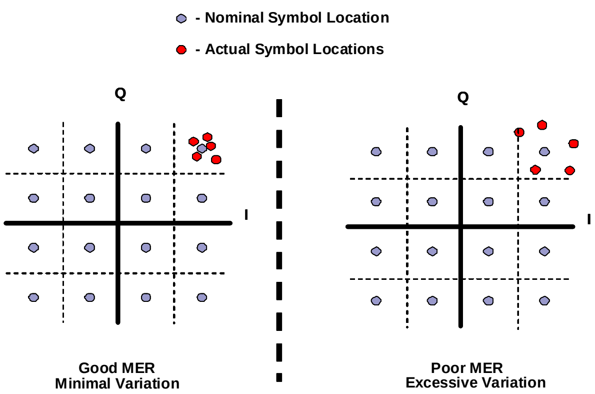
Application Note:
PathTrak QAMTrak Analyzer Functionality

Overview

Increasing customer demand for upstream bandwidth is a welcomed challenge for MSO's as it often stems from growth in profitable bi-directional applications like VoIP and advanced video services. A typical response to this increased demand is the addition of upstream carriers, resulting in a significant decrease in availability of unused spectrum to be used for traditional HFC maintenance and troubleshooting activities. The bursty nature of these DOCSIS carriers further hampers traditional monitoring and troubleshooting techniques, and with the looming addition of upstream channel bonding these challenges will only become larger. To address this, JDSU has implemented the QAMTrak™ analyzer including MER measurement capabilities for PathTrak™ Return Path Monitoring Systems containing RPM3000 cards. Based on JDSU's exclusive LivePacket™ technology, QAMTrak enables us of both in-service packets from live revenue-generating carriers or injected out of band carriers for measurement and diagnostic purposes.

Definition: MER (Modulation Error Rate):

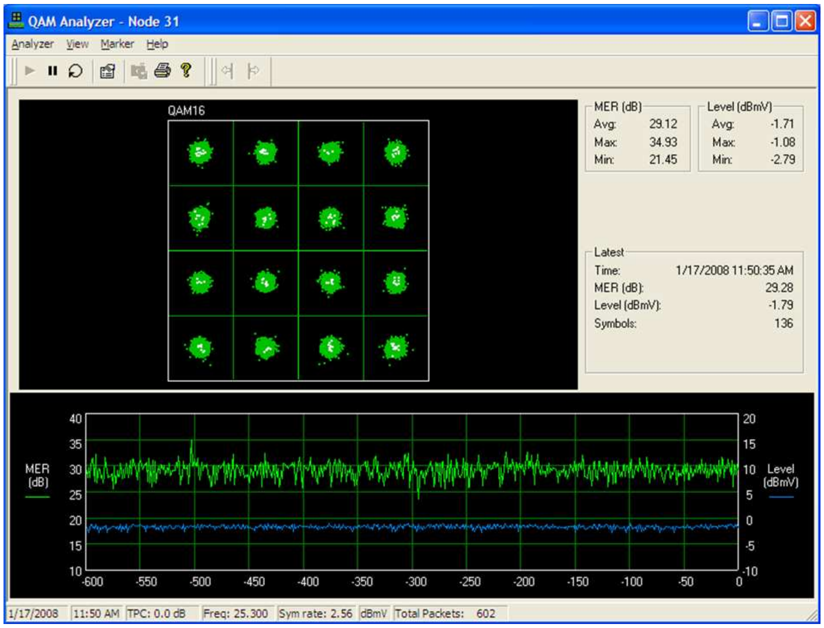
MER is an indication of variation in actual symbol location within a constellation relative to their nominal location (See Figure 1). Due to the "Digital Cliff" effect, a digital carrier will often not show signs of degradation until very near the point of carrier failure. MER quantifies how much margin a carrier has before this failure occurs and is therefore critical to measuring carrier health.



While many factors can impact the true performance of a digital carrier, the **unequalized** MER values below are a good rule of thumb for minimum value required for performance and minimum targets for acceptable carrier performance:

Modulation Scheme	Functional Minimum	Suggested Certification Min
QPSK	12dB	15dB
16 QAM	18dB	21dB
64 QAM	27dB	30dB

QAM Analyzer Overview



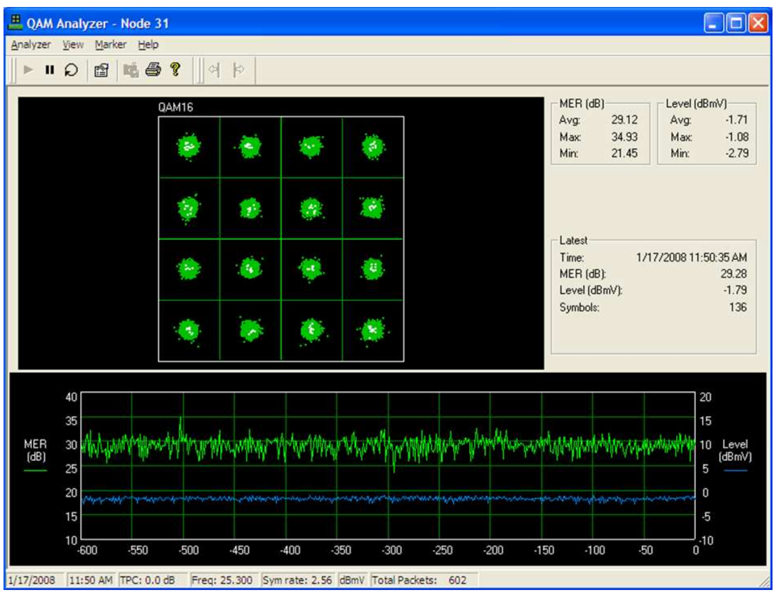
This application note will demonstrate use of the PathTrak QAM Analyzer (QAMTrak) in both PathTrak Client and WebView^{TM}. While the screen shots used will be a mix from the two programs, their operation is very similar as is the content of their output. The slight differences in format of the output should not affect how the tool is used to identify and troubleshoot difficult HFC impairments.

