Case Study

Case Studies Show That Return Spectrum Monitoring is Not Enough

Along with changing upstream technology, the VIAVI PathTrak™ Return Path Monitoring system has evolved. As the following real-world examples will show, the latest MACTrak™ performance monitoring features deliver exceptionally sharp troubleshooting insight. They also demonstrate that looking beyond spectrum analysis and focusing on the overall health of active upstream carriers can help system operators prioritize service calls based on customer-affecting issues, shorten repair time, and improve customer experience.

Case Study #1: Poor HSD/VOIP Service Quality/Availability

A cable company received multiple complaints from customers on a specific node regarding intermittent phone and Internet outages. Also, when the services did work, intermittently the quality was poor.

The cable company's first troubleshooting step was to observe the spectrum. Figure 1, shows some ingress at the low end of the spectrum on the PathTrak spectrum analyzer. Ingress in the return spectrum is very common and, therefore, did not indicate a specific cause for these issues.

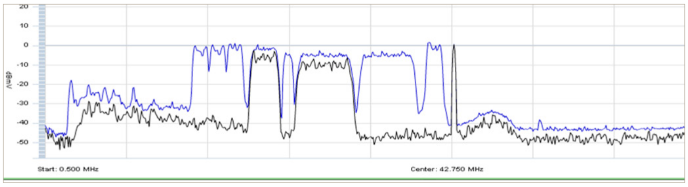

Figure 1. Upstream spectrum

The cable company then checked the MACTrak performance view, which showed a degraded equalized and unequalized modulation error ratio (MER) when customers were experiencing problems. Figure 2 shows the live QAMTrak™ analyzer view with a single media access control (MAC) address that appeared frequently on the node when performance degraded. While the performance of this modem was not significantly different than others on the node, it was consistently present when node performance dipped.

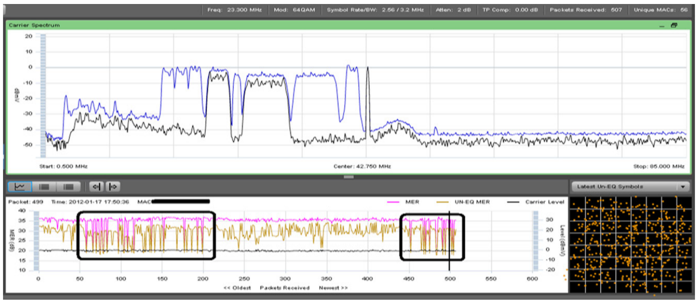

Figure 2. Intermittent degraded MER

Resetting the modem stabilized the MER until the modem came back online, as Figure 3 shows. Occasionally, the modem would come back on line, but on a different upstream carrier, followed by poor carrier performance. Therefore, it was determined that the modem was negatively affecting whichever carrier it was on.

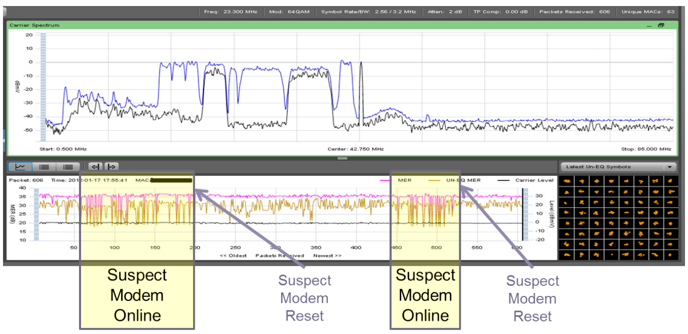

Figure 3. Improvement after resetting the modem

After replacing the problematic modem, the MER stabilized permanently on all of this node's upstream carriers, as shown in Figure 4, and permanently resolved the intermittent service issues affecting other customers on the node. It was determined that the faulty modem transmitting outside its Data Over Cable Service Interface Specification (DOCSIS®) time slot and colliding with other modems transmitting within their time slot was the root cause for the other modem(s) to go offline intermittently. This collision would randomly cause intermittent poor service for several customers on multiple upstream carriers on this node. Using MacTrak performance monitoring and the live QAMTrak analyzer helped the cable company quickly resolve an issue that would have otherwise taken a lot of time and caused a lot of frustration, and it avoided losing customers because of poor service quality.

