NIMBLE THIS PROACTIVE NETWORK MAINTENANCE AND COMSONICS SIGNAL LEAKAGE TOOLS

A Valuable System for Isolating RF Impairments that Radically Aid Drop and In-Home / Near Home Issue Resolution

A TECHNICAL WHITE PAPER BY:

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TIME IS VALUABLE

Nimble This Proactive Network Maintenance (PNM) is very effective at identifying subscribers' homes that are suffering RF impairments. This is done by looking at the cable modem's pre-equalizer and determining the amount of compensation the modem is doing in order to overcome upstream impairments. Additionally, full band capture-capable DOCSIS 3.0 modems provide visibility to downstream impairments such as RF ingress, suckouts and other anomalies that will eventually impact the subscriber. By analyzing these metrics, the Nimble This PNM system is able to proactively identify subscribers' homes that are likely to experience issues in the near future. In addition, these homes are most likely responsible for return path interference that enters the plant as ingress, causing issues for other data subscribers on the same node. The challenge with troubleshooting these homes is that the impairments are often difficult to locate, especially when they are inside the subscriber's house.

Recent testing with the Nimble This PNM suite and ComSonics' Mini Mobile Marker (M3) and QAM Compass have demonstrated the two products together can radically reduce or completely eliminate the time to locate drop and in-home / near home based impairments.

This valuable report describes the findings of an extensive field test in real world scenarios and provides recommendations and best practices for using these products together, as well as optimal home wiring to ensure your plant is clean and your subscribers experience the highest level of service.

NIMBLE THIS PNM TOOL EXPLAINED

A brief primer on DOCSIS pre-equalization: Upstream pre-equalization is a feature that was first added in the DOCSIS 1.1 specification. The objective of pre-equalization is to improve upstream performance in the presence of certain RF impairments. These impairments include, but are not limited to, degraded frequency response, micro-reflections and group delay.

The method with which DOCSIS pre-equalization improves upstream performance in the presence of these RF impairments is simple. The CMTS looks at messages coming from the cable modem and evaluates the signal quality of those messages. If the CMTS determines that the messages can be improved by pre-equalization, the CMTS sends equalizer adjustment values to the cable modem. The cable modem applies these equalizer adjustment values, called coefficients, to its pre-equalizer. The result is that the cable modem transmits a pre-distorted signal to compensate for impairments between the cable modem and the CMTS. Consequently, as the pre-distorted modem-generated signal makes its way through the HFC network toward the CMTS, it will experience the effects of RF impairments. By the time the pre-distorted signal from the cable modem arrives at the CMTS it will no longer have any of the original pre-distortion, because the RF impairments will have transformed it back into a near-ideal signal that the CMTS intended to see. If further adjustments are required, the CMTS will send refining pre-equalizer coefficient values to the cable modem and the cycle repeats. This cycle repeats at least once every 30 seconds for every cable modem in the DOCSIS network, provided pre-equalization is enabled in the CMTS.

An illustration of a cable modem signal is perhaps the best way to demonstrate pre-equalization in action. Figure 1 shows an upstream cable modem signal as seen at the CMTS. This RF signal shows significant roll-off due to plant impairments. This would cause the CMTS to have difficulty demodulating the signal, resulting in codeword errors, lost subscriber data and poor subscriber quality of experience (QoE)

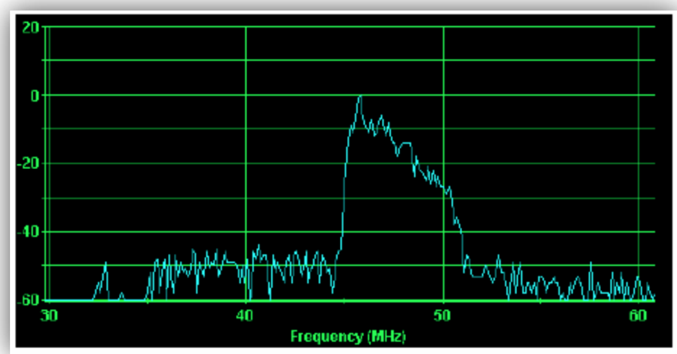


Figure 1: DOCSIS Upstream Signal at CMTS Before Pre-equalization

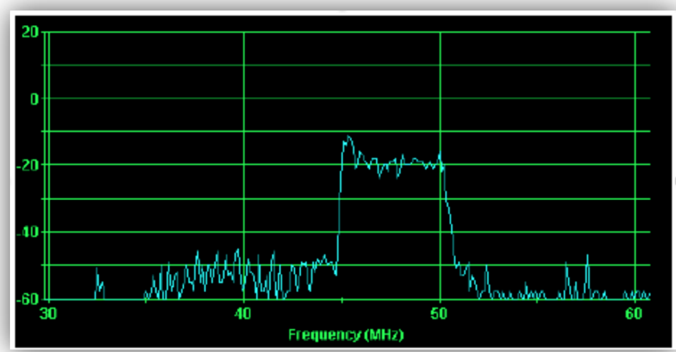


Figure 2: DOCSIS Upstream Signal at CMTS After Pre-equalization

Now the value of DOCSIS pre-equalization should be clear. What was once a very poor looking signal at the CMTS (Figure 1) is now a near-perfect signal at the CMTS (Figure 2) thanks to pre-equalization in the cable modem. For more information on this topic please go to Volpe Firm Website

Proactive network maintenance or PNM[1] is the practice of maintaining a network in a non-reactive method – that is, proactively. This statement is not meant to be sarcastic, but rather refers to the common practice of the past in which cable operators have primarily relied on reactive tools to maintain their networks. Those tools provide metrics such as FEC statistics, MER, SNR, or even offline modem counts. The challenge with these metrics is that they often provide too little information too late. In many cases when the metrics arrive the impairments are customer impacting.

Through the advent of the PNM initiative and InGeNeOs working groups at CableLabs, proactive network maintenance has become a viable alternative. This is primarily accomplished through the acquisition of cable modem pre-equalization data. The data is processed using specialized algorithms. Upstream impairments, distance to impairments and correlation of modems with common impairments can then be determined.

"PRESSURE TESTING" TOOLS

Because the channels and control signals transported through the cable network coexist with the over-the-air licensed and unlicensed frequency spectrum, the cable system must prevent its signals from escaping into free air so that they do not cause potential interference. The degradation of cable network shielding integrity can open a two-way door for potential interference: outbound (egress) and inbound (ingress). Cable egress is commonly referred to as "signal leakage."

Signal levels delivered to the house drop and in-home wiring are lower than those in the hardline distribution plant, typically averaging about 0 dBmV at the customer premises equipment. As a result, it becomes challenging through normal leakage detection practices to find the full range of cable related problems in the home and drop, except perhaps, those causing really bad leaks. Many intermittent problems are very difficult to find and may be missed even by the most experienced technician. Often damaged cable is not visible upon initial inspection because it can be located behind walls, ceilings, floors, and inside wall outlets. The results from a combination of hidden, intermittent, and smaller leaks from in-home wiring and the drop cable between the multi-tap and the dwelling can significantly degrade the service quality of the video and internet service within a home and contribute to upstream noise and interference accumulation at the CMTS. The cable drop from the tap to the home is often damaged over time by human, animal, and weather causes.

The solution to reliably and quickly find these types of cable problems in the home and drop is ComSonics' Mini Mobile Marker (M3) paired with the QAM Compass Signal Leakage Detector. The M3 produces a uniquely encoded signal at a relatively high signal level that is injected into the cable drop and in-home wiring; the **M3 Mini Mobile Marker** provides "the pressure." The QAM Compass is used to detect and locate any of the resulting leakage points that are uncovered by the M3 signal. The M3 output level is variable with the two standard values set at +60 dBmV and +40 dBmV. Inserted at the tap location, the entire cable drop is energized ("pressurized") with a signal level much higher than normal values. This elevated level forces its way through shielding flaws that are typically undetectable using a test signal intended for conventional leakage detection methods. The ComSonics' QAM Compass is set to detect the M3 signaling only and will ignore leakage from other sources. Using the built-in antenna and level readings from the QAM Compass, a technician can walk the drop path and inside the house to locate any cable defect that has a shielding integrity below 120 dB.

M3

QAM Compass

AN EFFECTIVE TEAM

Each of the two tool sets just described, Nimble This PNM and ComSonics' M3/QAM Compass, is a very effective solution when used independently. However, when the two are combined they become a much more potent solution for proactive network maintenance and eliminating return path ingress.

Each of these solutions plays an important part:

- Nimble This PNM identifies homes that have significant cable impairments that are affecting service quality or will be affecting service quality in the near future, proactively finding and isolating impairments. It also provides additional testing information about the problem and if the issue is at the home or in the outside plant.   For this field test we focused only on in-home / near home drop, and not the outside plant (OSP). What's missing: A tool that quickly identifies the impairment location when it is at the home. Home impairments are often difficult due to the complexity of in-home wiring.

- The ComSonics M3 and QAM Compass provide a robust and efficient troubleshooting method for finding cable impairments in the cable drop and in-home wiring. What's missing: A method to proactively monitor or reveal issues within a home prior to on-site testing and provide a method to re-check the home after repairs to confirm the home's modem is operating within recommended parameters.

Each of these tool sets complements each other by providing the missing component that each needs to be a more effective solution. **Combining the two solutions forms an "Effective Team" that provide a proactive maintenance solution that appears to outperform any other solution in the marketplace.**

That's a pretty bold claim! We can back it up. The following information is from a series of actual field tests using real customers to validate how well these tools work together.

REAL WORLD TESTING

Proactively using the Nimble This PNM suite, a number of severely impaired subscriber homes were identified as needing maintenance. Note, none of these homes currently had active work orders assigned to them, nor had the subscribers called in for service complaints. The Nimble This PNM application was used to identify modems which were severely impaired in either the upstream, downstream or both. Remember, the subscribers had not yet complained. Using Nimble This PNM, a high confidence factor was assigned to each home that would likely experience service-affecting impairments sometime in the near future if no action was taken. Further, each home, unbeknownst to the subscriber, was currently experiencing problems with return path ingress, which made them a good candidate for repair of issues affecting both the node and the cable plant.

SUBSCRIBER 1

The first modem identified had significant in-channel frequency response (ICFR) and its pre-equalizer digital tap #9, shown in Figure 3, is elevated above the red threshold line.

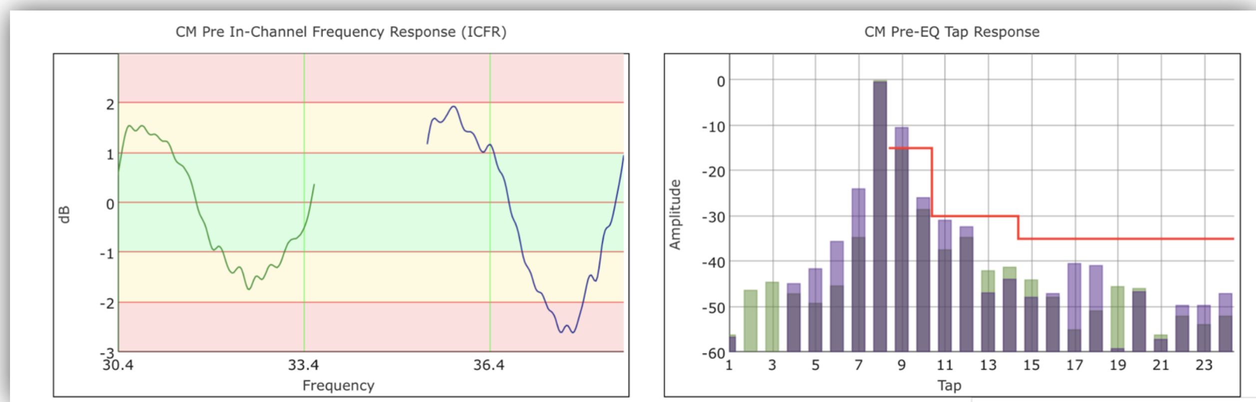


Figure 3: Poor ICFR and Digital Tap #9 above red line (likely drop or in-home problem)

The PNM statistics for this modem were captured by a mobile device running the Nimble This PNM mobile app while on-site and are shown in Figure 4.

Severity		
ICFR (dB)	3.29	4.55
MTC (dBc)	0.15	0.45
MR Level (dBc)	-14.56	-11.83
Delay (ns/MHz)	335.74	653.33
TDR (Feet)	91	81
vTDR (Feet)	0	0
Corr		
Freq (MHz)	32	37
BW (MHz)	3.2	3.2

Figure 4: Subscriber 1 modem's PNM Stats

From Figure 4 one can observe that both upstream channels are experiencing significant micro-reflections of -14.56 dBc and -11.83 dBc at 32 MHz and 37 MHz, respectively. As a reminder, micro-reflections occur when the characteristic impedance of the RF plant is something other than 75 ohms. This is called an impedance mismatch and typically happens when the coaxial cable is damaged, a connector is loose or not properly installed, or there is some other device that is not 75 ohms like a bad tap, splitter or even amplifier.

The micro-reflection will cause the cable modem’s signal to bounce back and forth in the cable in what is called an echo cavity. You can think of this like standing in a canyon and yelling “Hello” and then hearing the echo of yourself coming back as “Helloooo.” The same basic principle is occurring with a micro-reflection, except the frequency is much higher than your voice.

At subscriber 1’s house we knew there is a micro-reflection based on the Nimble This PNM data. There are two approaches to fix the problem. The first and most common approach is to replace connectors, splitters and maybe even the drop until the modem status turns from red to green. The second and quicker option is to disconnect the drop at the mainline tap, connect ComSonics’ M3, which injects high level RF signals and then look for RF leaks along the drop and inside the home with the ComSonics QAM Compass. Figure 5 shows the technician installing the M3 at the tap end of the drop.

Figure 5: Technician installing M3 Signal Injector

Once the M3 and QAM Compass were powered on, the technician immediately found a high level leak at the mainline tap while he was still in the bucket. There he found a splice had been made just feet away from the tap. Figure 6 shows the splice enclosure and Figure 7 shows the connectors inside the splice enclosure, which includes two crimp-on F-connectors, one of which is severely corroded. Note that even though the connectors were in a waterproof splice enclosure, water still penetrated the enclosure and corroded the connectors. Do not count on your waterproof splice enclosure to protect your inline splices. **They will eventually fail.**

Figure 6: Inline Splice with Weather Enclosure

Figure 7: Corroded Crimp-on F-Connectors Exposed to Water

Best Practice #1: Avoid crimp-on F-connectors. Always use approved outdoor rated compression F-connectors to minimize future water ingress and corrosion, which will cause subscriber issues. It is recommended to avoid splices when possible. Further, do not count on your waterproof splice enclosure to protect your inline splices. **They will eventually fail.**

The fix was to cut off both connectors and replace with a single weatherproof Snap-N-Seal compression connector. There was enough slack in the drop to connect it directly back to the drop without the inline splice. The resulting response is shown in Figure 8.

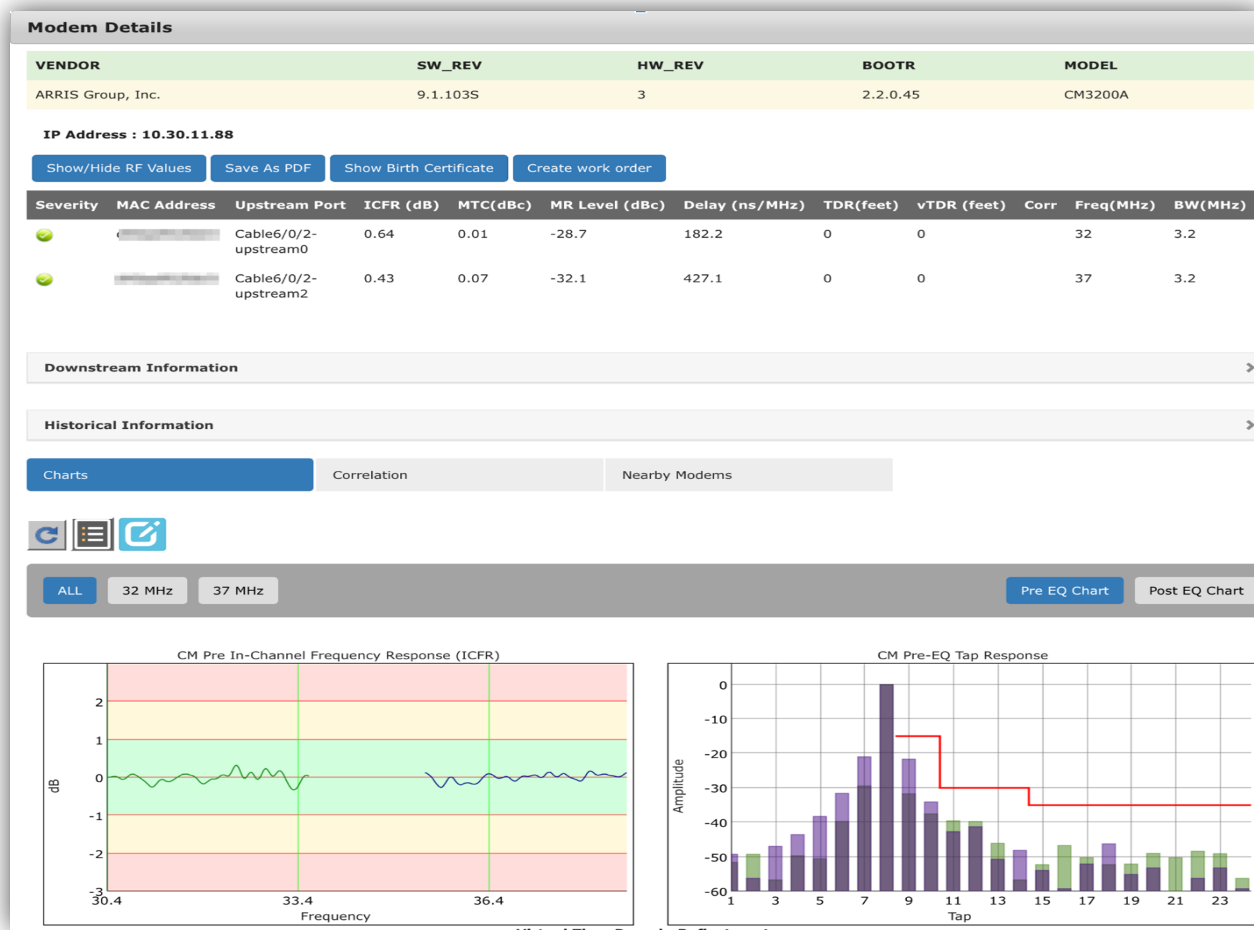


Figure 8: Subscriber 1 After Repair

Notice in Figure 8 that both upstream channels on subscriber 1's modem are now green. The MR Level (or micro-reflection level) values are down to -28.7 dBc and -32.1 dBc for 32 MHz and 37 MHz, respectively. Previously these values were at -14.56 dBc and -11.83 dBc at the same two frequencies. An ideal micro-reflection level is any value less than -25 dBc, so this is a very good upstream after the repair.