The Constellation Display
  - The white points are the last packet demodulated or currently selected packet in a paused display
  - The Green points are all of the packets that have been demodulated.
  - The number of grids on the constellation changes with the type of modulation selected

- Statistics at the top Right
  - MER (dB)
    - The average, minimum, and maximum unequalized MER for all packets captured in this session (or since reset)
  - Level (dBmV, dBm or dBuV)
    - The average, minimum, and maximum Level for all packets captured in this session (or since reset)
    - This can give an indication if the plant contains modems that are transmitting with RF power too high or too low. This may cause demodulation issues at the input of the CMTS resulting in communication failure.
      - RF power too high – can lead to laser clipping or saturation
      - RF power too low – can leave modem susceptible to noise
      - Low RF levels may indicate modems incapable of reaching CMTS at requested level due to in-home wiring (most likely) or plant alignment issues
      - Oscillating levels may be indicative of a rapidly changing RF plant due to such issues as loose center seizure screw, cracked hardline, etc

        - If many modems are transmitting too high this can be a symptom of a CMTS line card issue

    - Latest
        - Shows the time that the packet was captured
        - The unequalized MER of the packet
        - The receive level of the packet
        - The number symbols captured in the packet.
    - This display is updated when the analyzer has captured the minimum required number of symbols or at most 2 times a second if the node is very active
    - This display is also useful when the analyzer is paused. You can move the marker in the strip chart and get the data from any packet captured.
    - QAM analyzer sessions can be exported for later offline analysis (see PathTrak Users Manual for details)



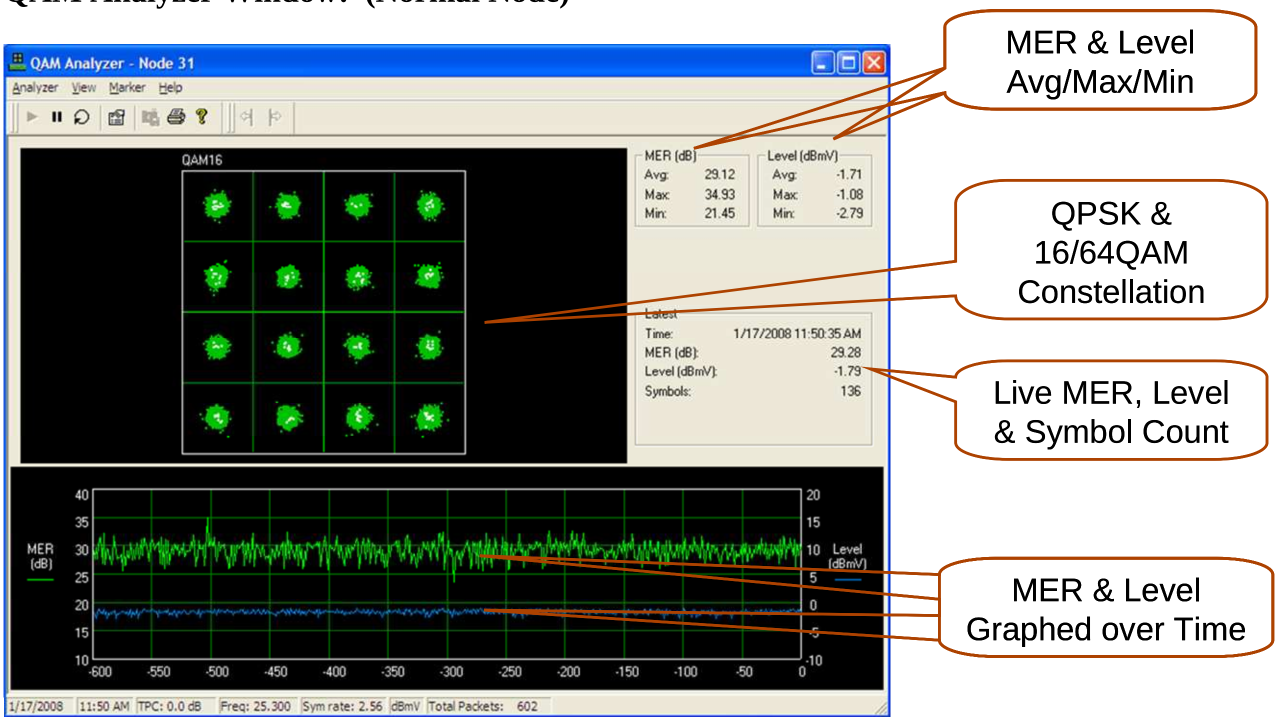
- The strip chart shows the general quality of each sample taken (MER and Level are displayed).
    - Graphing starts with the most recent symbol on the right edge of the screen.
        - As the symbols get older they move to the left.
        - Statistics from the last 600 demodulated packets are displayed