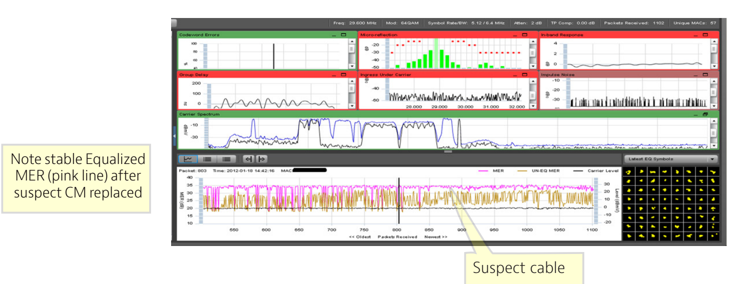

Figure 4. Equalized MER improved after replacing modem

Case Study #2: Excessive Codeword Errors on Node

Customer modems were experiencing excessive codeword errors on a specific node. The cable modem termination system (CMTS)/customer premises equipment (CPE) polling data indicated that there was degraded port signal-to-noise ratio average (SNR Avg)/equalized MER. Further analysis revealed that many, but not all, cable modems were affected and it showed some corrected/uncorrected codeword errors but did not indicate the cause. Even though the transmit and receive levels were good, customers were still impacted, without evidence for the cause. Figure 5 shows the spectrum view and some low-end ingress, but whether it is the issue remains unclear.

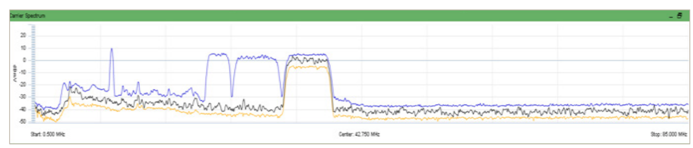

Figure 5. Spectrum showing low-end ingress

At first glance, the channel in-band response appears very poor, but the total response variation is less than 1 dB. It appears worse than it actually is in Figure 6, because the amplitude scale was set for high sensitivity when the screen capture was taken.

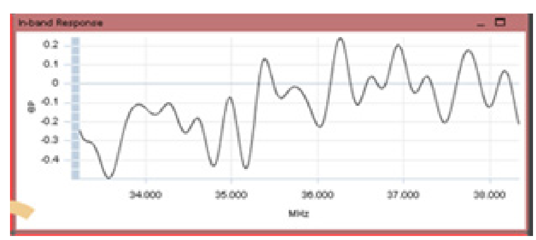

Figure 6. In-band response, less than 1 dB, but appears worse – vertical scale

Reviewing the ingress under carrier display shows an obvious interfering transmission, as Figure 7 shows. In the live QAMTrak analyzer session, scrolling back through previously captured packets, with and without codeword errors, revealed a correlation between the errors and the presence of the ingress under the carrier.

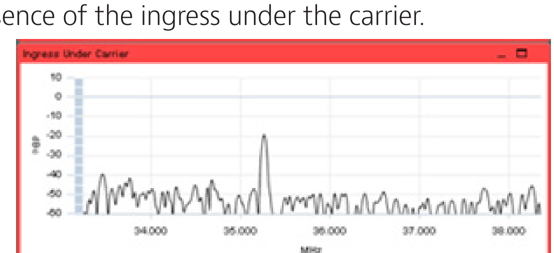

Figure 7. Obvious ingress under the carrier

As a temporary resolution, the cable company moved the carrier to another spectrum location which dramatically reduced the codeword errors. The spectrum display in Figure 8 reveals that the ingress signal remained present during some of the modem bursts, but it does not appear in the minimum-hold trace, shown in yellow. This analysis clearly indicates a bursty ingress signal and it explains why good and bad packets exist.

