs the key RF and modulation measurements quickly and accurately.

Agilent 8594Q QAM Analyzer Measurements

Qualitative and Quantitative Testing

The 8594Q is capable of a range of qualitative and quantitative measurements. Qualitative measurements are an important first step in troubleshooting.

Qualitative Measurements

When verifying modulation quality from the headend modulator or checking signal quality throughout the distribution network, the constellation display can provide invaluable information. After installation or adjustment of modulators, amplifiers or splitters, the constellation display will give a good indication of the "health" of the signal. For example, spurious interference will cause the constellation clusters to turn into rings and gain compression will cause the outer clusters to be pulled in towards the center.

When measuring the quality of the transmitted signal, it is very useful to see a graphical representation of the constellation. The 8594Q QAM analyzer carries out real-time demodulation and adaptive equalization to provide fast updating displays of the constellation and measurements. This fast update rate is critical for making system adjustments.

When troubleshooting, the constellation can help isolate problems. Examining the constellation will quickly show if only one or both I and Q signals are affected. If only one signal is affected it can indicate a problem in the

- I/Q modulators
- Baseband amplifiers and filters

These impairments can occur in either I or Q components of the signal and can therefore create different amplitude and phase distortions. The consequence is that the I and Q signals are distorted by differing amounts.

Figure 3 shows a measurement of a 64 QAM signal with I/Q imbalance using the 8594Q QAM analyzer.

Note how the constellation is not exactly square because the gain in the I and Q paths are not the same.

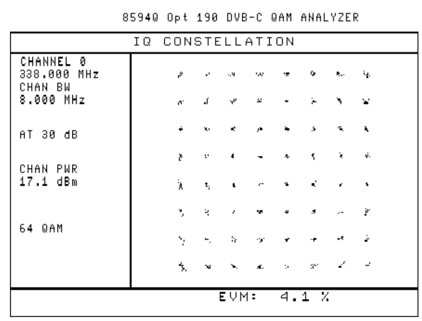

Figure 3: A QAM signal with I/Q imbalance

If both I and Q are affected equally it can indicate problems in the:

- IF amplifiers and filters
- RF amplifiers and filters
- Up/down converters
- Clock recovery circuits
- IF equalizers

Figure 4 shows the measurement of a 64 QAM signal with gain compression affecting both I and Q signals using the 8594Q QAM analyzer.

Note how the outer (higher amplitude) constellation points are pulled in towards the center whereas the central points remain virtually unaffected.

Armed with this qualitative information, you can start to make more detailed measurements to quantify and isolate the problem.

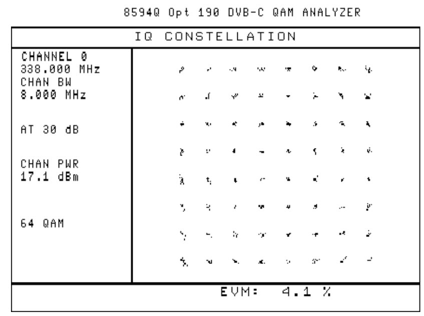

Figure 4: A QAM signal with gain compression

Quantitative Measurements

Average channel power

Maintaining the correct carrier power levels throughout your system is crucial in both analog and digital cable systems. Unlike the measurement of analog visual carrier level, average channel power in a digital system is a wide-bandwidth measurement. The 8594Q QAM analyzer carries out the measurement by sweeping the channel and taking an average of the power levels at each measurement point across the trace. When testing low-level carriers at the subscriber drop, the 8594Q QAM analyzer's built-in preamplifier may be switched in to provide additional sensitivity.

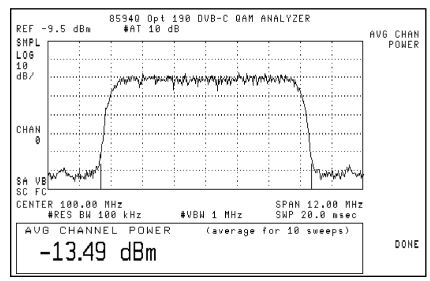

Figure 5: An average channel power measurement

Why it is important

To verify signal levels from the headend through the network.

Adjacent channel power

Transmission distortions can cause leakage of RF energy into the adjacent channels and therefore interfere with other digital or analog transmissions. The 8594Q QAM analyzer carries out this measurement using a similar technique to the average power measurement. An average power measurement is taken over all of the points of the frequency sweep in the upper and lower adjacent channels. These power levels are then compared to the average channel power in the transmission channel. The channel set-up can be changed to allow for adjacent 2 MHz, 4 MHz, 8 MHz, or custom channel bandwidths.

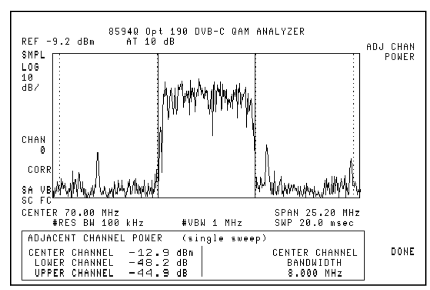

Figure 6: An adjacent channel power measurement

Why it is important
Measuring adjacent channel power ensures that the signal produced by the headend modulator will not cause interference problems with other channels.