    - MER
        - The green trace represents the unequalized MER
        - The MER scale is on the left side
        - Fluctuations in MER independent of fluctuations in level indicate that the impairment is most likely ***NOT*** CPD or constant Gaussian noise since these impairments are “constant” over a short time interval and would affect all packets of the same amplitude equally. Impairments in this case are more likely indicative of linear impairments such as group delay, microreflections, or laser clipping

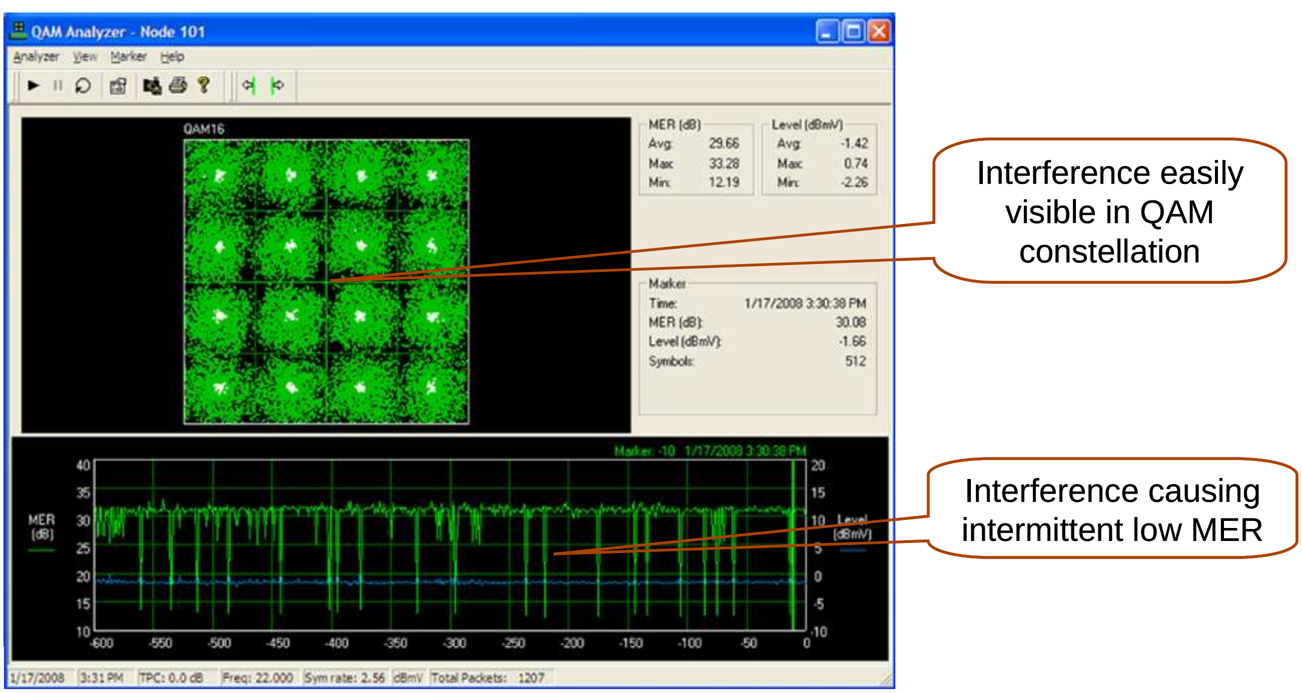
    - The Level scale is on the right side
        - This is the power of the entire carrier

Below are examples of normal and bad node as viewed on the QAM analyzer. Note the differences in the constellation display and MER strip charts.

QAM Analyzer Window: (Normal Node)



QAM Analyzer Window: (Bad Node)