Note that by using ComSonics' M3 and QAM Compass, the technician was able to locate and repair the impairment very quickly. The technician then used the QAM Compass to scan the remainder of the drop, ground block and around the house, but found no additional leaks. Further, the Nimble This mobile PNM application was used to re-scan the modem, which provided immediate verification that both upstream channels on the modem were green and showing no signs of impairment. At this point verification can be established that the modem will perform well in the upstream and no ingress should be leaking into the return path from this subscriber's home.

Best Practice #2: Avoid splices in drops when at all possible. Whether aerial or buried, splices will eventually fail due to environmental conditions causing unnecessary degraded subscriber quality of experience or even an outage resulting in a truck roll and the splice being replaced.

SUBSCRIBER 2

The second modem for analysis was identified with both upstream channels as having significant in-channel frequency response (ICFR) and micro-reflection levels. All surrounding modems in nearby homes were not impaired, so the confidence level was high that the impairment was either the drop or in-home related. Figure 9 shows the pre-equalizer response of the cable modem. Both digital pre-equalizer taps #9 and #10 are significantly elevated, which typically indicates a short echo cavity often associated with short span distances common to drop cables.

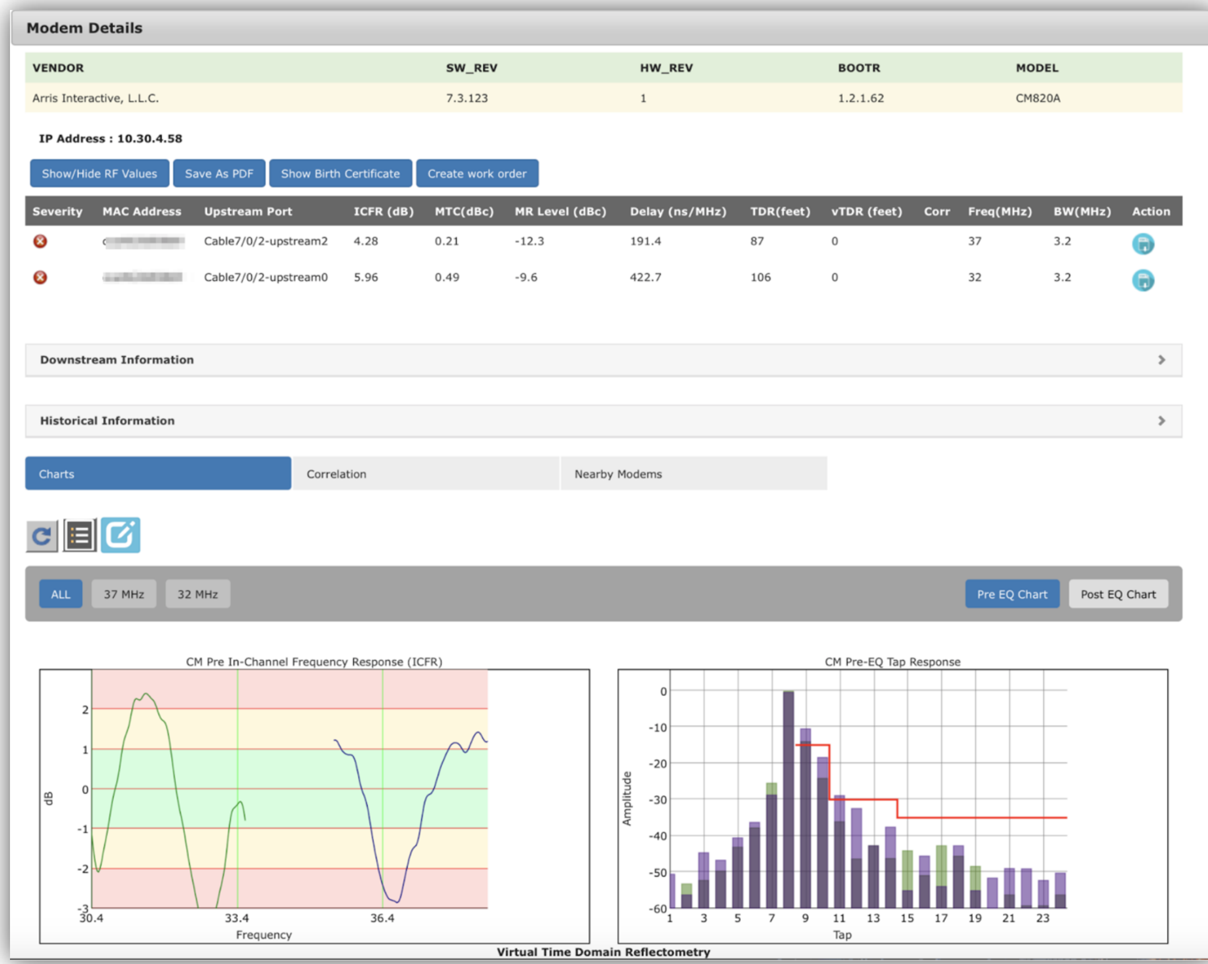


Figure 9: Subscriber 2 Pre-Equalizer Data

As shown in Figure 10 the drop is buried and ComSonics' M3 is connected to that drop.

Figure 10: ComSonics’ M3 Connected to Buried Subscriber Drop Cable

Once connected and powered up, the M3 transmits high signal levels into the subscriber’s drop and home (not the HFC plant!). Almost immediately the ComSonics’ QAM Compass detected a leak. The technician started walking around the subscriber’s house where low level signals appeared present nearly everywhere. Over a period of five minutes the technician found the highest signal level to be near the buried drop cable. This indicated that the RF leak was coupled to the shield of the drop cable buried underground.

The technician walked in the direction of increasing RF signal leakage as shown on the ComSonics QAM Compass device. After several more minutes the highest level leak location was pinpointed near the road. The technicians started digging in the hopes of finding the coax cable as seen in Figure 11.

Figure 11: High Leak Location Being Excavated

After 10 minutes of careful digging the coaxial cable was located along with a weatherproof splice enclosure. A technician pulled lightly on the splice enclosure when one end of the coax came loose from the splice enclosure indicating that the F-connector was not properly compression fitted to the cable. Figure 12 shows the splice enclosure with the missing cable.

Figure 12: Buried Splice Enclosure with Series 11 Cable Pulled from F-Connector

Best Practice #3: Avoid splices in buried drops. Not only are buried splices difficult to find, but unless they are in a very dry location, water ingress will almost always cause these to fail over time resulting in the splices needing to be replaced.

The splice enclosure was removed and opened. It was observed that quality F-connectors were installed, however the installation of at least one of the F-connectors allowed the coaxial cable to pull free. Additionally, there was water in the splice enclosure and some corrosion on the F-connectors as can be seen in Figure 13.

Figure 13: Opened Splice Enclosure with Water Ingress and Corrosion

A temporary drop was connected to the existing splice. A permanent drop will be installed in the future when the drop can be buried under the adjacent road without a splice. Once the temporary splice was in place all signal leakage stopped as measured by the ComSonics' QAM Compass. The modem was then rescanned using the Nimble This PNM mobile application. The modem performance improved significantly, however it still showed an RF impairment with an echo cavity of roughly 500 feet, which was approximately the length of the newly spliced drop combination. Since no other adjacent subscribers showed this same impairment it was deduced that the impairment was isolated to this subscriber's home. No additional leaks were detected from the drop or near the home. Consequently it was not necessary to go inside the home as leakage inside the home is normally detectable from outside of the home too. Therefore, we focused on all hardened devices on the drop.

A data-only trap was found at the mainline tap. This device is used to allow only the DOCSIS SC-QAM channels to pass, while it blocks all other video channels. It can be seen in Figure 14 as the red object connected to the tap.

Figure 14: Bad Drop Trap Causing a Micro-Reflection

The red filter was removed and replaced with a new one. It is possible that the filter was damaged by lightning or failed with age. Upon rescanning the cable modem with the Nimble This PNM application the modem returned a near perfect upstream response as seen in Figure 15.

Best Practice #4: If you live in an area where lightning is prevalent be sure to check traps, filters and terminators for lightning damage. Most of these devices have small components which will fail if lightning strikes nearby the drop or mainline coax cable, causing micro-reflections.

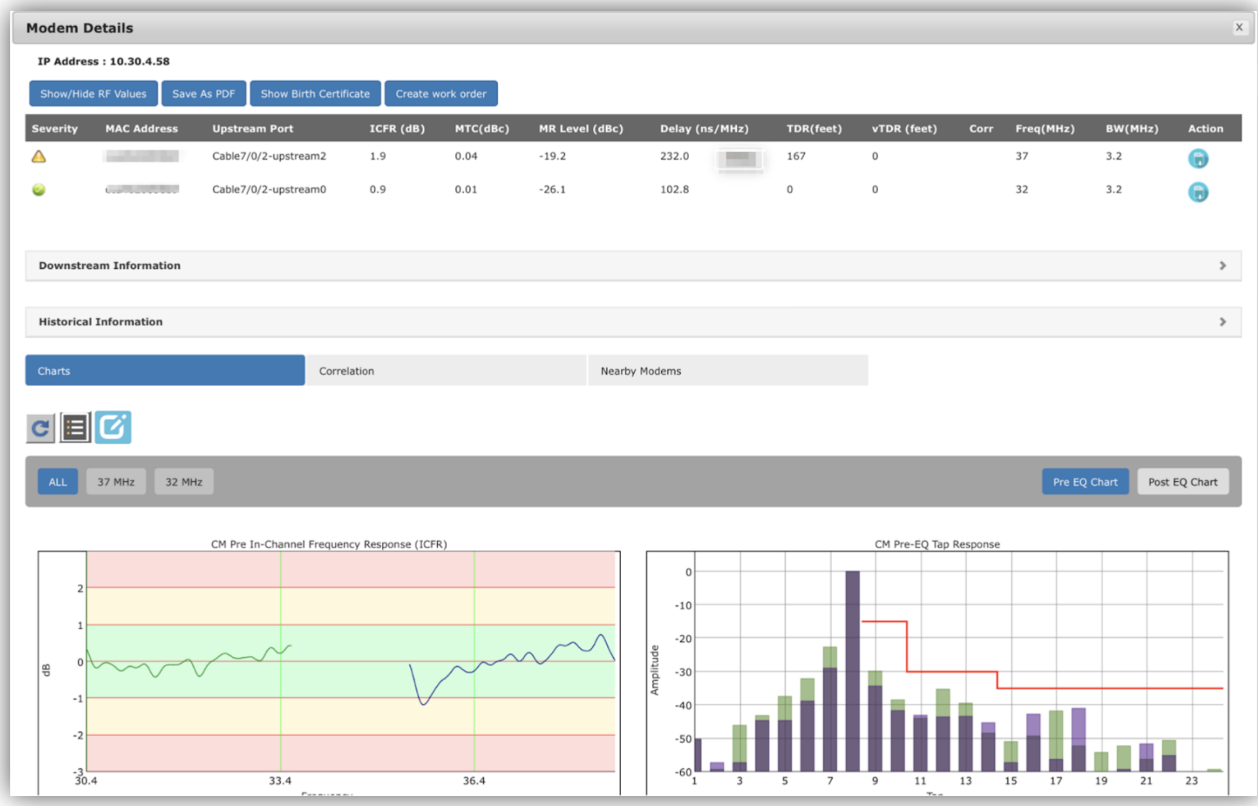


Figure 15: Subscriber 2 Modem After Splice and Trap Repair

Note that the second upstream (37 MHz) on the modem in Figure 15 has a slight group delay impairment which is common to all modems in this part of the RF spectrum. The group delay impairment is causing all taps to the left of the main tap (main tap is position #8) to be elevated (green taps) from left to right and is causing the ICFR of the 37 MHz modem signal to be non-optimally flat. This impairment cannot be fixed at the subscriber home, but was fixed later by replacing a faulty diplex filter in a fiber node.

SUBSCRIBER 3

The next modem was again selected based on having poorly performing upstream channels, each with high micro-reflections and digital taps #9 and #10 elevated. Further, no other adjacent homes were experiencing similar characteristics. Figure 16 shows the modem's response before the repair.

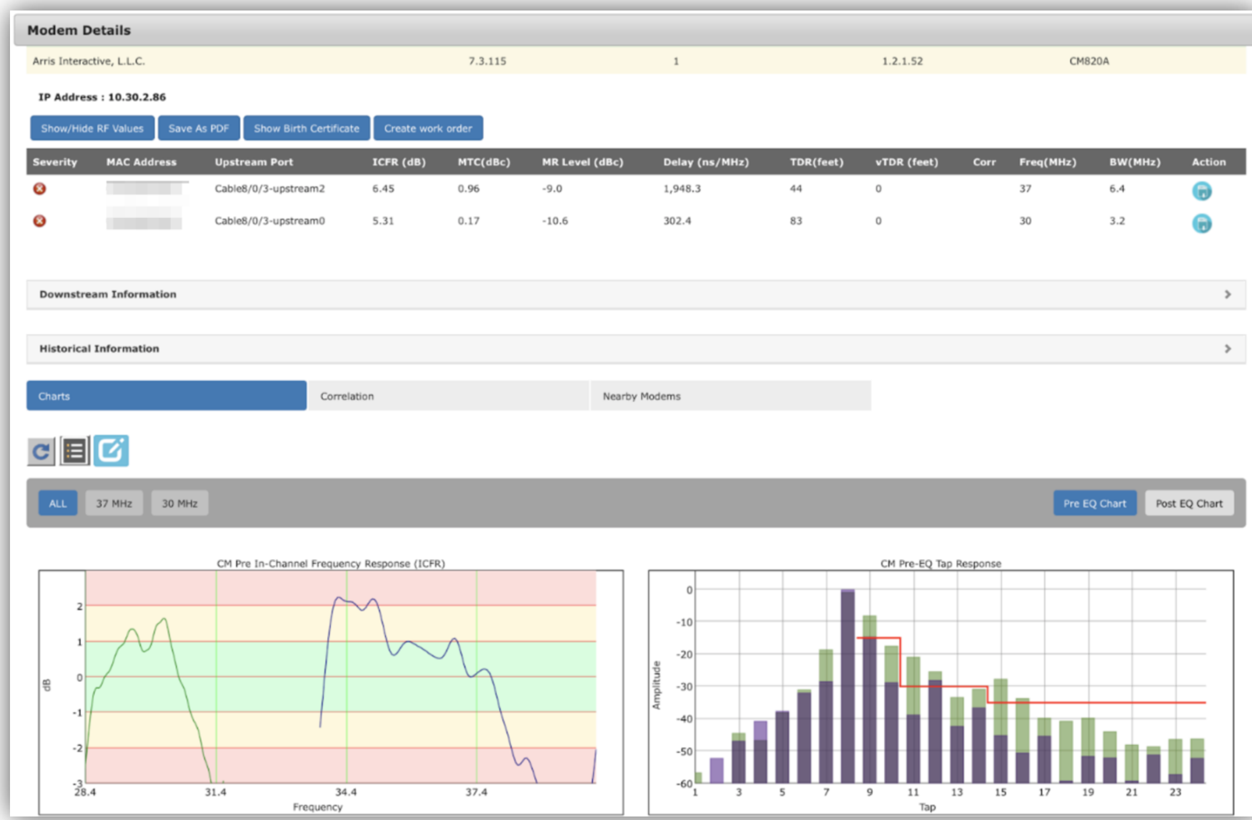


Figure 16: Subscriber 3 Modem Before Repair

Upon connecting the ComSonics M3 to the subscriber drop substantial leakage was detected by the QAM Compass along the entire underground drop path. The technician followed the leakage to the side of the subscriber's home where a non-cable company splitter and twist-on[2] F-connectors were discovered as shown in Figure 17 (note the picture was taken just after the technician cut the cable at the output side of the splitter).