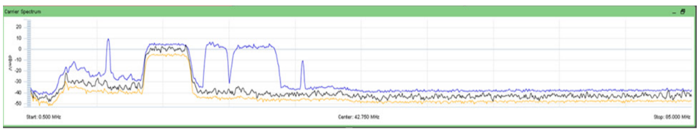

Figure 8. No ingress visible in minimum-hold trace - intermittent

Troubleshooting revealed that the ingress signal was caused by an illegal hookup tapping into a 3-way splitter, which allowed off-air interference into the network. Correcting this situation eliminated the codeword errors, significantly improving the MER. The low-end ingress remained a problem; however it was not the problem. This case study illustrates the powerful troubleshooting capability of evaluating refined details about each modem burst captured precisely during individual packet demodulation. These refined details include spectrum display, constellation, ingress under the carrier, as well as linear impairment charts. Service-level parameters, such as equalized and unequalized MER and codeword error counts per packet, are also captured for more in-depth troubleshooting analysis.

Case Study #3: Another Codeword Error Example

In another case, “the worst” offending node was identified based on the MACTrak node performance index ranking, shown in Figure 9.

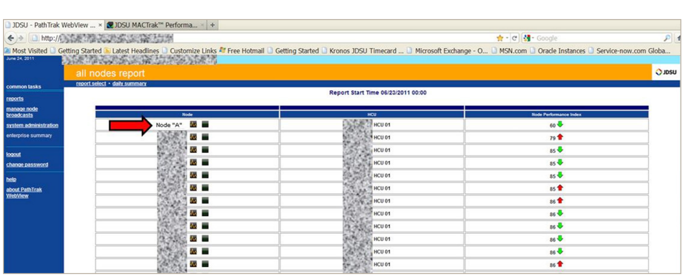

Figure 9. Node performance index ranking

Clicking on the node gives a 24-hour node summary, as shown in Figure 10.

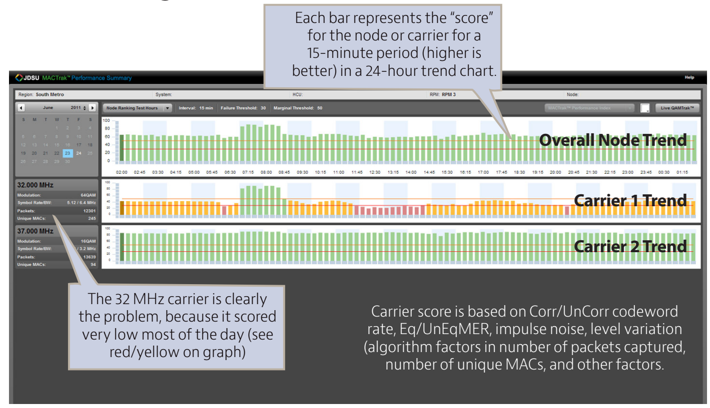

Figure 10. 24-hour node summary shows problem carrier

Clicking one of the bars in the graph will display a spectrum summary for a 15 minute period. The cause of the poor performance is clearly seen in the historical spectral shots during the periods with degraded performance (Figure 11).

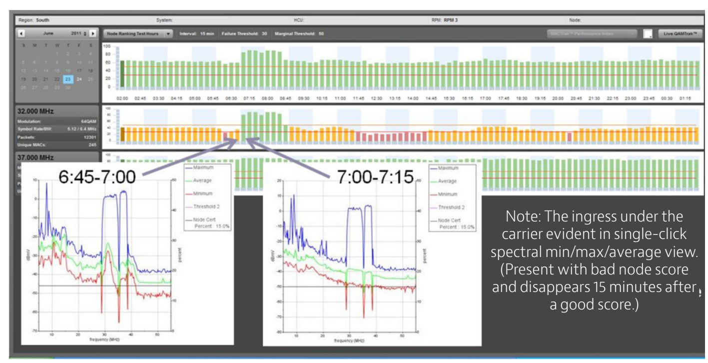

Figure 11. 15-minute spectrum summary display

Double-clicking any bar on the node summary reveals packet-by-packet details shown in Figure 12. Clicking on a transition period from bad performance to good shows a dramatic change in equalized MER and codeword error rates.