MER (in-channel signal-to-noise ratio)
MER is a measure of the modulation impairments which will affect the ability of the receiver to recover the data bits. The measurement was proposed by to the DVB Standards Committee and has now been adopted in ETS 300-429. It is analogous to in-channel signal-to-noise in analog cable TV measurements. The 8594Q QAM analyzer compares the modulation error power to the average transmission power in decibels. When an averaged measurement is carried out, the 8594Q QAM analyzer generates a statistical display of the measurement results. The minimum, maximum, mean, and ninety percent confidence limit measurements are calculated and stored. This makes it easy to identify trends over multiple measurements.

$$\text{Modulation Error Ratio} = 10 \text{ X} \log \left(\frac{\text{average symbol power}}{\text{average error power}} \right) \text{dB}$$

Why it is important
MER indicates the total in-channel signal-to-noise ratio. It is a quantitative measurement of the quality of the data delivered.

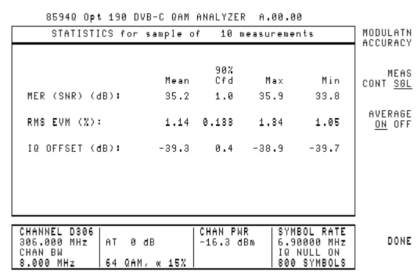

Figure 7: A statistical view of modulation quality measurements

EVM (Error vector magnitude)
EVM is the measurement of modulation quality of the transmitted signal before the forward error correction stage. EVM will indicate how much interference or distortion is present on the signal. If there is significant degradation on the signal, the constellation points will become unclear and the decoder may not be able to reconstruct the received signal correctly. The 8594Q QAM analyzer demodulates the QAM signal, equalizes and then calculates the average size of the error vector in relation to the maximum magnitude at a given symbol.

$$\text{Error Vector Magnitude} = \left(\frac{\text{r.m.s. error magnitude}}{\text{maximum symbol magnitude}} \right) \text{X } 100\%$$

Why it is important
To verify the quality of the signal before it leaves the headend and starts to be degraded by the network. It is also used to measure the signal quality at the subscriber drop to ensure that the customer's set-top box is able to demodulate and reconstruct the signal with adequate margin.

Equalizer response
The Agilent 8594Q QAM analyzer incorporates real time adaptive equalization. The response of the equalization filter may be examined in both frequency and time domains to help troubleshoot problems in your transmission medium.

Why it is important
The frequency response can be used to identify power “suck outs” in the channel. The impulse response can be used to identify echoes.

Symbol Error Rate vs. Carrier to Noise
Symbol error rate versus carrier to noise is a measure of how tolerant the digital signal will be to the addition of noise. The 8594Q QAM analyzer calculates the probability of the constellation points being misinterpreted at a given noise level. The probability of symbol error is plotted against the carrier-to-noise level. This operating point is displayed relative to the theoretical performance curve for 64 QAM.

Why it is important
This measurement is used to indicate how much the signal will degrade when noise is added. It is a particularly important measurement at the subscriber drop to verify that the noise added by the set-top box will not cause a large degradation in the signal.

Standard spectrum analyzer features
The 8594Q QAM analyzer contains all of the features of a standard spectrum analyzer. It can also be used for manual measurements on an analog channel or for searching for spurious signals.

The 8594Q may also be used as a general purpose 2.9 GHz spectrum analyzer. For signals under 1 GHz, low level spurs may be detected by using the built-in preamplifier.

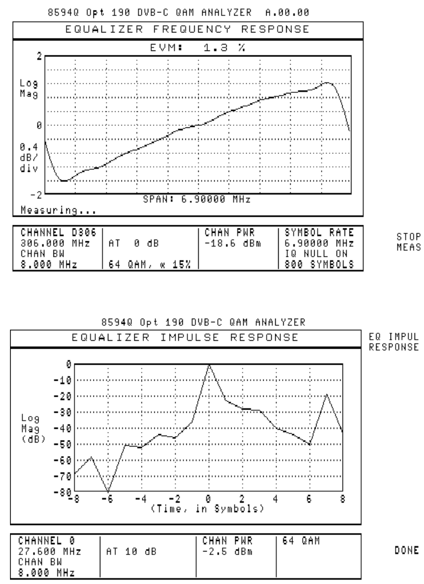

Figure 8: Using the 8594Q to look at the real-time equalizer response

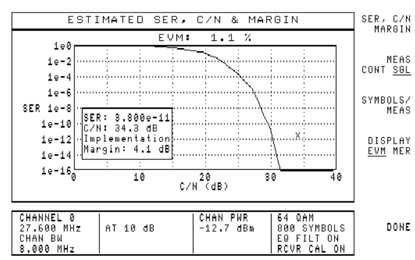

Figure 9: An estimated SER versus carrier-to-noise measurement

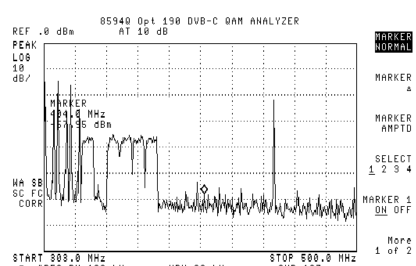

Figure 10: Using the 8594Q in spectrum analyzer mode to look at a range of analog and digital channels

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