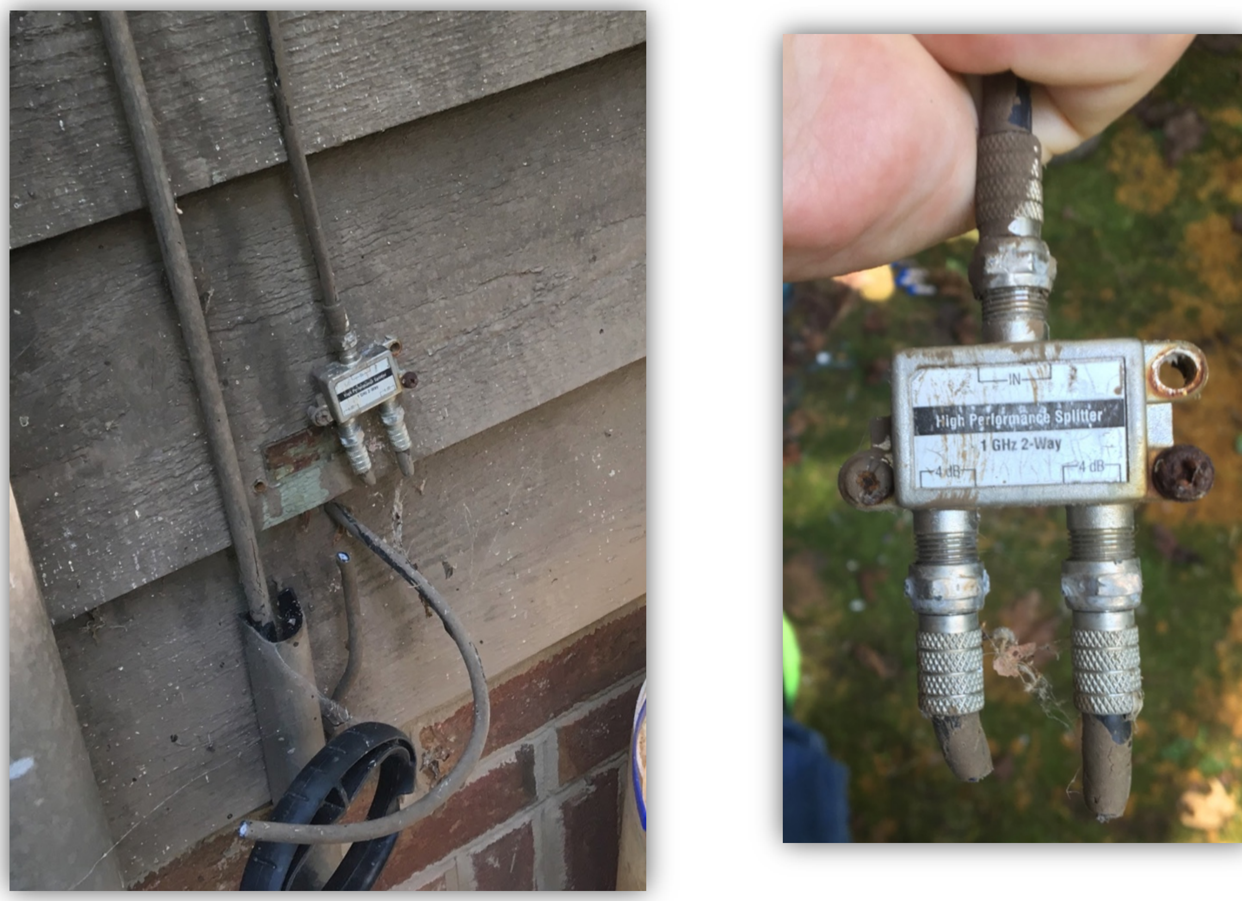


Figure 17: Old Splitter and Twist-on F-Connectors

The splitter was removed and terminated at the single twist-on F-connector feeding the splitter, but substantial RF leakage was still detected. This indicated the primary source of leakage was the single twist-on F-connector. All twist-on F-connectors were replaced with weatherproof Snap-N-Seal compression F-Connectors and the splitter was replaced and relocated to the existing house box.

Best Practice #5: Never use twist-on F-connectors. It is not possible to sustain an effective ground connection over long or even relatively short periods of time with twist-on F-connectors as those shown in Figure 17.

Best Practice #6: Locate all splitters in a weather protected house box or inside the subscriber's home or MDU (multi-dwelling unit). Unprotected splitters will rust and corrode causing premature failure and micro-reflections. Be sure to weatherproof all outdoor F connectors, even those installed in house boxes.

Upon completing the work, all RF leakage stopped and leaks were no longer detectable with the ComSonics' QAM Compass. The drop was reconnected and the Nimble This PNM mobile app was used to rescan the modem. The modem(s) performance was found to be significantly improved except for the group delay present on the upstream as seen on Subscriber #2's modem. This response can be seen in Figure 18.

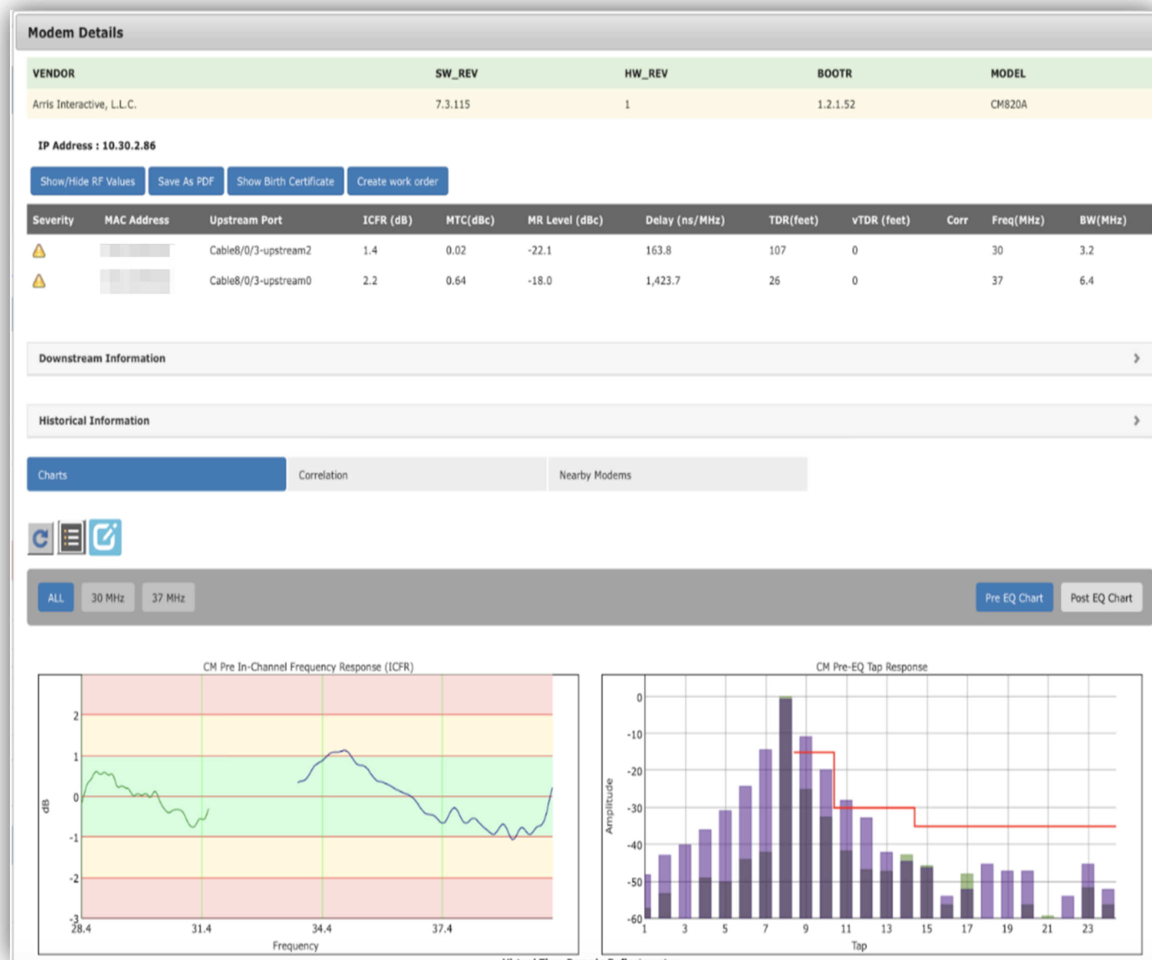


Figure 18: Subscriber 3 Modem After Repair of Twist-On F-Connectors

Note the elevated taps (in purple) are due to significant group delay in this section of plant. This cannot be fixed at the subscriber home, but was later fixed by replacing a faulty diplex filter in a fiber node.

SUBSCRIBER 4

Subscriber #4 was selected as a modem with high micro-reflections and no adjacent subscribers experiencing similar impairments. The performance can be seen in Figure 19. A similar troubleshooting approach was used as with other subscribers in this field study, however it was apparent that the RF leakage was emanating from inside the subscriber's home.

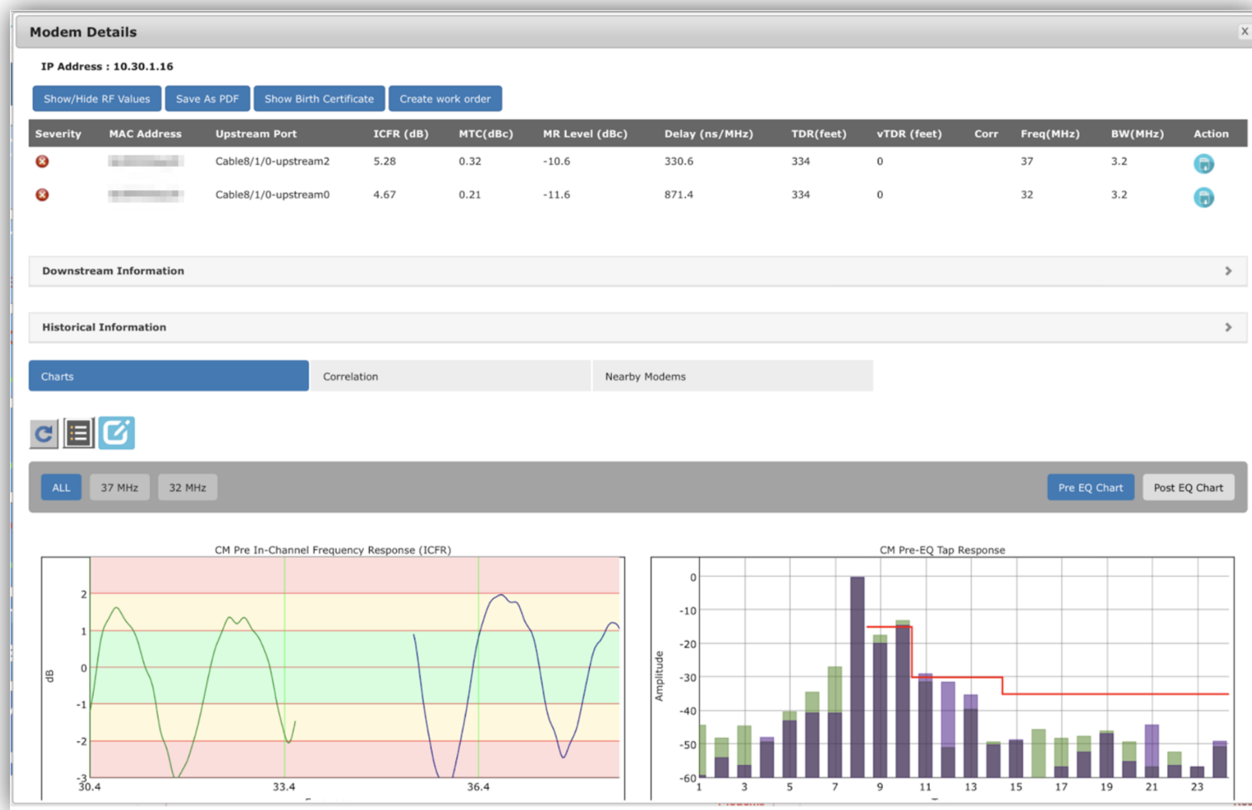


Figure 19: Subscriber 4 Modem Response Before Repair

Since all trouble calls had been scheduled with the subscribers, they were available to allow access to the home. It should be mentioned that this was the first time it was necessary to enter a subscriber's home - most repairs were able to be completed outside.

Upon entering the home the ComSonics' QAM Compass quickly led the technician to the strongest source of the signal leakage, at the back of the cable modem. The technician found a crimp on F-Connector on the back of the cable modem. As soon as the connector was cut off the leak stopped immediately. The crimp-on-connector was replaced with a quality compression F-connector. Additional leakage was traced to a crawl space, but it was not significant and the technician indicated that he would return later to repair this minor leak.

Figure 20: Crimp-on F-connector On Back of Modem Causing Micro-Reflection

Upon rescanning the modem with the Nimble This PNM mobile app the modem pre-equalizer response confirmed that the majority of the impairment had been resolved turning the modem from red to yellow, however the leak in the crawl space was likely preventing the modem from turning to green. Figure 21 shows the modem's response after repairing the crimp-on F-connector on the back of the modem.

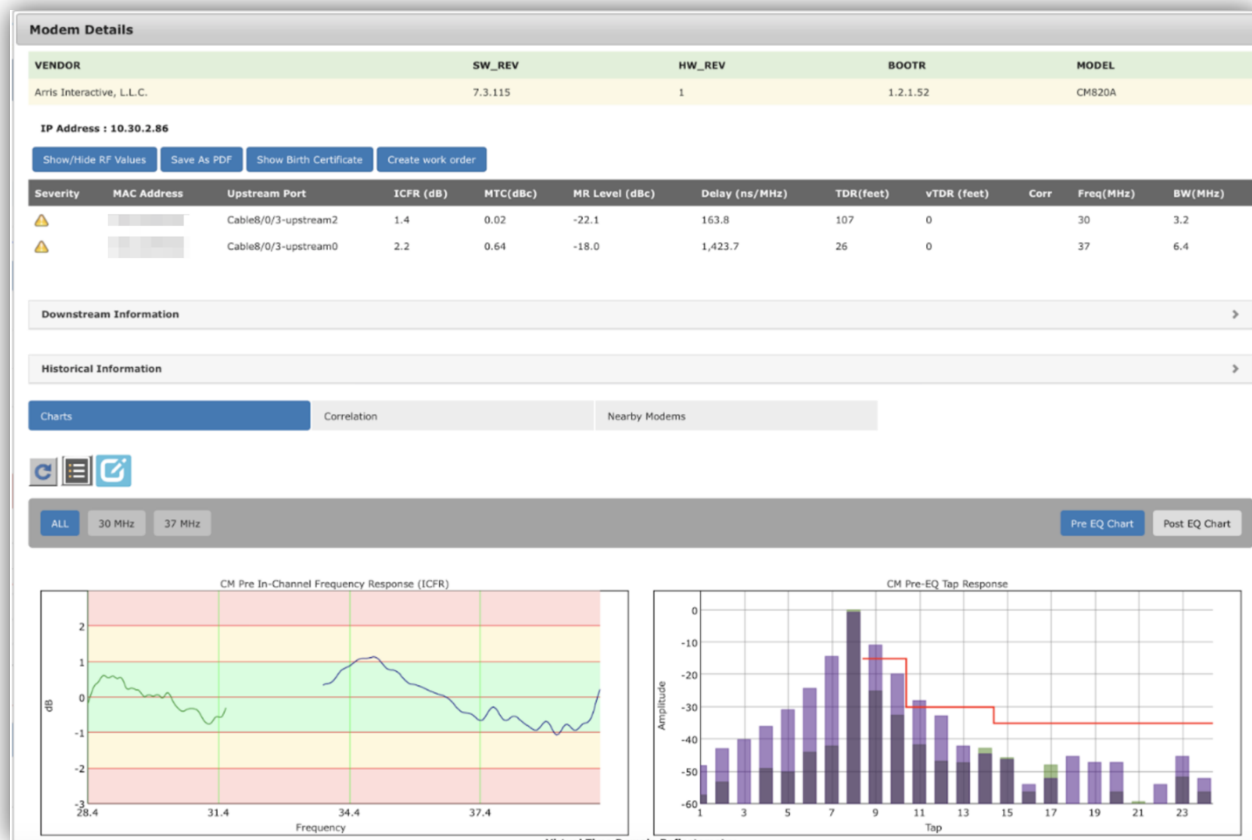


Figure 21: Subscriber 4 Modem After Repair of Crimp-on F-Connector

SUBSCRIBER 5

Subscriber #5's modem was chosen in the Nimble This PNM application as having both severe micro-reflections and operating in partial mode. Partial mode means that the modem is not using all of the available upstream channels. In this case it was only using one upstream channel when it should have been using two upstream channels (i.e., channel bonding).