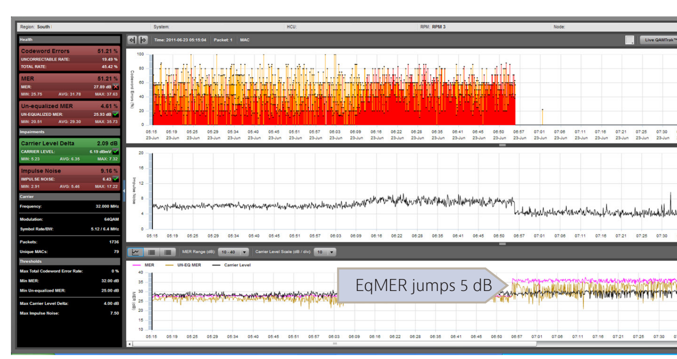

Figure 12. Codeword error cleanup

Case Study #4: Codeword Errors at Regular Intervals

One customer experienced fluctuating codeword error rates between 0 and 80 percent at fairly regular intervals. Observing the spectrum during the high-error rates showed no obvious issues, as seen in Figure 13.

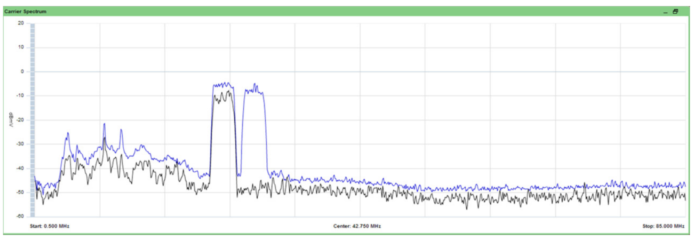

Figure 13. The spectrum showed no obvious anomaly during high error rates.

The CMTS data yielded no clues, because all modems were affected equally. The problem was apparent when the user opened the PathTrak live QAMTrak analyzer, shown in Figure 14.

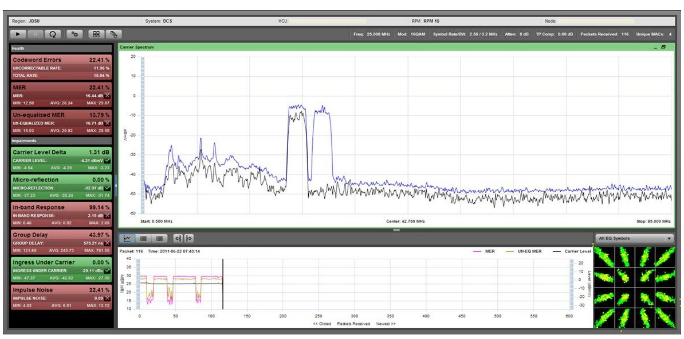

Figure 14. Constellation and MER chart reveal the problem

Comparing the spectrum and constellation displays of good and bad packets, shown in Figure 15, the constellation displays clearly indicate a problem, while

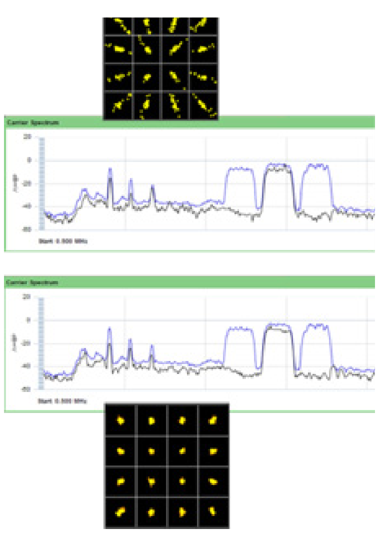

Figure 15. Spectrum vs. Constellation

the spectrum displays look virtually identical. However, a relatively clean spectrum above the diplex filter, shown in Figure 16, seems to rule out laser clipping