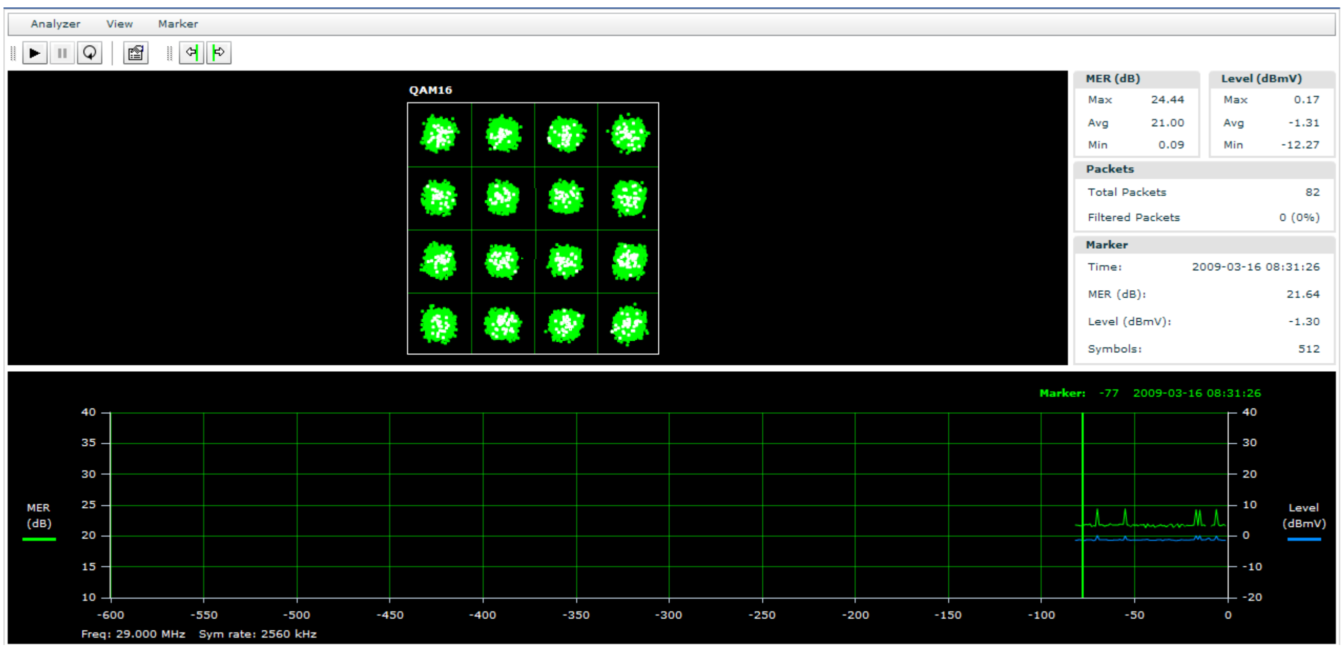


Common Impairment Footprints As Viewed on QAM Analyzer Screen

Several common impairments tend to reveal themselves on the constellation display which can help determine the cause of the reduced MER levels. Below are examples of several of these common impairments and their footprints.

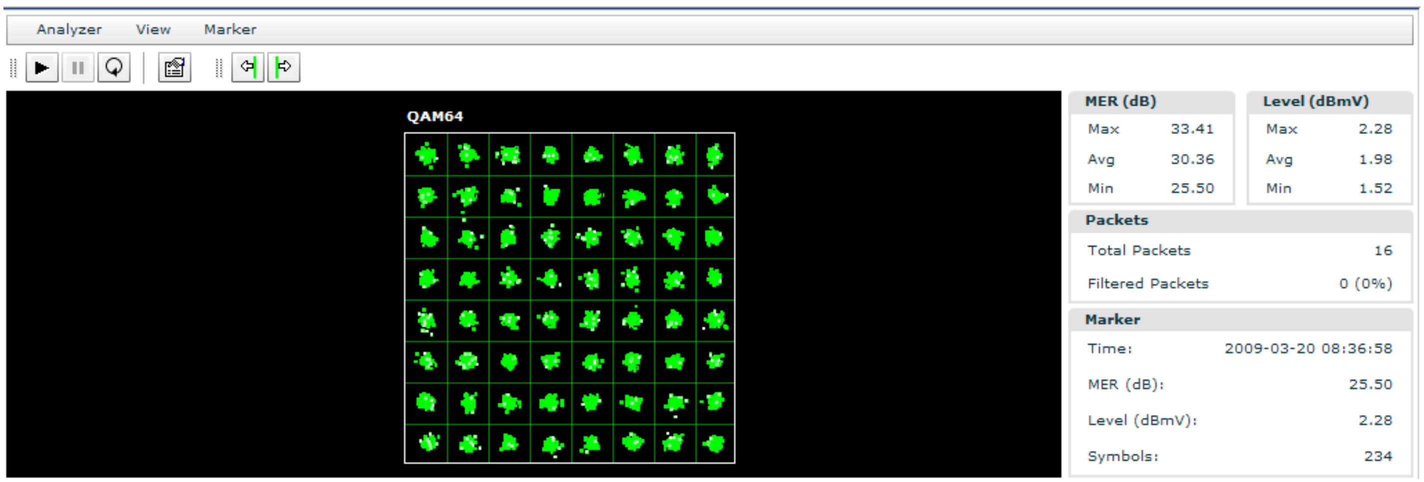
Gaussian Noise/White Noise

- Display will generally have a random pattern for affected packets
    - Increased variation in symbol location will cause constellation display to “bloom”
    - Often a majority of packets will be affected, packet to packet variation will be minimal
- This is perhaps the most common type of impairment
- Usually caused by ingress into HFC
- Most common source is between tap and CPE, can also be corroded connectors, poor termination, or other outside plant impairments
- Viewing exported or paused constellation views packet by packet can yield clues as to similarities between the footprints of low MER packets



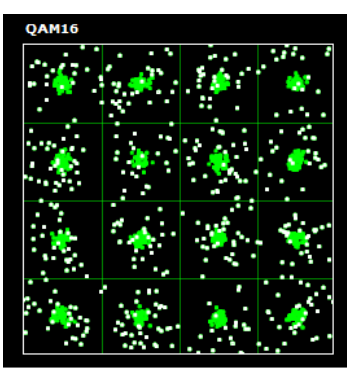
Impulse Noise

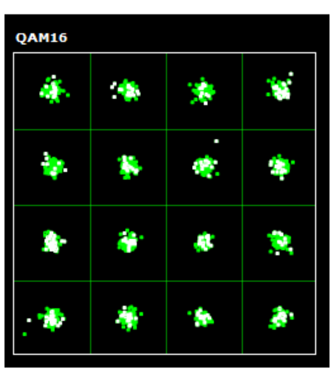
- Display will sometimes show just a few symbols randomly scattered when impulse noise is present
- Impulse noise may also manifest as a single burst with much greater than average random variation across all symbols
  - Note the white dots in the WebView screen capture below (The last packet captured)
  - This pattern is likely the result of an impulse noise issue



The packet's MER (25 dB) is below the functional minimum for 64QAM (27dB), but the MER for the overall session is well above functional min (27dB) and just above the certification min (30dB). Impulse noise can have a severe impact on individual bursts while allowing overall carrier MER to remain above specification due to its transient nature. Also note that because MER is a measurement averaged over the whole packet, impulse noise affecting just a few symbols may not severely degrade the MER for that packet.