Figure 22 shows the modem's upstream response, with only one channel at 32 MHz and a micro-reflection level of -8.2 dBc. No adjacent subscribers were having this same issue and digital tap #9 is the highest amplitude, indicating a likely drop, near home or in-home related impairment.

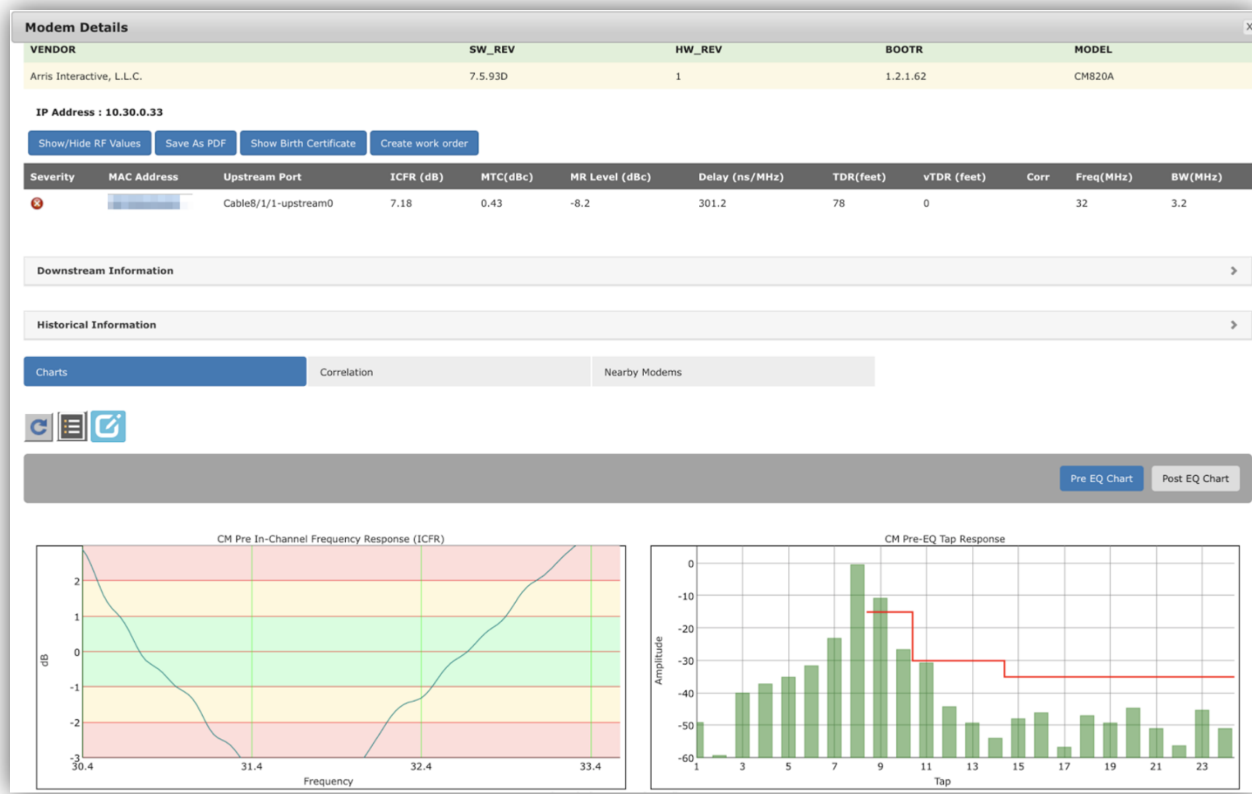


Figure 22: Subscriber 5 Before Repair

Upon attaching the ComSonics' M3 to the subscriber drop, the QAM Compass quickly picked up leakage along the drop. While there were no signs of damage to the drop, the drop was clearly leaking substantial M3 RF signals.

The technician removed the aerial drop and put it on the ground. It was inspected from one end to the other. While the drop showed no signs of physical damage from the outside, one F-connector showed possible signs of electrical surge as observed in Figure 23, where the insulating dielectric and center conductor were blackened. A significant electrical surge could have seriously damaged the drop at a bend location or perhaps along the entire drop cable causing RF leakage throughout.

Figure 23: Blackening of Center Conductor and Insulating Dielectric Indicating Possible Surge

Upon replacing the drop cable all signs of RF leakage disappeared. Further, upon reconnecting the drop and rescanning the modem using the Nimble This PNM mobile app it was found that not only had the original upstream channel turned from red to green, but the modem was no longer in partial mode. Now the modem was able to bond to both upstream channels and both upstream channels were green with minimal micro-reflections, as can be seen in Figure 24.

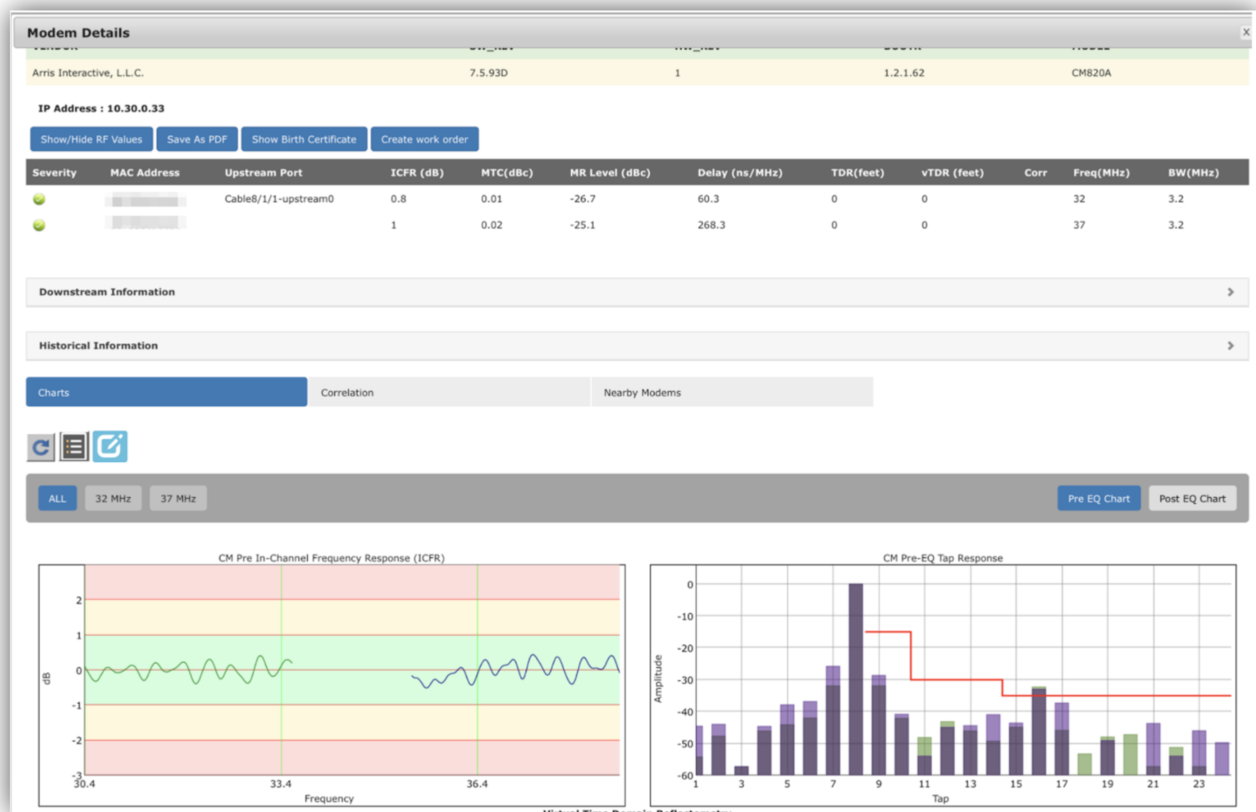


Figure 24: Subscriber 5 Modem After Replacing Bad Drop

Pro Tip: Just because a cable looks good from the outside does not mean it is good. Often micro-cracks, radial cracks, melted dielectric and other non-visible impairments can cause problems. PNM can show which homes have these problems and leakage tools will lead to the exact location of the problems.

SUMMARY

The objective of the field study was to determine if a direct correlation exists specifically between Nimble This PNM drop, in home / near home data and leakage. More specifically:

What percentage of the time can Nimble This PNM data be used to proactively identify drop, near home / in home impairments that will have cable integrity issues that the subscriber will notice in the immediate future and these impairments can be located / fixed using ComSonics M3/QAM Compass solution?

Due to time limitations and the need to pre-arrange subscribers' in home approval the field study selectively identified 15 homes that exhibited: 1. Very poor modem performance, i.e., Red Modems, and 2. Specifically focused on impairments either near or inside the home. For this study modems that exhibited OSP problems were not selected.

The data that was used to select the target subscribers included:

- Failing readings on the Nimble This PNM application
- Poor in-channel frequency response (ICFR) on the DOCSIS return channels
- Pre-EQ tap response with bad levels of micro-reflections on digital pre-eq taps 9 and 10
- Modems operating in an upstream partial-mode condition (i.e., running on one upstream channel instead of two)
- FM ingress in the downstream

The findings exceeded the predicted expectations and can be summarized as follows:

1) OF THE 15 SUBSCRIBERS SELECTED FOR THE DROP, IN HOME / NEAR HOME IMPAIRMENTS STUDY USING THE NIMBLE THIS PNM TOOL, 100% OF THE SUBSCRIBERS EXHIBITED CABLE DEFECTS EITHER IN THE CABLE DROP OR IN HOME / NEAR HOME UPON SITE INSPECTION. ONCE ON SITE THOSE DEFECTS WERE QUICKLY LOCATED BY THE COMSONICS M3/QAM COMPASS.

2) OF THE 15 HOMES SELECTED USING THE PNM DATA, THE CABLE IMPAIRMENTS IN 13 OF THE 15 (OR 87%) OF THE HOMES WERE QUICKLY LOCATED AND FIXED USING THE M3/COMPASS ONCE ON SITE, BRING THE MODEM STATUS BACK TO GREEN. THE NIMBLE THIS PNM INDICATED THE SUBSCRIBERS' HAD IN-HOME / NEAR HOME IMPAIRMENTS WHICH WERE STILL NOT NOTICEABLE BY THE SUBSCRIBERS THEMSELVES BUT WOULD BE IN THE NEAR FUTURE. THE OTHER TWO HOMES DID HAVE LEAKAGE THAT CONTRIBUTED TO THE MODEM PROBLEMS, BUT ALSO HAD DATA-ONLY TRAPS AT THE ENDS OF THE DROPS THAT WERE FAULTY AND DID NOT EXHIBIT LEAKAGE. THE PROCESS OF ELIMINATING THE LEAKAGE-RELATED PROBLEMS ALLOWED THE TECHNICIANS TO LOOK FOR OTHER PROBABLE CAUSES, SUCH AS THE DATA-ONLY TRAPS.

3. A FEW OF THE HOMES EXHIBITED OUTSIDE PLANT (OSP)-RELATED IMPAIRMENTS UNCOVERED BY NIMBLE THIS PNM. THIS WAS DETERMINED AFTER THE IN THE HOME LEAKAGE WAS REPAIRED. UPON ELIMINATING THE CABLE IMPAIRMENT THE TECHNICIAN USING THE PNM MOBILE APP DETERMINED IT WAS AN OSP IMPAIRMENT. THIS DATA CAN BE RELAYED TO A OSP TECHNICIAN WITH A VERY HIGH LEVEL OF CONFIDENCE THAT THE RESULTING REPAIR WILL FIX THE REMAINING MODEM ISSUES.

4. ONCE THE TECHNICIANS WERE ON SITE WITH THE PRE-SELECTED SUBSCRIBERS' HOME LOCATION, THE TECHNICIANS WOULD ALSO USE THE NIMBLE THIS MOBILE APP TO LOCATE OTHER NEARBY HOMES IN THE AREA WITH IMPAIRMENTS. *WHERE POSSIBLE, THE TECHS WOULD RESOLVE ISSUES THAT COULD BE LOCATED AND FIXED OUTSIDE THE HOME USING THE COMSONICS M3/QAM COMPASS. ISSUES DETERMINED TO BE INSIDE THE HOUSE REQUIRED A SCHEDULED HOUSE CALL. THESE ISSUES ARE NOT INCLUDED HERE BUT WERE PROACTIVELY RESOLVED BEFORE A SUBSCRIBER WAS CALLED FOR SERVICE.*

The results of this study are very exciting and go a long way to supporting the claim stated earlier in this paper: **"Combining the two solutions forms an "effective team" that provides a superior proactive maintenance solution that appear to outperform any other solution in the marketplace."** To put this in another perspective, the efficiency of sustaining a proactive network maintenance program with tangible results can approach 100%. Return service calls will be reduced to near zero. To date, no other solution set can make this sort of claim with real world data to back it up.

Nimble This and ComSonics invite you to verify these findings in your own network. The results will exceed your expectations.

ADDITIONAL TEST DATA

Further testing at subscriber locations followed the same strategies as outlined in the scenarios for Subscriber 1 through 5 in the previous sections. For brevity, the following sections will only show the before and after screenshots with a short description of the impairment found.

Best Practice #7: Finger tight is never tight enough for F-connectors. The male "F" pin type connector shall withstand a minimum tightening torque of 60 lb-in., without damage when measured per ANSI/SCTE 98 2004. Be sure to always use a 7/16" or appropriate wrench when tightening all F-connectors. Note: In practice, the recommended tightening torque on mating interfaces such as tap ports, splitters, and ground/bond blocks, is typically in the 20 to 30 lb-in range, although some interfaces may use less torque.

SUBSCRIBER 6

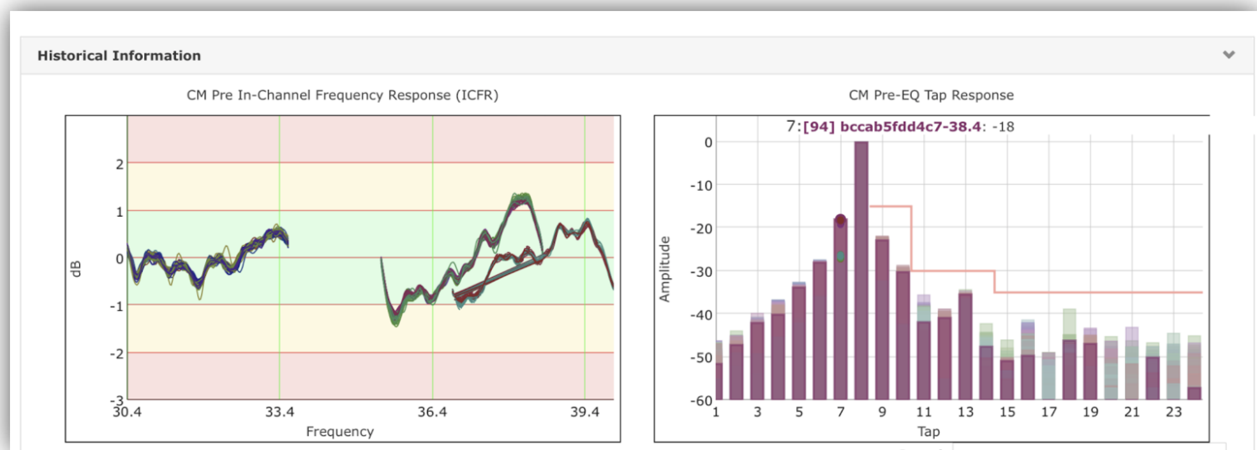


Figure 25: Subscriber 6 Modem Before Repair

Impairment Found: Intermittent issue due to faulty TVC Arrestor Ground Block. The faulty ground block shown in Figure 26 was only detected because it was leaking significant amounts of ComSonics' M3 RF energy. Faulty ground blocks are not common, but it is assumed this "surge arresting" type ground block had been damaged by a surge.