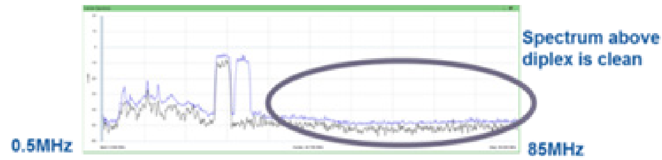

Figure 16. Clean above diplex

Furthermore, checking optical power levels showed they were within specification. The problem was traced to a faulty optical receiver. Redundant optical receivers in the headend contributed to the intermittent codeword errors when switching between primary and secondary receivers.

Case Study #5: Poor Modem Performance

Customers on a node intermittently experienced slow modem speeds and connectivity. Plant-related issues could not be identified. The upstream spectrum in PathTrak showed no ingress or other visible distortions, and node utilization was good. A QAMTrak session indicated that several modems had high group delay, micro reflection, and in-band response issues, as shown in Figure 17. The worst offenders identified by MACTrak were correlated with street addresses and plotted on a plant map to find a common point. This analysis helped discover a defective amplifier which was replaced, resulting in overall improved performance and eliminated the intermittent issues.

Figure 17. Group delay improvement

Case Study #6: Slow Modem Speeds and Connection Problems

Customers on a particular upstream carrier experienced slow speeds and connectivity problems. The cable company's basic DOCSIS CPE tools did not reveal any obvious impairment and the upstream SNR/MER averages were 36 dB. The CMTS data node health indicated good SNR, which is often determined by quadrature phase-shift keying (QPSK) station maintenance packets and not the 16 or 64 quadrature amplification modulation (QAM) data packets. A high codeword-error rate was also present, but it failed to present the root cause of the problem. Technicians swept the plant and found very high packet loss and delay at the fifth cascaded amplifier. Similar results were observed on another cascade on the same node.

The PathTrak QAMTrak analyzer showed poor equalized and unequalized MER for this node which could also be seen in the constellation display, shown in Figure 18. Some packets had good MER (upward spikes on strip chart) which were from modems located at more shallow points in the cascade.

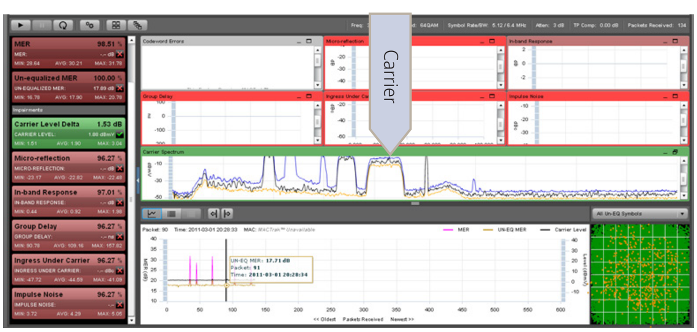

Figure 18. Session viewing carrier closest to diplex filter

Focusing on the lower-frequency carrier, farther from the diplex filter edge, revealed much better constellation and MER, but linear distortion remained poor, as seen in Figure 19. A correlation between the billing data and MAC addresses from MACTrak indicated that five amplifiers deep in cascade, modems packets were marginal but adequate on this carrier.