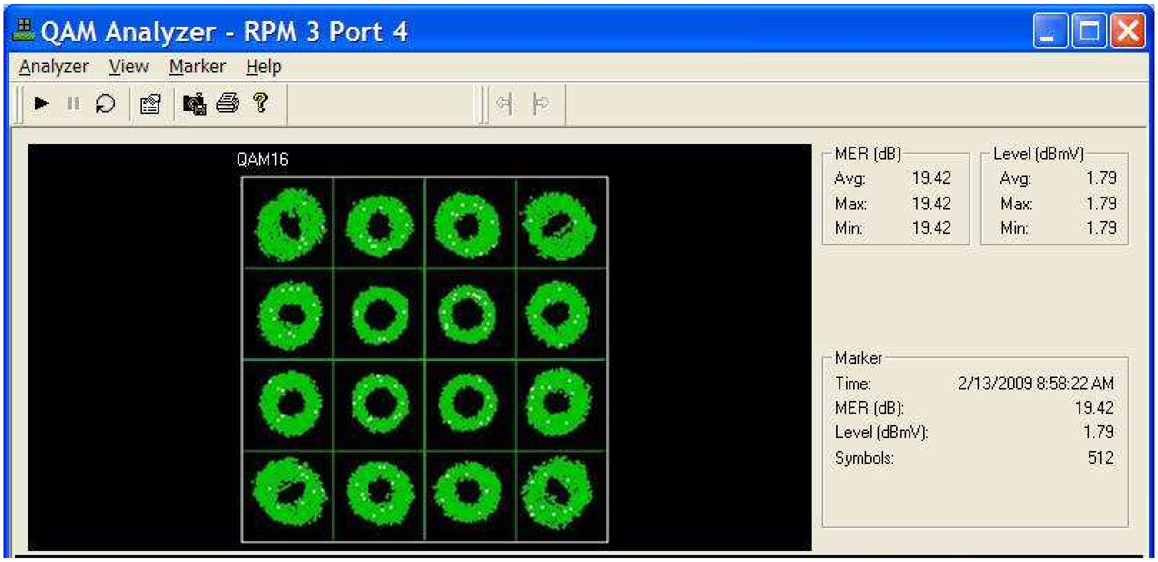
Other examples of impulse noise constellations:





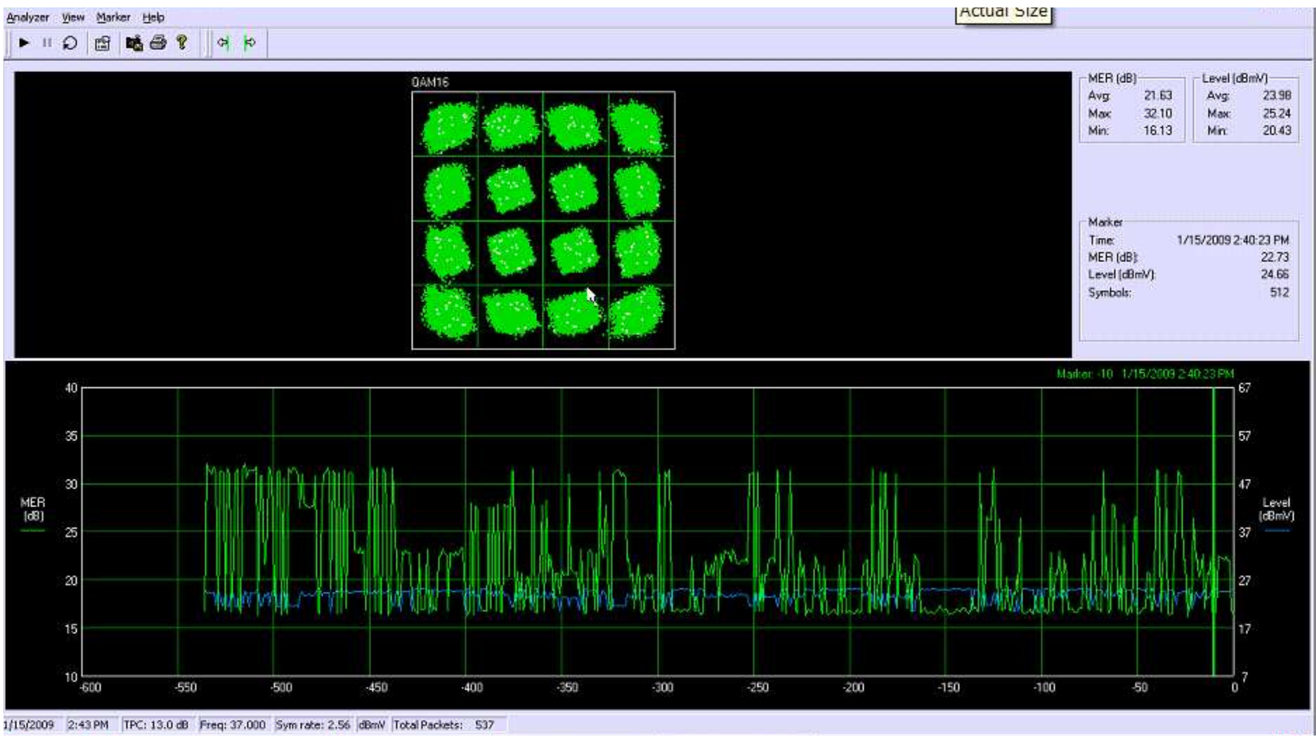
Coherent Interference

- If the accumulation looks like a “donut”, the problem is likely coherent interference
  - Often caused by off-air ingress such as citizens band radio, shortwave radio, or other AM-based ingress sources
  - May also be caused by FSK signal