Figure 26: Faulty Surge Arresting Ground Block

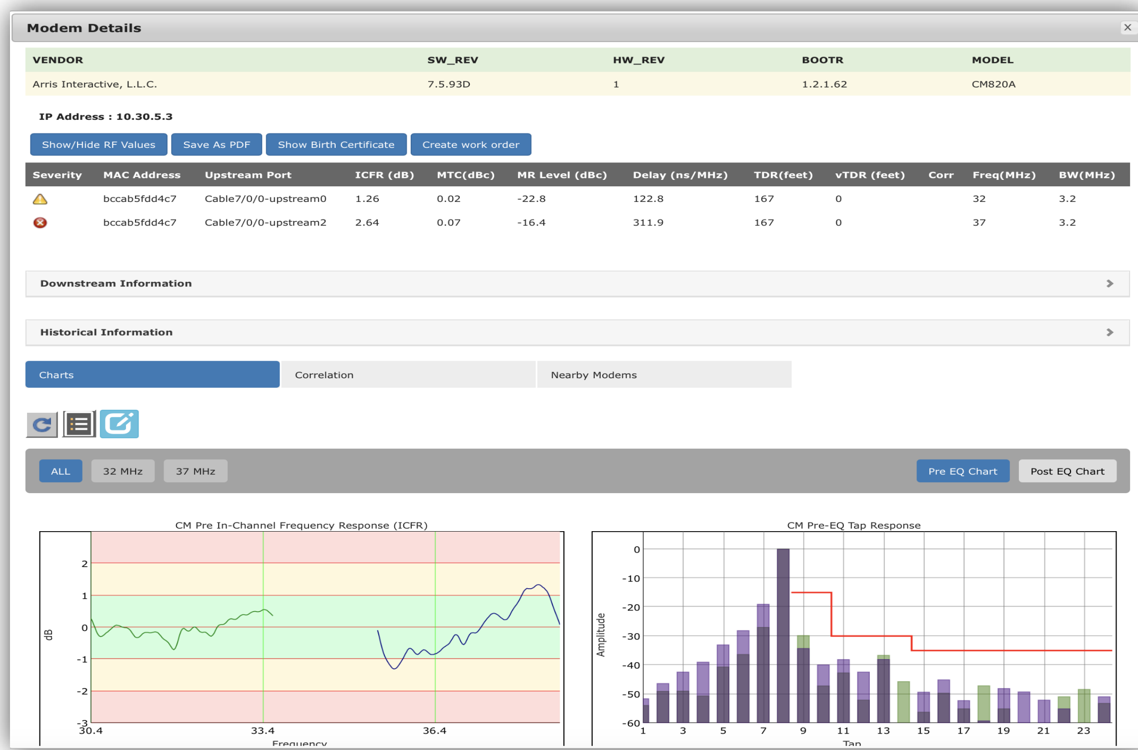
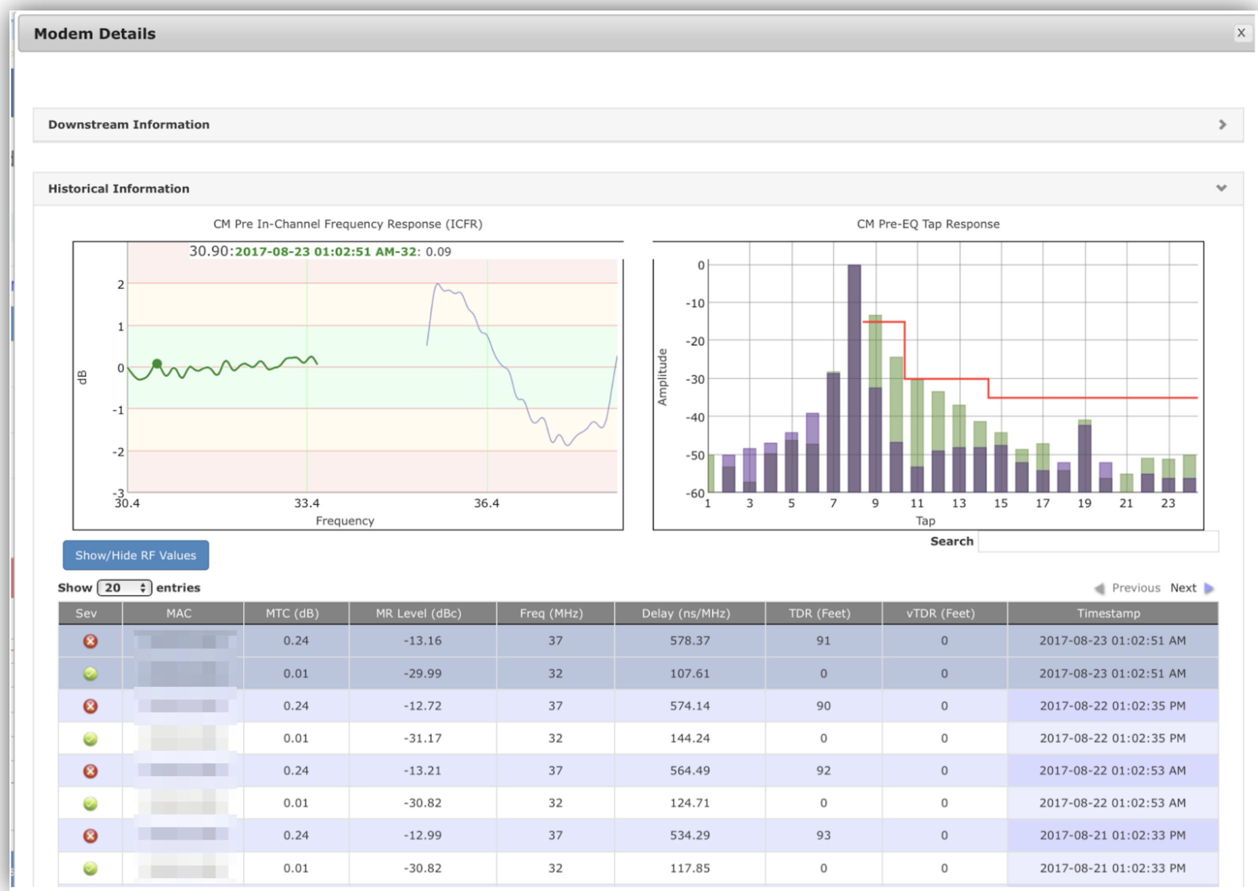


Figure 27: Subscriber 6 Modem After Repair



Sev	MAC	MTC (dB)	MR Level (dBc)	Freq (MHz)	Delay (ns/MHz)	TDR (Feet)	vTDR (Feet)	Timestamp
		0.24	-13.16	37	578.37	91	0	2017-08-23 01:02:51 AM
		0.01	-29.99	32	107.61	0	0	2017-08-23 01:02:51 AM
		0.24	-12.72	37	574.14	90	0	2017-08-22 01:02:35 PM
		0.01	-31.17	32	144.24	0	0	2017-08-22 01:02:35 PM
		0.24	-13.21	37	564.49	92	0	2017-08-22 01:02:53 AM
		0.01	-30.82	32	124.71	0	0	2017-08-22 01:02:53 AM
		0.24	-12.99	37	534.29	93	0	2017-08-21 01:02:33 PM
		0.01	-30.82	32	117.85	0	0	2017-08-21 01:02:33 PM

Figure 28: Subscriber 7 Modem Before Repair

Impairment Found: Multiple leaks inside the house due to crimp-on style F-connectors and an unnecessary house-amp in front of the modem. Upon replacing all older style connectors with quality connectors, no leaks were observed, and the modem response in Figure 29 resulted.

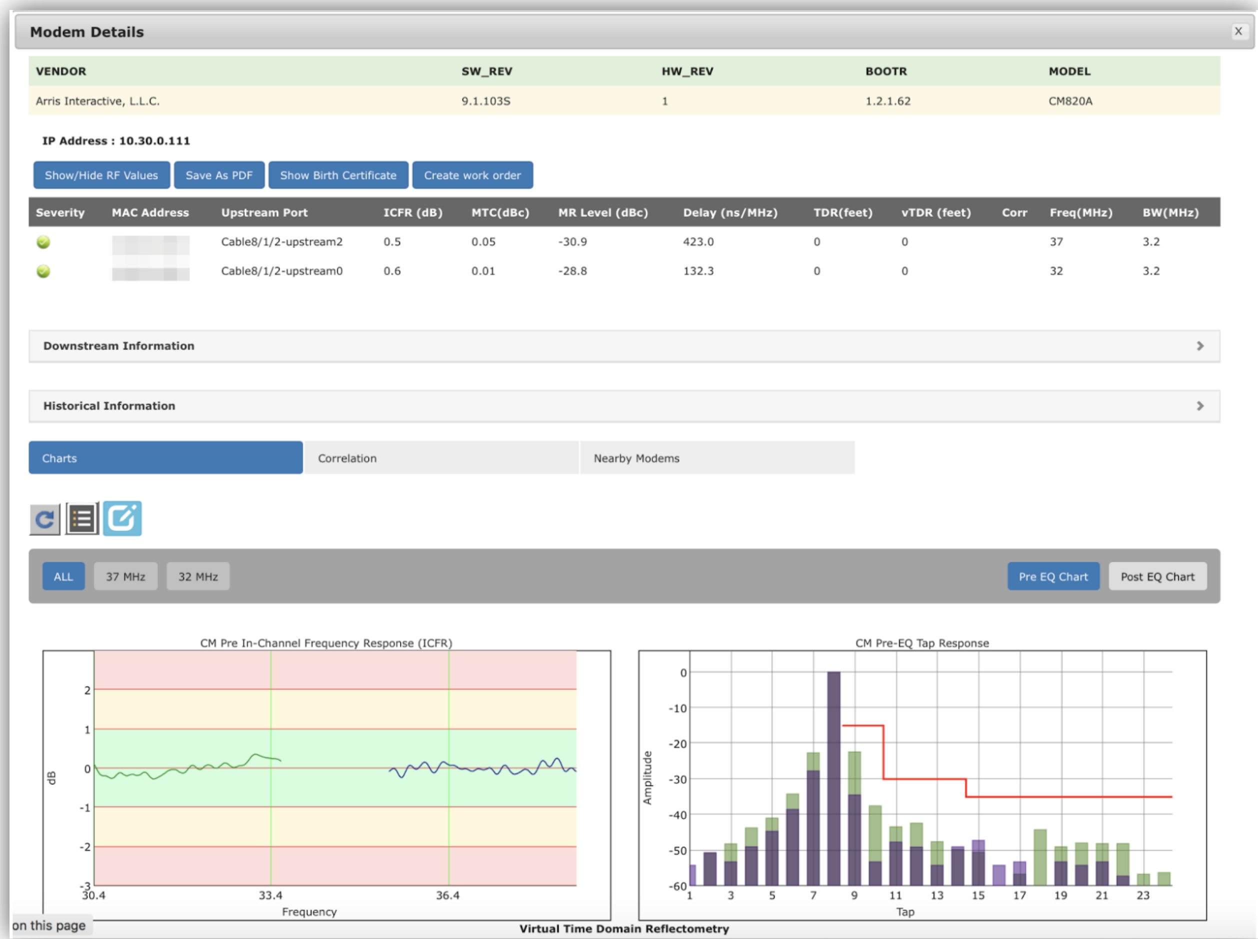


Figure 29: Subscriber 7 Modem After Repair

SUBSCRIBER 8

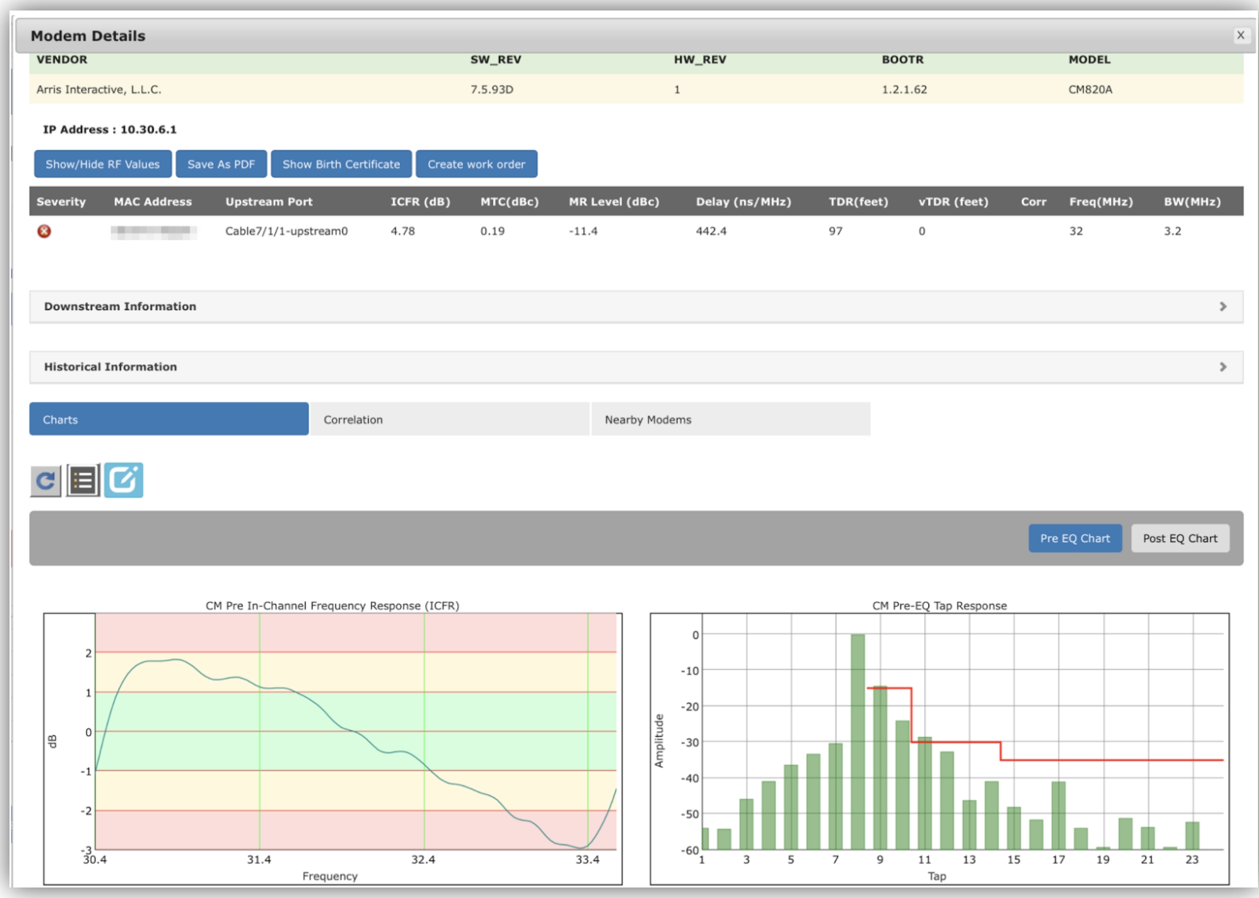


Figure 30: Subscriber 8 Modem Before Repair

Impairment Found: RF leakage was found at a twist on connector at the ground block, and twist-on connectors and splitter at the back of the subscriber's TV on a common splitter with the modem. Visible braid was wrapped around the center conductor of the connector. In addition the connector at the tap was blackened due to electrical or water damage (hard to tell), and multiple bad connectors and jumpers inside of home. All impairments were detected by ComSonics' M3 leakage indicated on the QAM Compass. Repair success was verified using the combination of Nimble This PNM and ComSonics M3.