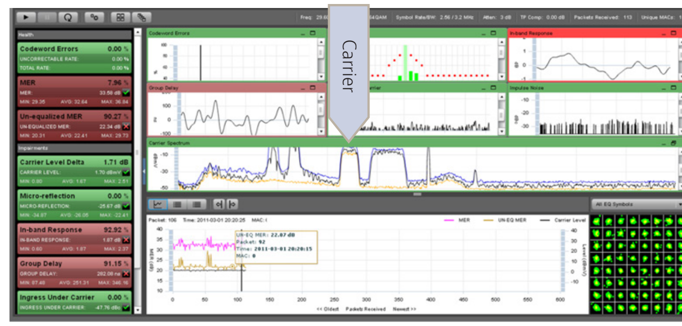

Figure 19. Lower-frequency carrier performs better

MACTrak troubleshooting clues indicated the carrier closer to the diplex was experiencing greater impact than the lower-frequency carrier, and modems deeper in the cascade were affected more heavily than the shallow ones. After the technician notified data engineers about the MACTrak troubleshooting clues, they analyzed the node and discovered that a CMTS configuration file had inadvertently disabled pre-equalization. Without pre-equalization, modems could not correct for group delay in the longer amplifier cascades. Using MACTrak to quickly identify the symptoms as non-HFC-related, it pointing to the real source of the problem and enabled issue resolution in minutes. MACTrak troubleshooting reveals the true cause of customer-impacting issues increasing technician efficiency. The following dashboard samples in Figure 20 show dramatic improvement after the fix.

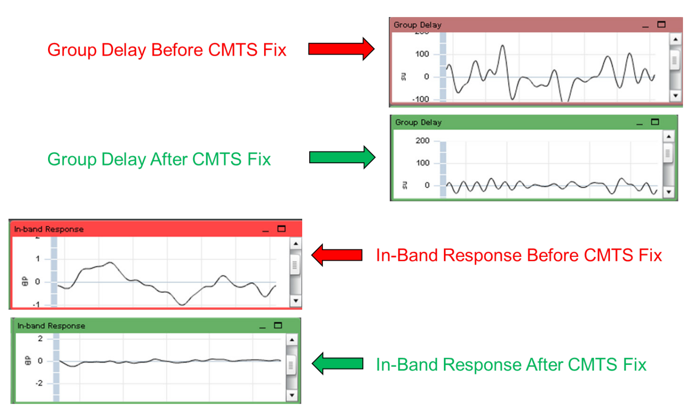

Figure 20. Dramatic improvement after the fix

Case Study #7: Laser Clipping

A cable company technician noticed a laser clipping signature in the equalized constellation, as shown in Figure 21. Even more interesting, however, was that the noise floor was drastically elevated every time two carriers transmitted simultaneously. However, as Figure 22 shows, the common sign of aliased carrier "humps" did not appear in the spectrum at the carrier harmonic frequencies.

Figure 21. Constellation shows distortion (corners extending)

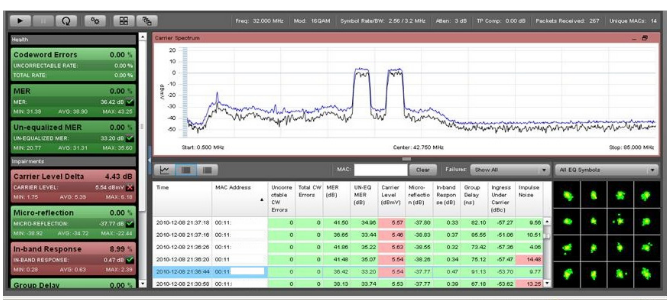

Figure 22. Elevated spectrum noise floor during simultaneous transmission

This node included combined node returns each on one fiber with a different frequency. After injecting a carrier and measuring the optical level in the headend, the technician discovered that padding was being applied in the headend and not in the node. The problem disappeared after moving the 5 dB padding to the node at the input of the return laser, as shown in Figure 23. This is only one of many examples illustrating the power of capturing measurements beyond spectrum analysis, including constellation and spectral appearance at the exact instant of packet demodulation.