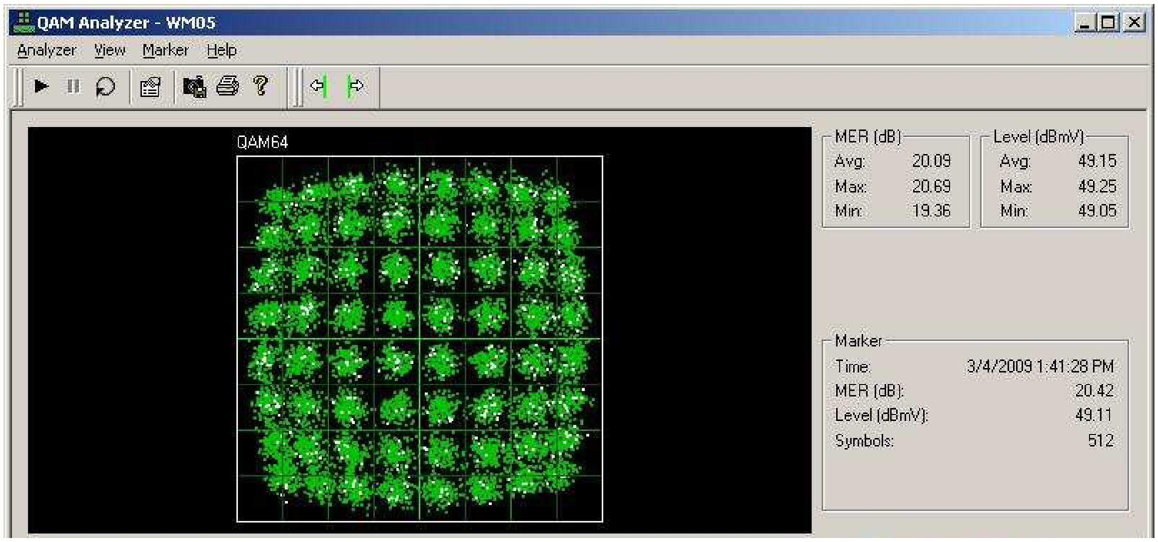
Group Delay / Microreflections

- If the accumulation takes on a diamond shape, the problem is likely a group delay issue
  - Constellation may take on a diamond or square shape
    - Clarity of diamond shape will vary with percentage of packets affected
  - Microreflections are a common cause of group delay
  - Often caused by unterminated or improperly terminated lines or faulty CPE (cheap TV or VCR)
  - Group delay can also result from a carrier placed too close to the band edge of the diplex filter



Amplifier Compression / Laser Clipping

- Amplifier compression often manifests as rounding of the corners of the constellation
- Laser clipping often manifests as increased spread in the corners of the constellation
- These are caused by overdriving an amplifier or laser usually due to ingress or misalignment (unity gain)
- May become more prevalent as more DOCSIS upstream carriers are added



Amplifier Compression Constellation

Laser Clipping Constellation

Troubleshooting tips for in-band HFC issues

While most experienced cable service and maintenance techs are familiar with traditional divide and conquer troubleshooting techniques for linear impairments such as simple ingress, CPD, and impulse noise, problems resulting from linear impairments such as group delay create new challenges. Below are some troubleshooting techniques which can be utilized with your existing PathTrak toolset to help pinpoint the nature and location of these impairments.

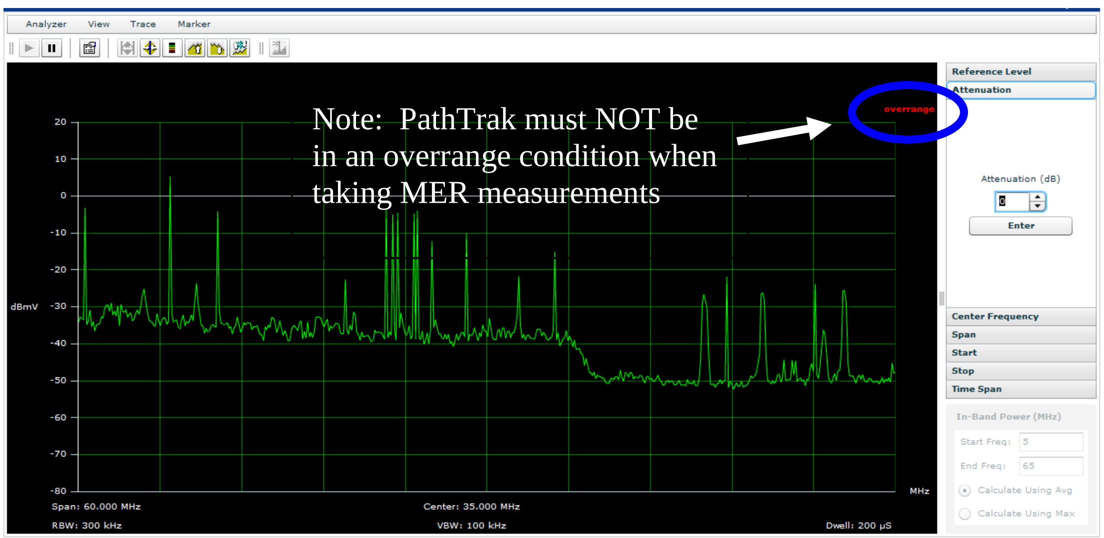
The first troubleshooting technique is field insertion of a QAM carrier using your DSAM then demodulating at the headend with your RPM3000 card. If your DSAM is equipped with the optional Return QAM Generator feature, you can use a traditional divide and conquer strategy of inserting an out of band carrier from different points in the HFC plant and quantifying the impact of the impairment on the particular portion of the plant that you have isolated. The MER measurement and constellation can be viewed in the field using WebView on a wireless-equipped laptop. Once the offending portion of the plant has been identified and the root cause addressed, the same insertion technique can be used to verify the fix was effective.