Figure 31: Twist on F-Connector at Ground Block

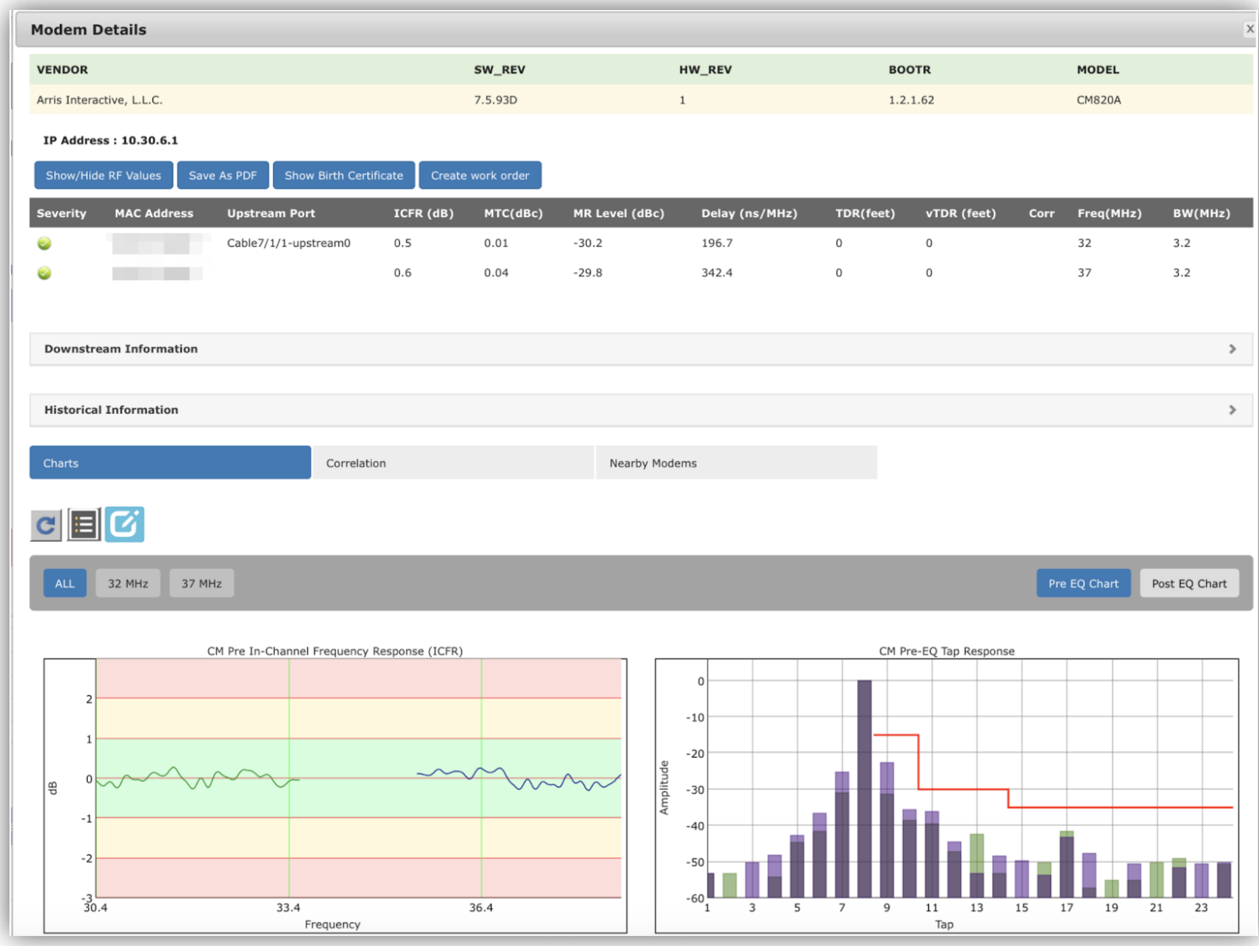


Figure 32: Subscriber 8 After Repair, Now Showing Two Green Upstreams

SUBSCRIBER 9

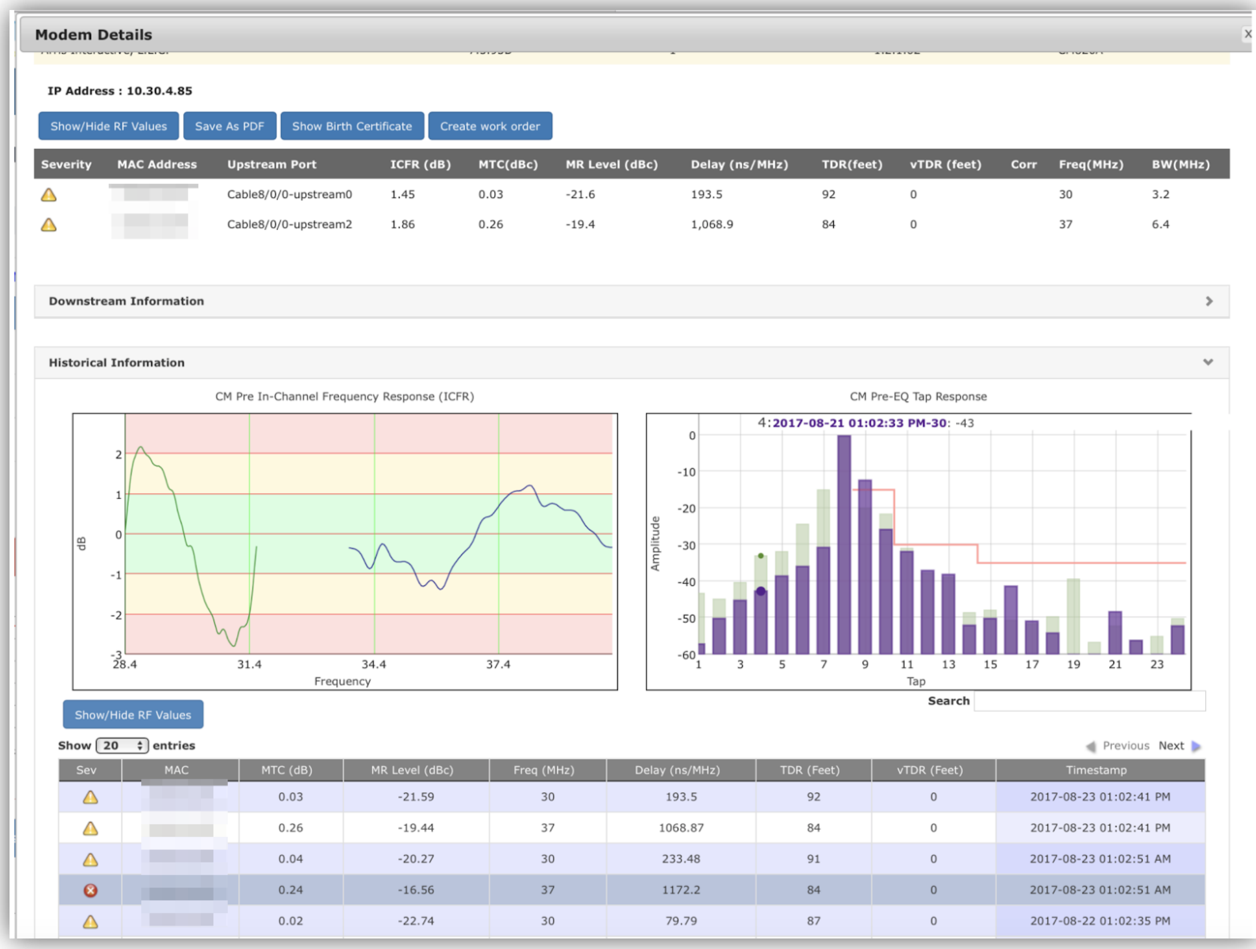


Figure 33: Subscriber 9 Modem Before Repair

Impairment Found: Bad connector at pole ground block and possible bad trap at tap

Figure 34: Bad Compression Type F-Connector

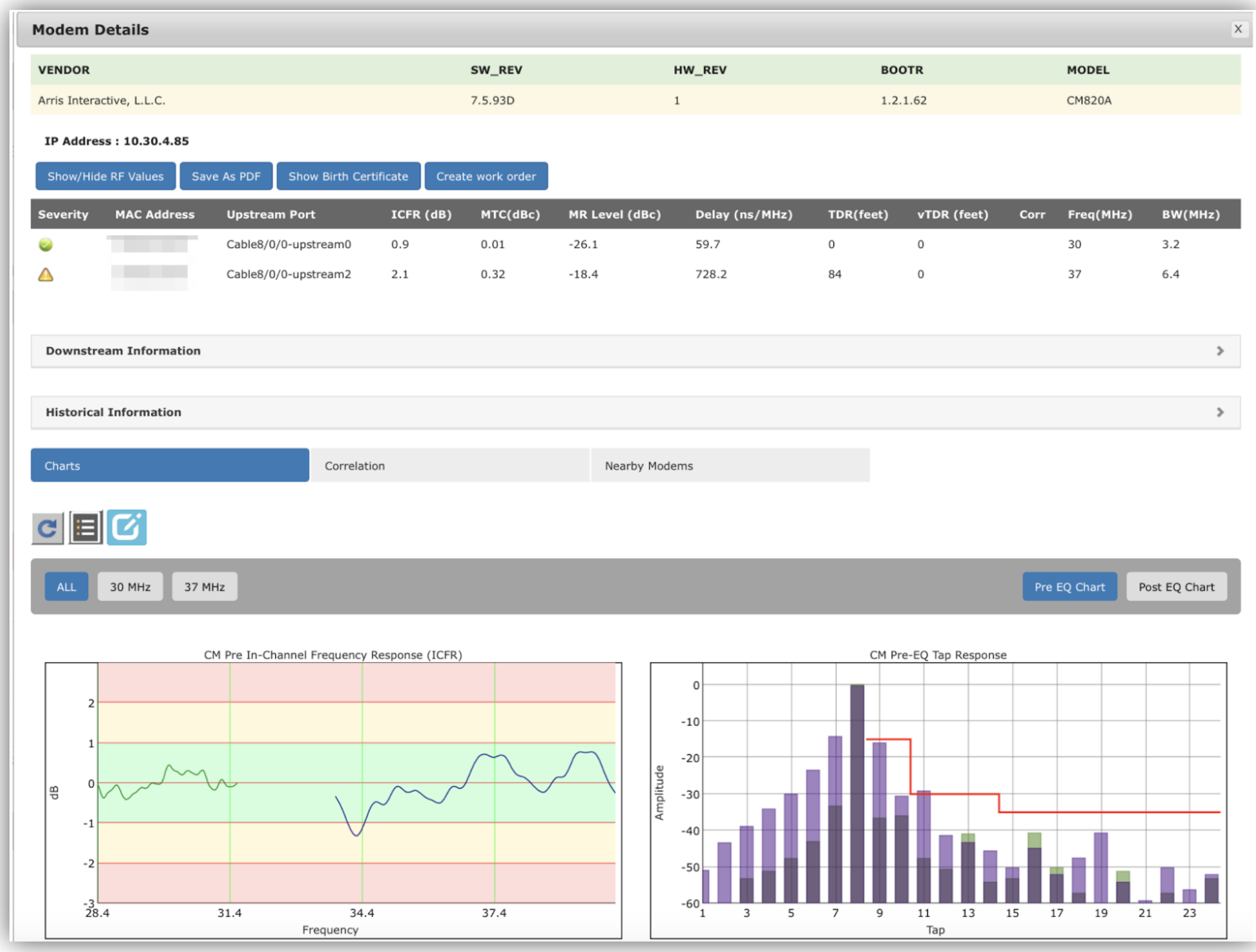


Figure 35: Subscriber 9 Modem After Replacing Bad F-Connector - Note there is still an impairment associated with the outside plant on the upstream near the band edge at 37 MHz

SUBSCRIBER 10

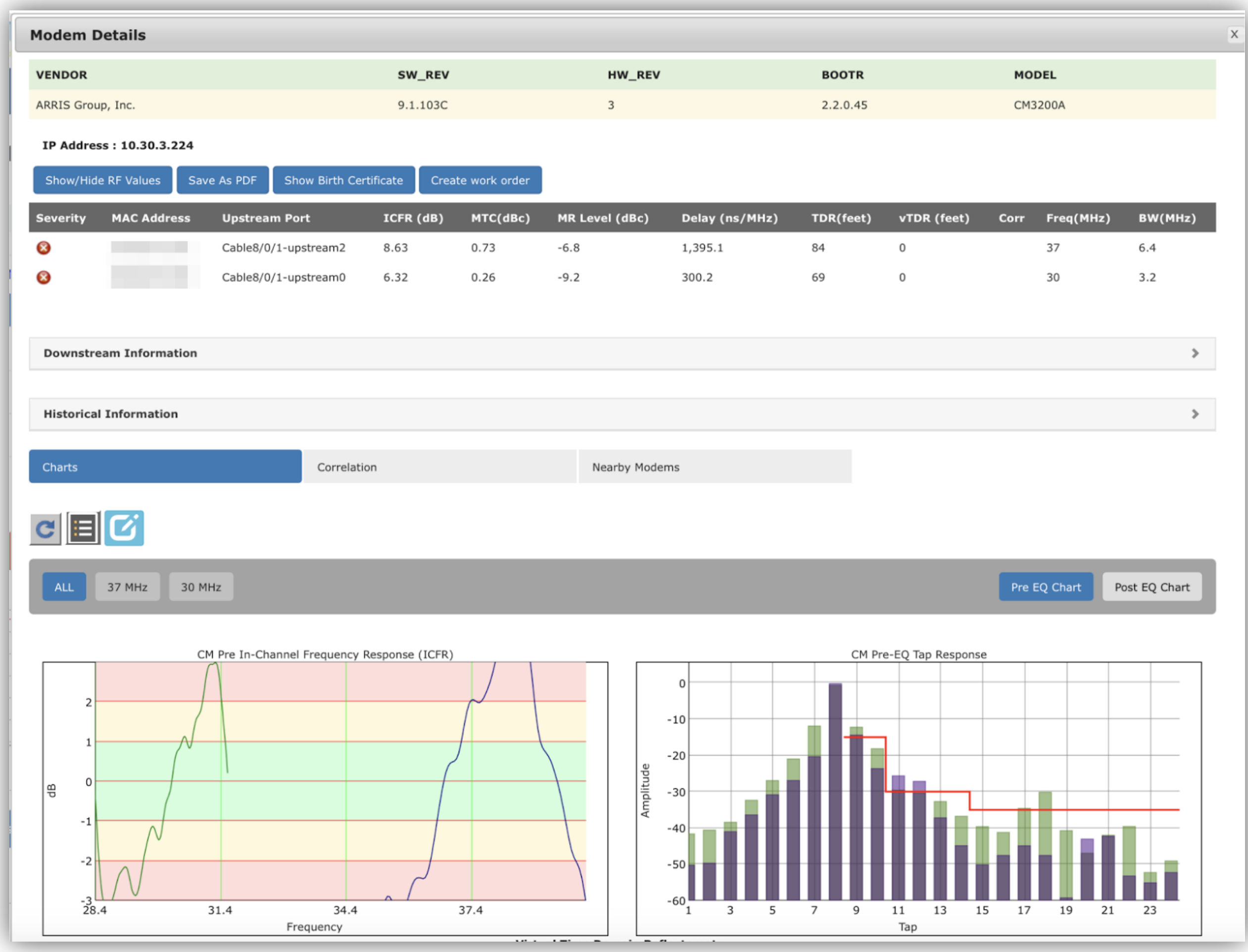


Figure 36: Subscriber 10 Modem Before Repair

Impairment Found: Cable from ground block was connected to an unused Dish TV splitter sitting in a small pond of water hidden in a crawl space under the subscriber dwelling. The splitter was fortunately leaking large ComSonics' M3 test signal amounts, which the QAM Compass made finding it easy. The Dish TV splitter was removed and a direct run was installed to the modem.

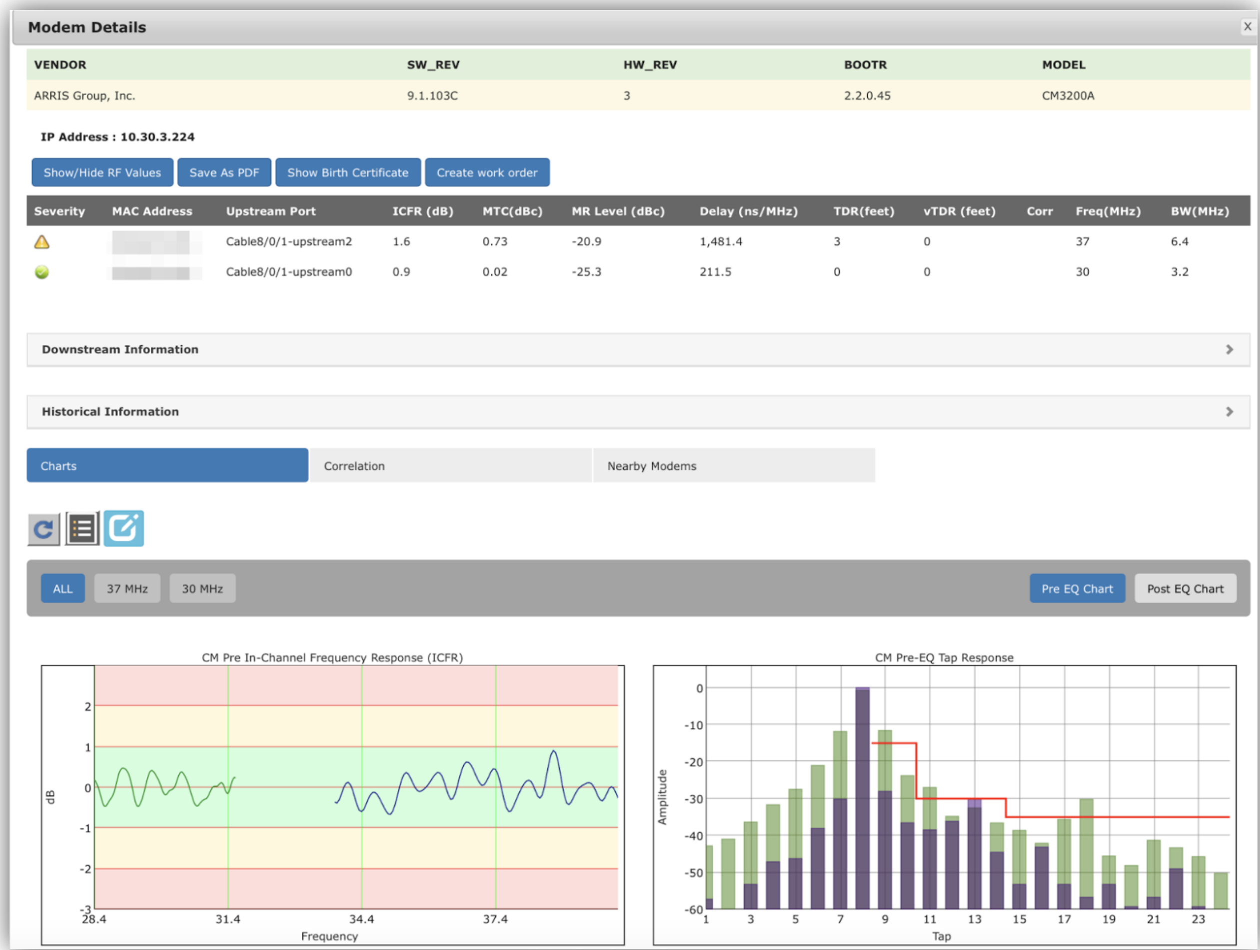


Figure 37: Subscriber 10 Modem After Removing Dish TV Splitter (Impairment at upper channel due to outside plant)