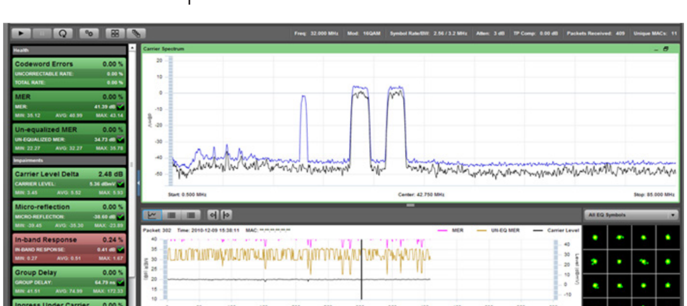

Figure 23. Clean constellation and spectrum after fix

Case Study #8: Failed VoIP Node Certification

A system performing node certification tests in preparation for a telephone services launch failed to pass return path certification for node "A", even after system balancing. The next troubleshooting step was to conduct and analyze a short-term packet capture. Figure 24 shows the results.

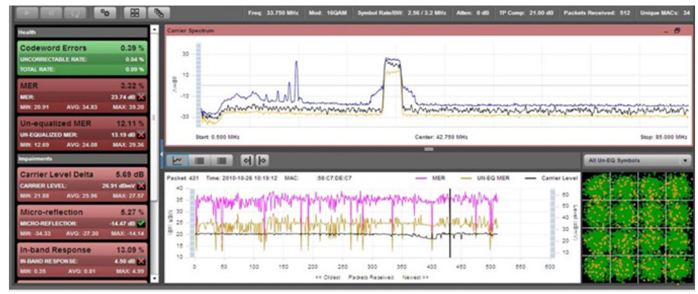

Figure 24. Short-term packet capture analysis

From this capture, several suspect modems were localized using the MAC address. The downward spikes in the MER strip chart in Figure 25 indicated bad packets, the pink line is equalized MER, and the brown line is unequalized MER.

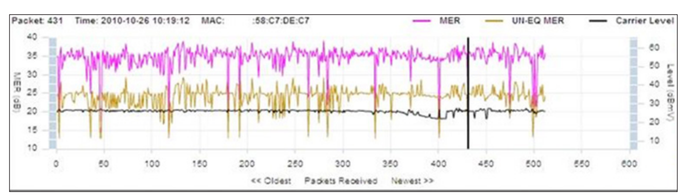

Figure 25. MER chart for a specific MAC address

As Figure 26 shows, the first modem in the radio frequency (RF) path was verified from the subscriber's tap and confirmed to be good before the work began, indicating that the problem was located south of the tap.

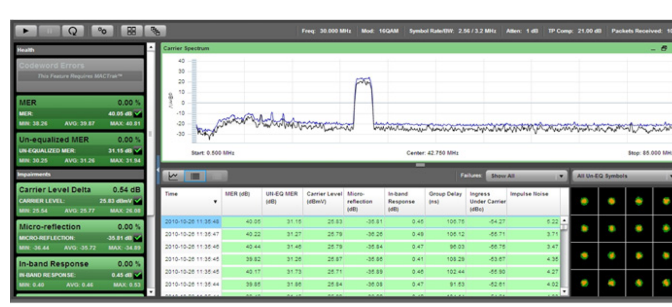

Figure 26. Analysis at tap

Some typical in-house issues, such as loose or poorly made RF connectors or old passives, were discovered and repaired. More customers located downstream had similar issues. After addressing these home network issues, the node performed very well.

Conclusion

These real-world examples clearly show that simple return-spectrum monitoring, while important, does not provide all the information needed to determine the root cause for service-affecting issues, leaving technicians in the dark regarding troubleshooting. With the increased visibility that MACTrak performance monitoring provides, cable systems providers can efficiently improve return-path performance. Cable systems providers can concentrate their efforts on customer-affecting issues and rapid troubleshooting, thus shortening repair times and maintaining or even increasing customer satisfaction. For more information about PathTrak and MACTrak performance monitoring, contact your VIAVI representative or visit our website **www.viavisolutions.com/PathTrak**.

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