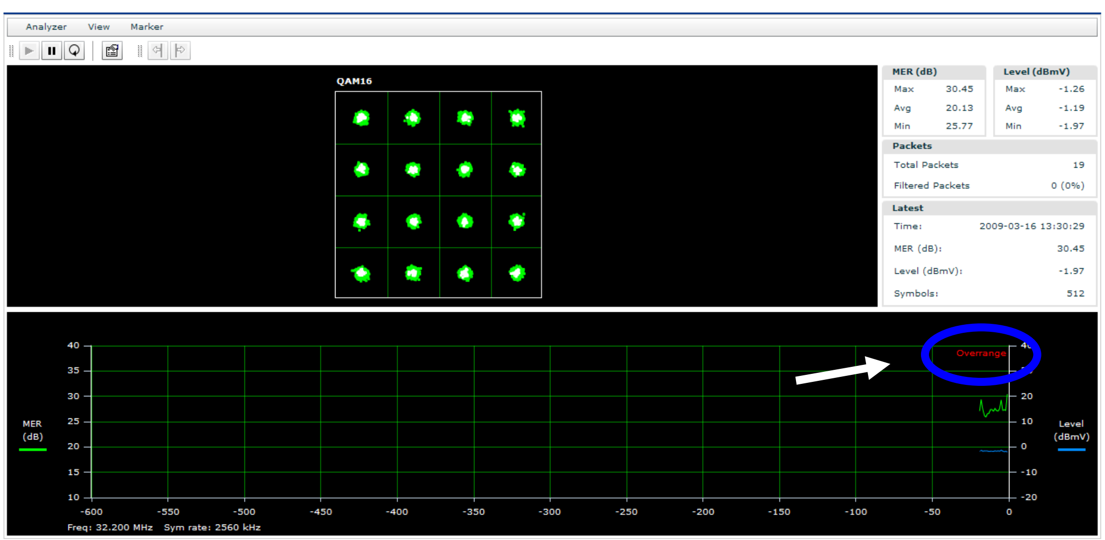
This same insertion technique can be used to verify currently empty spectrum is truly available for turn-up of additional QAM carriers. Injection of a QAM carrier at different points of the plant ensures that there are no linear impairments which would prevent the new carrier from operating. By reviewing historical PathTrak monitoring data for the area of spectrum in question, one can also determine the worst-case noise floor which could impact the service.

Proper RPM3000 Card Setup for MER/QAM Analysis

When specifying carrier level in the QAM analyzer properties window, it is important to have the level correct within +/- 5dB to achieve accurate MER values.

It is critical that the RPM3000 card have the appropriate attenuation settings to achieve accurate MER readings. When the spectrum is viewed in either PathTrak Client or WebView there should not be an overrange error present. If the overrange error is present, add attenuation to the port via the Port Properties screen until the overrange is gone (See PathTrak Users Manual for details of changing port settings.) ***Note: changing attenuation in the PathTrak Client or WebView spectrum analyzer windows will not fix the overrange issue***