SUBSCRIBER 11

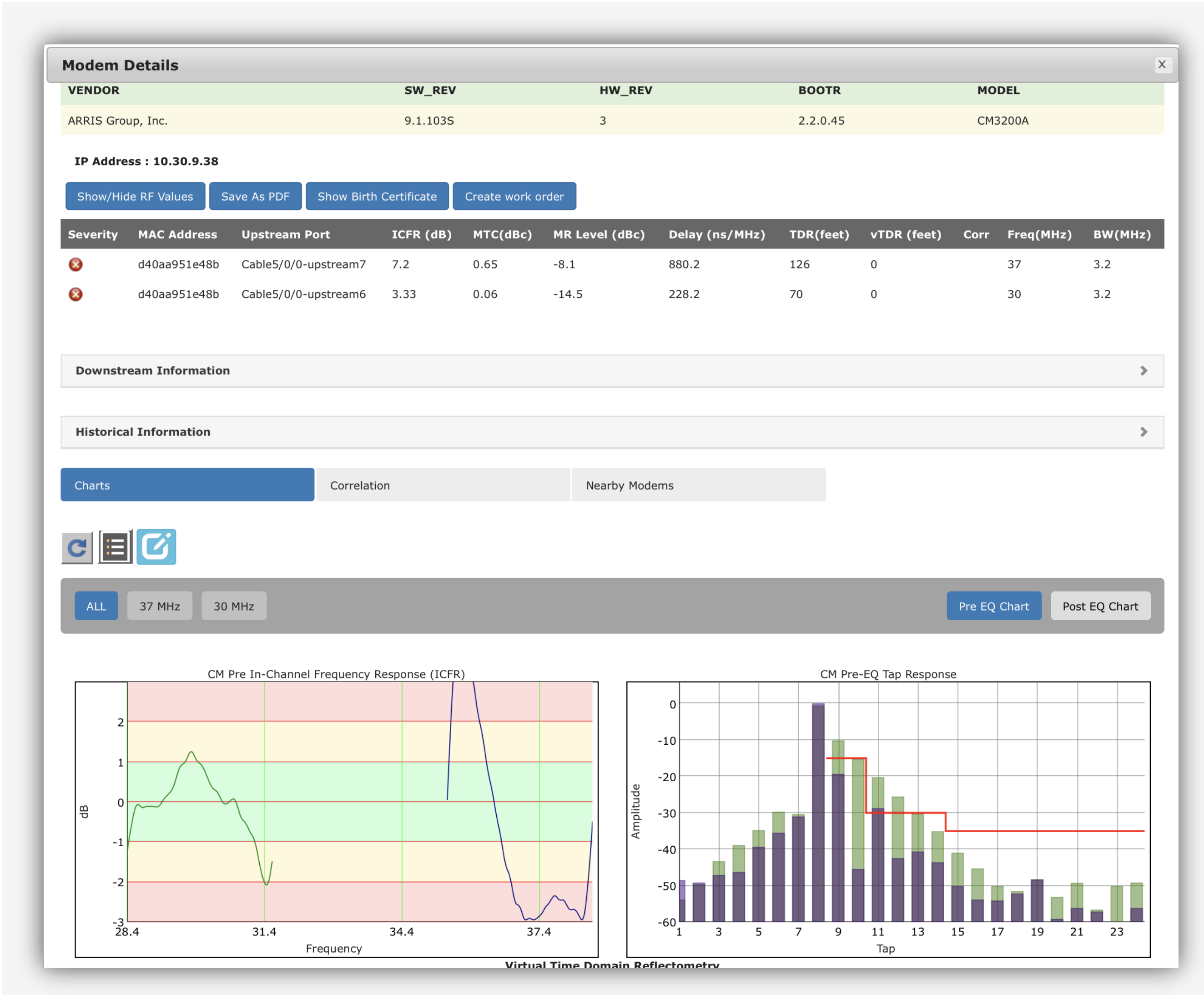


Figure 38: Subscriber 11 Modem before replacing drop

Subscriber 11: Replaced the drop which was damaged or had an existing bad splice (tracked with M3/Compass). Found a unterminated cable outlet inside the house with a very large amount of leakage. The rest of the inside was quiet. After repairs, the downstream improved significantly, but there was still an issue with the modem. The problem was most likely due to a problem on the network side.

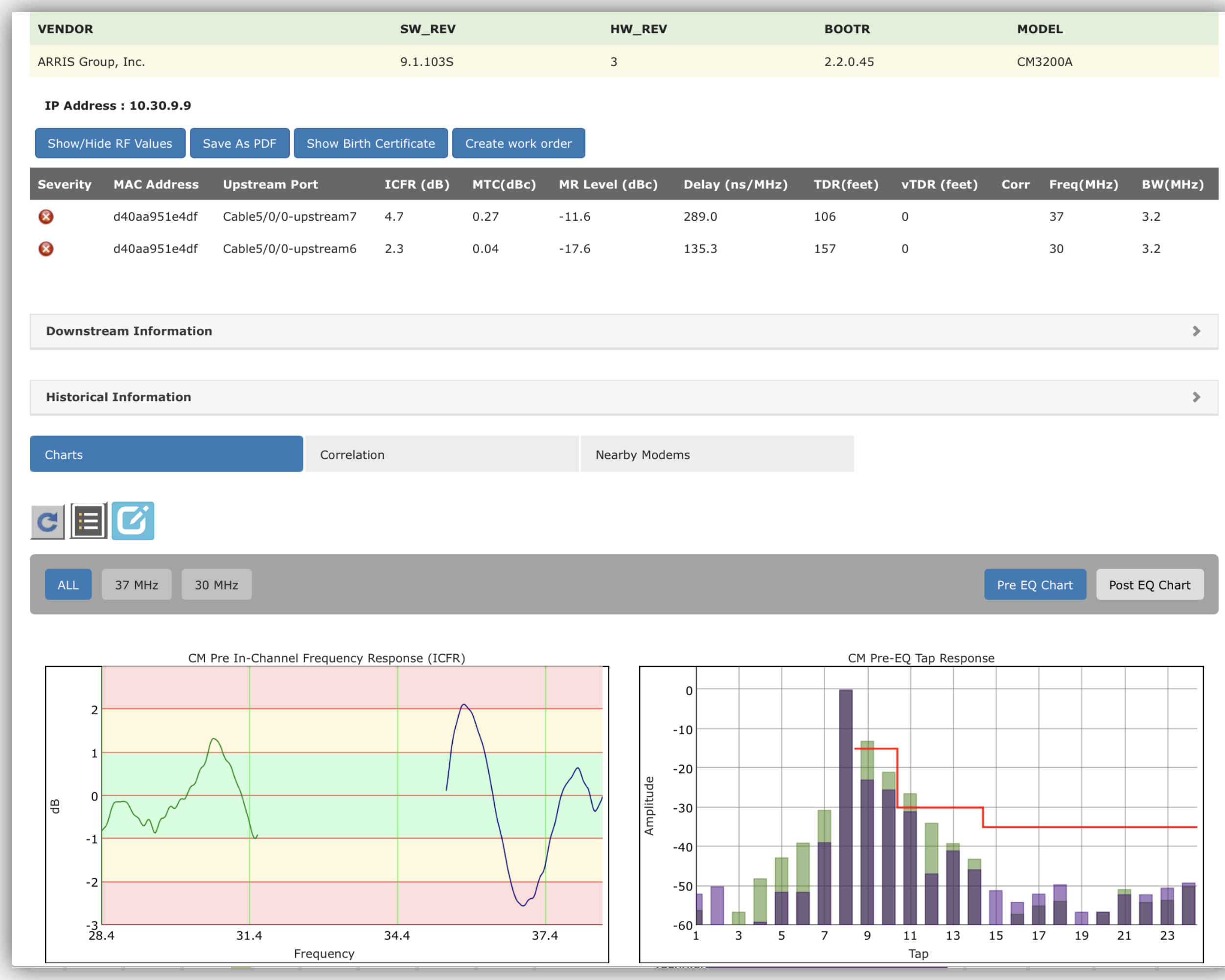


Figure 39: Subscriber 11 Modem After replacing drop

SUBSCRIBER 12

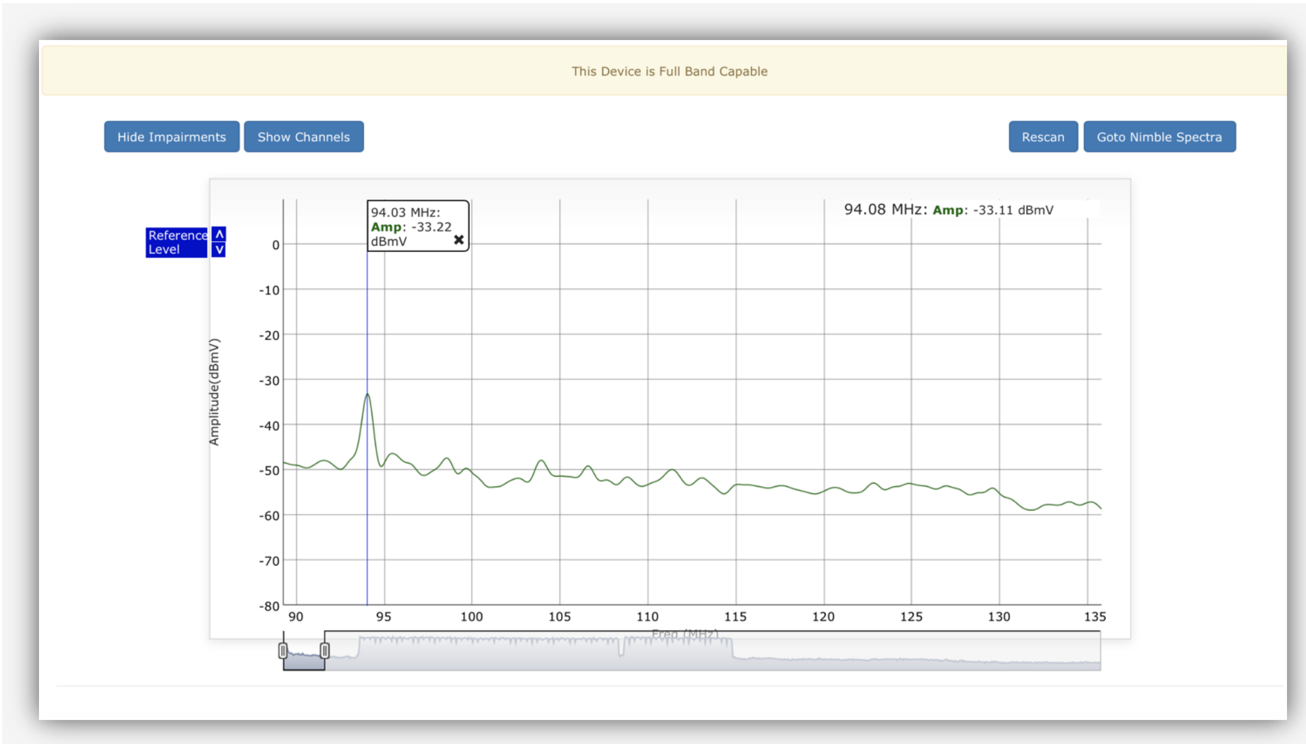


Figure 40: Subscriber 12 Modem Before replacing Connectors

As shown in Figure 40, this subscriber was experiencing FM ingress in the downstream at a frequency of 94.1 MHz. This is an expanded view of the full spectrum capture from the modem. The problem was found to be a series of problems including a bad drop, bad splitter, and crimp-on connectors.

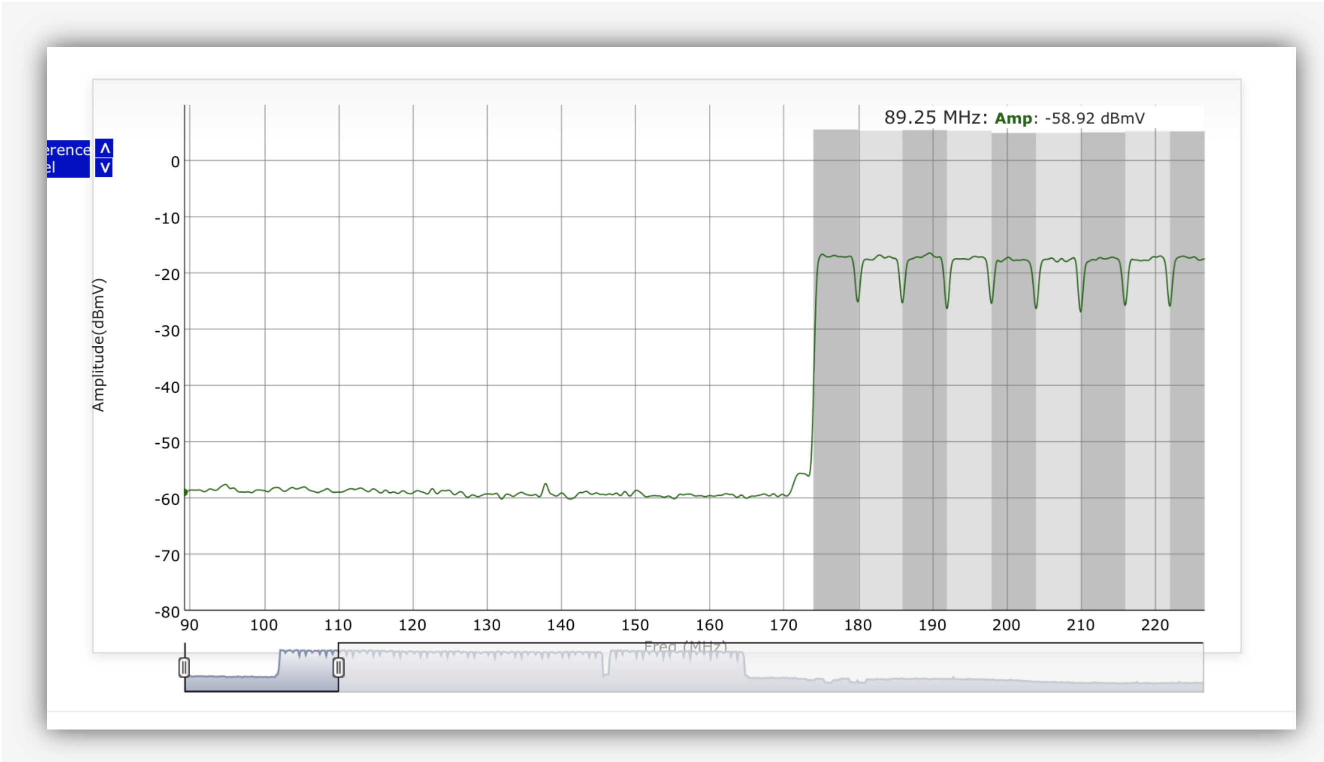


Figure 41: Subscriber 12 After replacing Drop and Bad Connectors. Note that the FM ingress is gone at 94 MHz

SUBSCRIBER 13

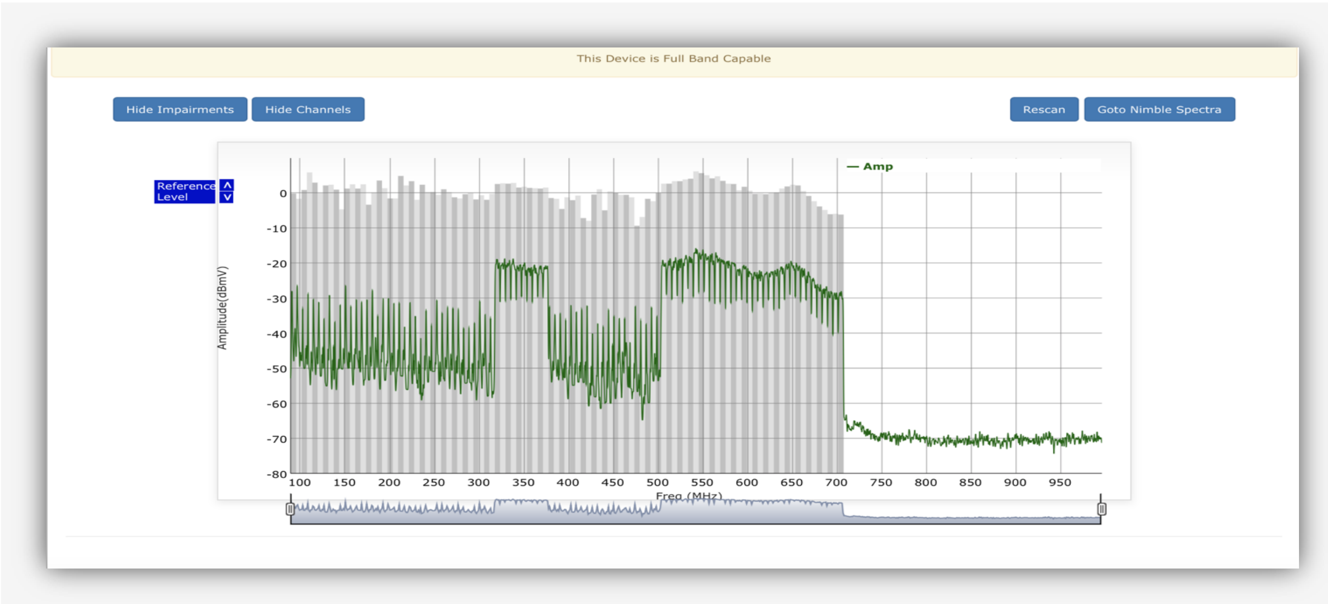


Figure 42: Subscriber 13 Before Repairs. Note the channel suck outs in the 400 MHz range

Subscriber 13 exhibited bad downstream channel response and FM band ingress. Note that some of the channels between 400 MHz and 500 MHz have dropped in level to about -10 dBmV as shown in Figure 42.