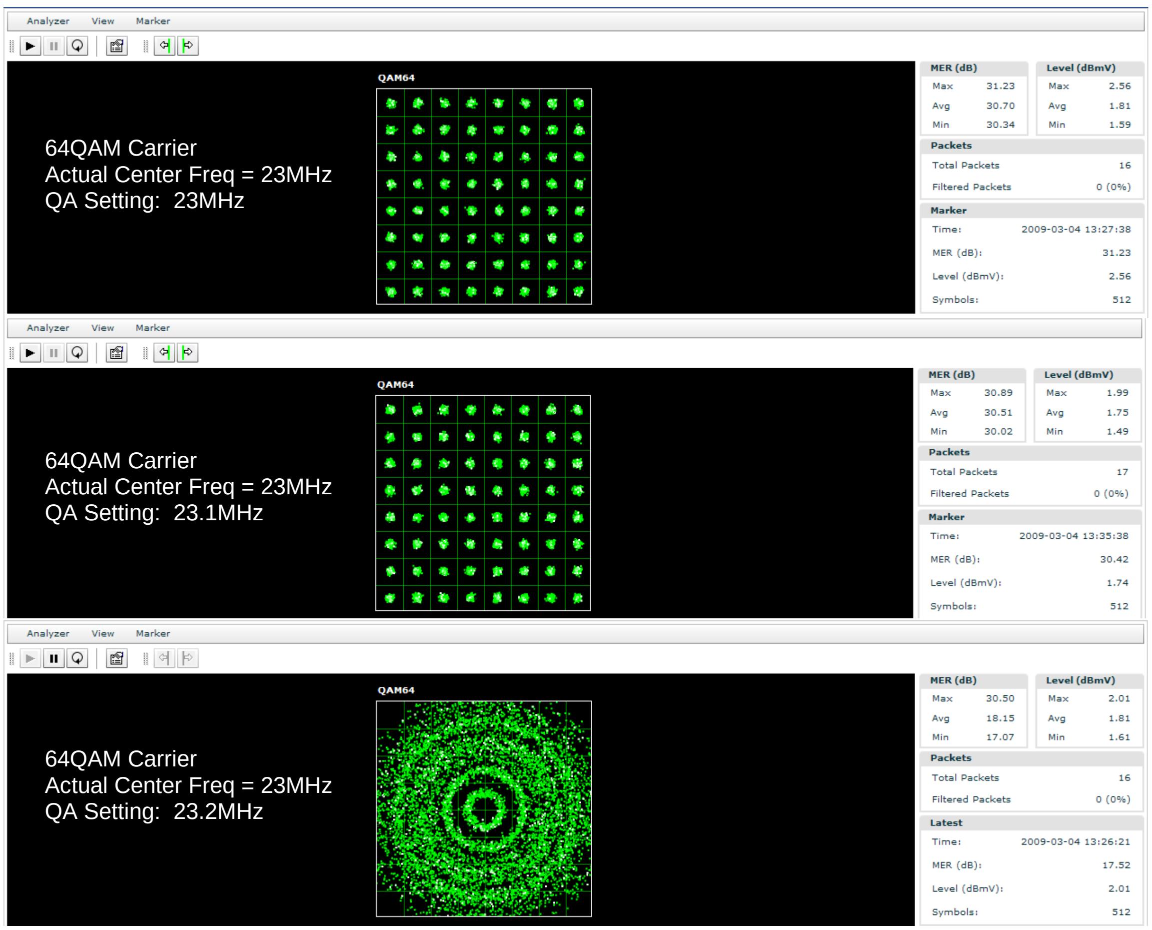




Other QAM Analyzer Setup Considerations

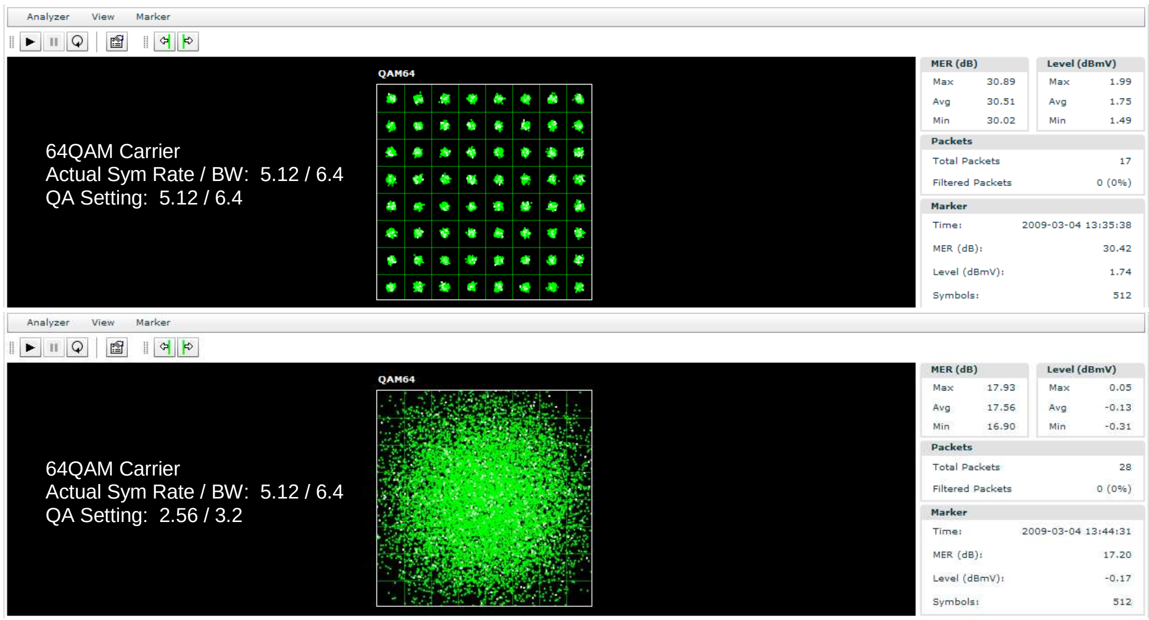
Carrier Center Frequency

At times if the upstream carrier frequencies are not known one must estimate their center points using the max hold trace of a spectrum analyzer session. If the center frequency is not specified correctly the QAM analyzer may demodulate some packets but the constellation will often appear as a circular pattern. The example below demonstrates the impact on constellation display with an error of >100 kHz from the true carrier center frequency. For RPM3000 firmware version 1.10 or higher, the center frequency must be correct within ~2% of the symbol rate. This equates to 100kHz for 5.12 MSPS, 50kHz for 2.56 MSPS. For earlier versions of firmware the center frequency tolerance requirement is tighter by approximately 50%. For this reason alone is strongly recommended that all RPM3000 cards be upgraded to the latest firmware to allow the QAM analyzer to operate properly.



Incorrect Symbol Rate / BandWidth

Similar results can occur if the incorrect symbol rate / bandwidth is chosen. The example below demonstrates the result of selecting the incorrect settings for a 64QAM carrier.



Incorrect Mode (Applies to Pre-V1.10 RPM3000 Firmware only)

The screen shots below demonstrate the result of an incorrect mode being chosen in the QAM Analyzer Properties window using the **WebView QAM Analyzer**. Selection of the incorrect mode in PathTrak Client will result in no constellation display at all.