Replaced complete drop (two sections). The drop was looped around a j-hook causing significant depressions on adjacent sides of the drop. Also added a data only trap. See Figure 43.

Figure 43: Drop cable looped around a j-hook connector causing the cable shielding to fail.

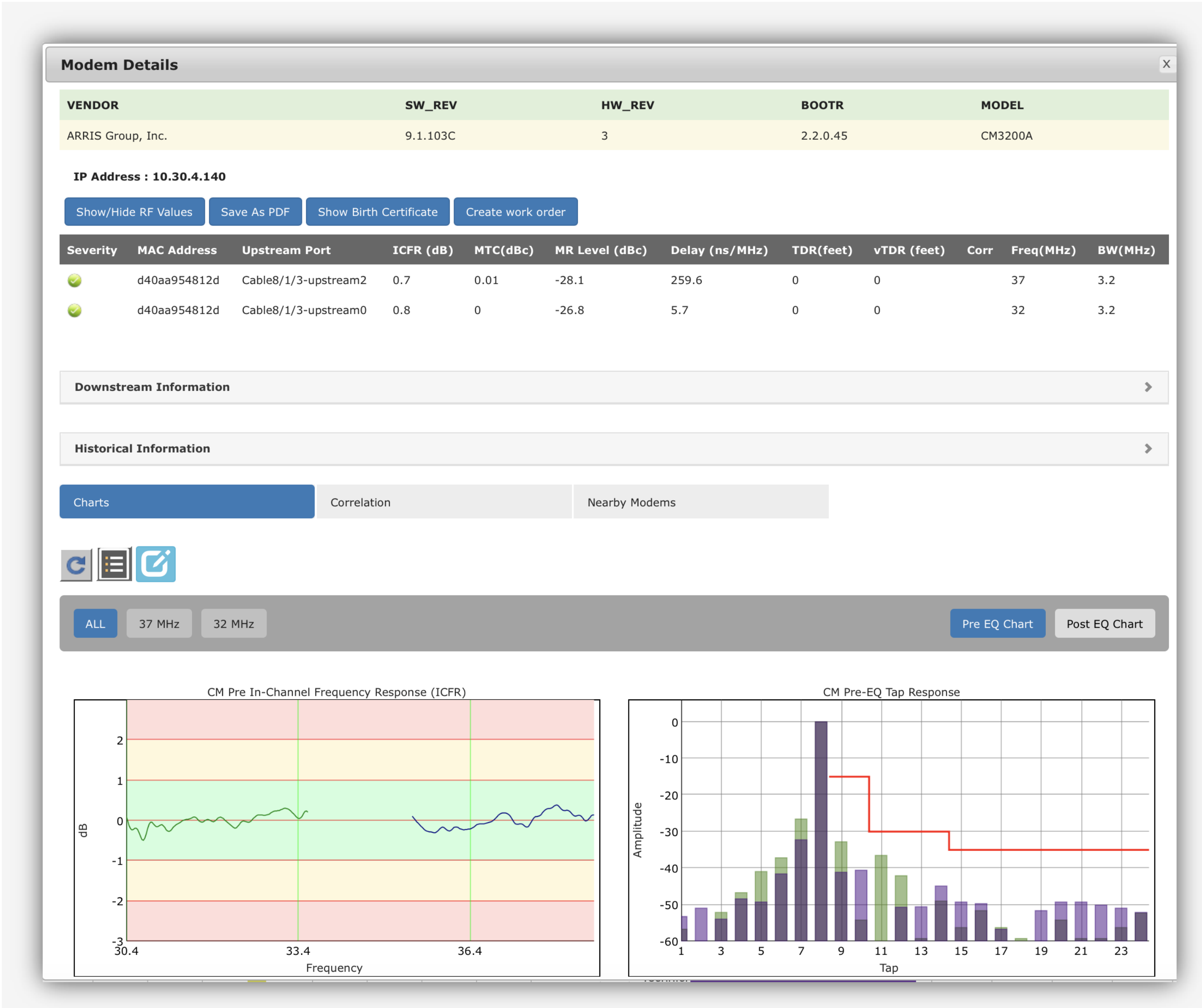


Figure 44: Subscriber 13 After Repairs

SUBSCRIBER 14

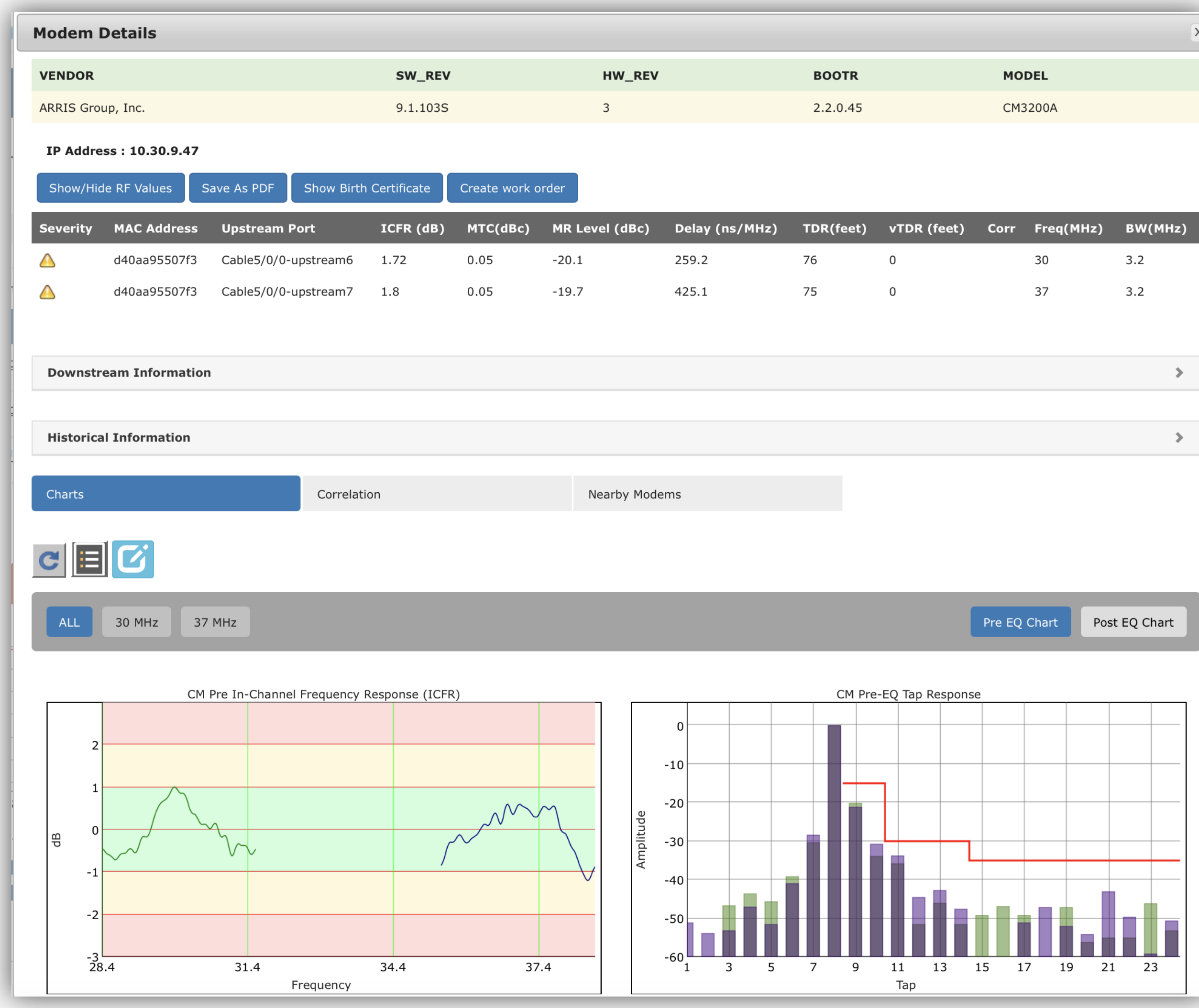


Figure 45: Subscriber 14 Before Repairs

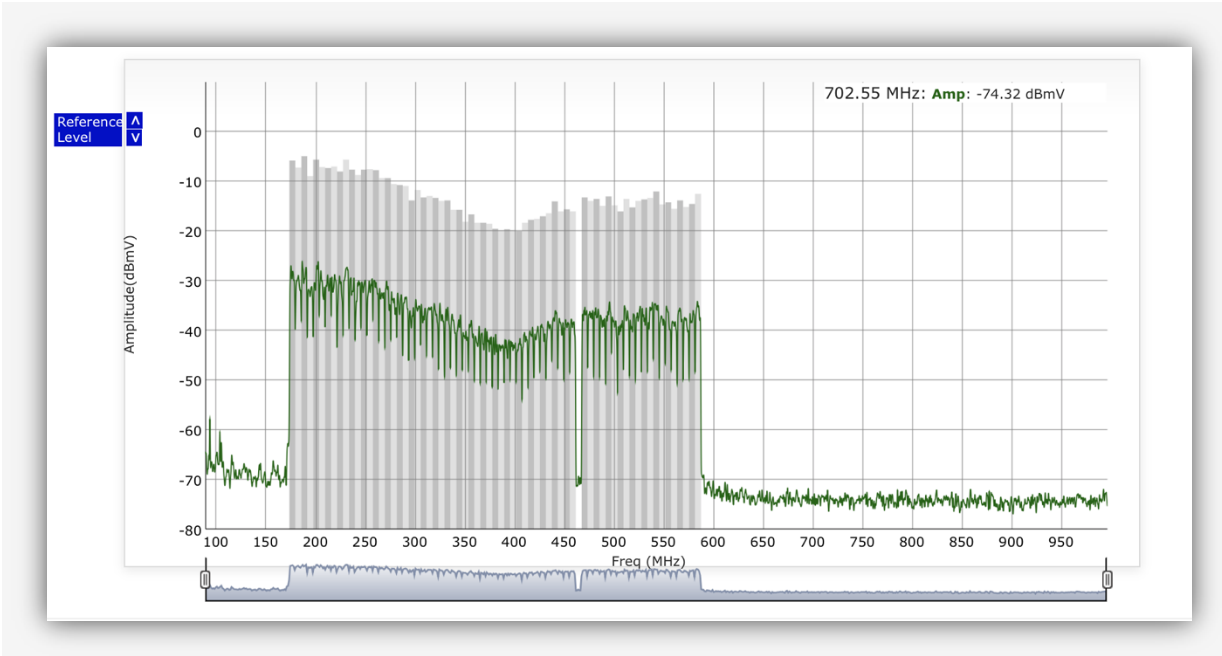


Figure 46: Subscriber 14 Levels before Repair. The levels drop to about -18 dBmV at 400 MHz

This subscriber was dealing with upstream noise issues, FM Ingress in the downstream, and a bad in-channel frequency response. The downstream level was very low at -18 dBmV. (See Figure 46). After troubleshooting with the M3 and QAM Compass, the drop was found to have multiple leaks. After speaking with the homeowner, it was revealed that the drop was buried shallow, just under the grass. The grass has been aerated several times and we suspected that the lawn aerator hit the cable line. The cable was also missing an earth ground / ground block.

After replacing the drop, the downstream level increased from -18 dBmV to +2 dBmV.

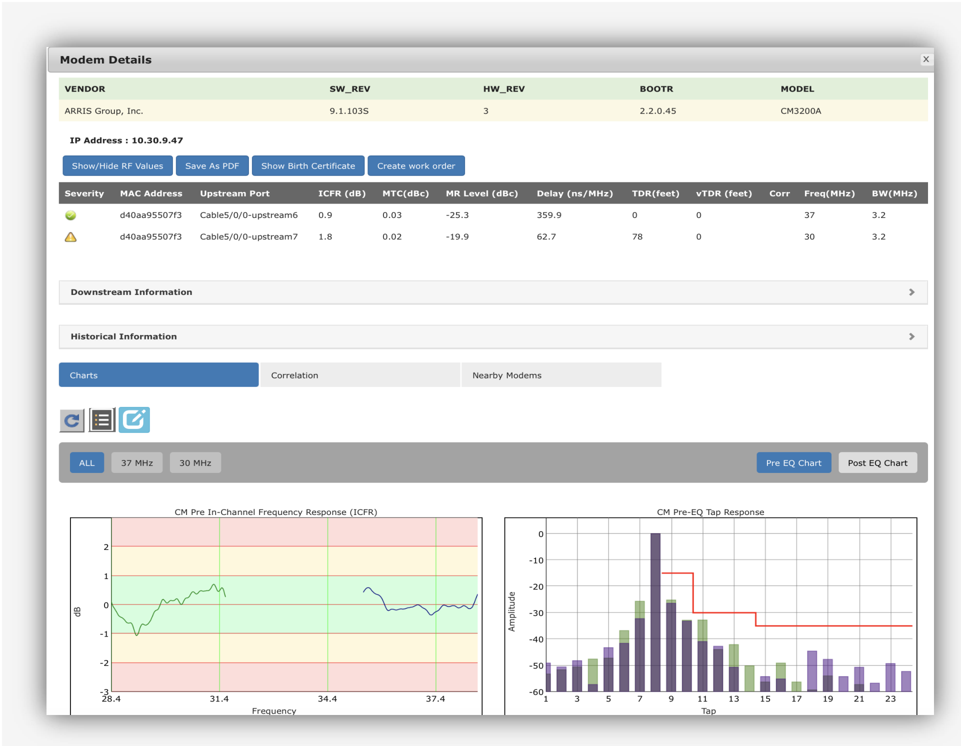


Figure 47: Subscriber 14 After repair. In-Channel frequency response has improved

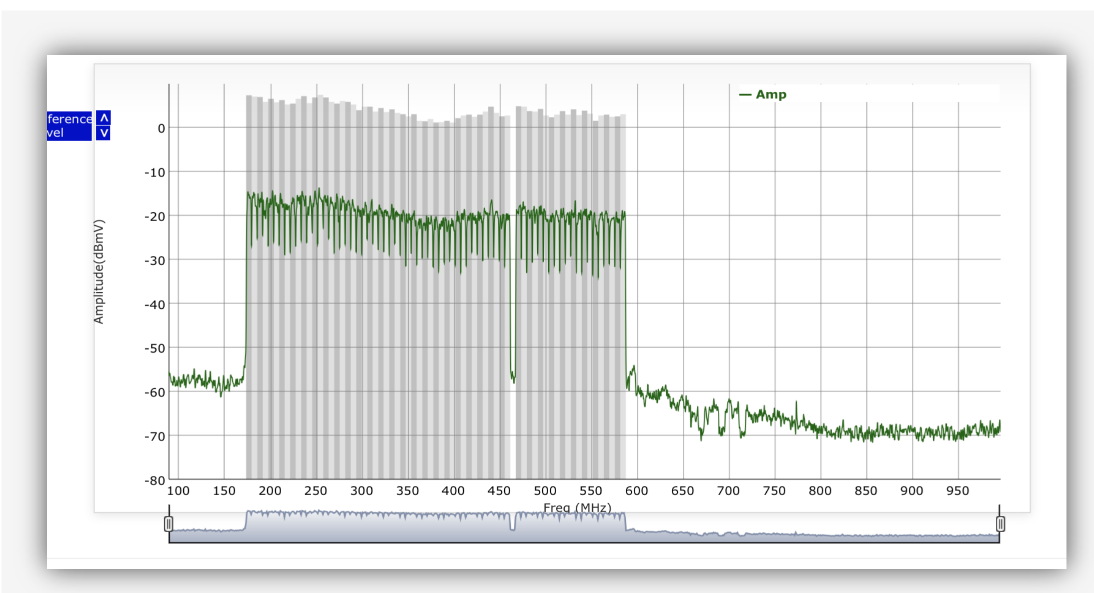


Figure 48: Subscriber 14 After repair. Channel Levels back to +2 dBmV

SUBSCRIBER 15

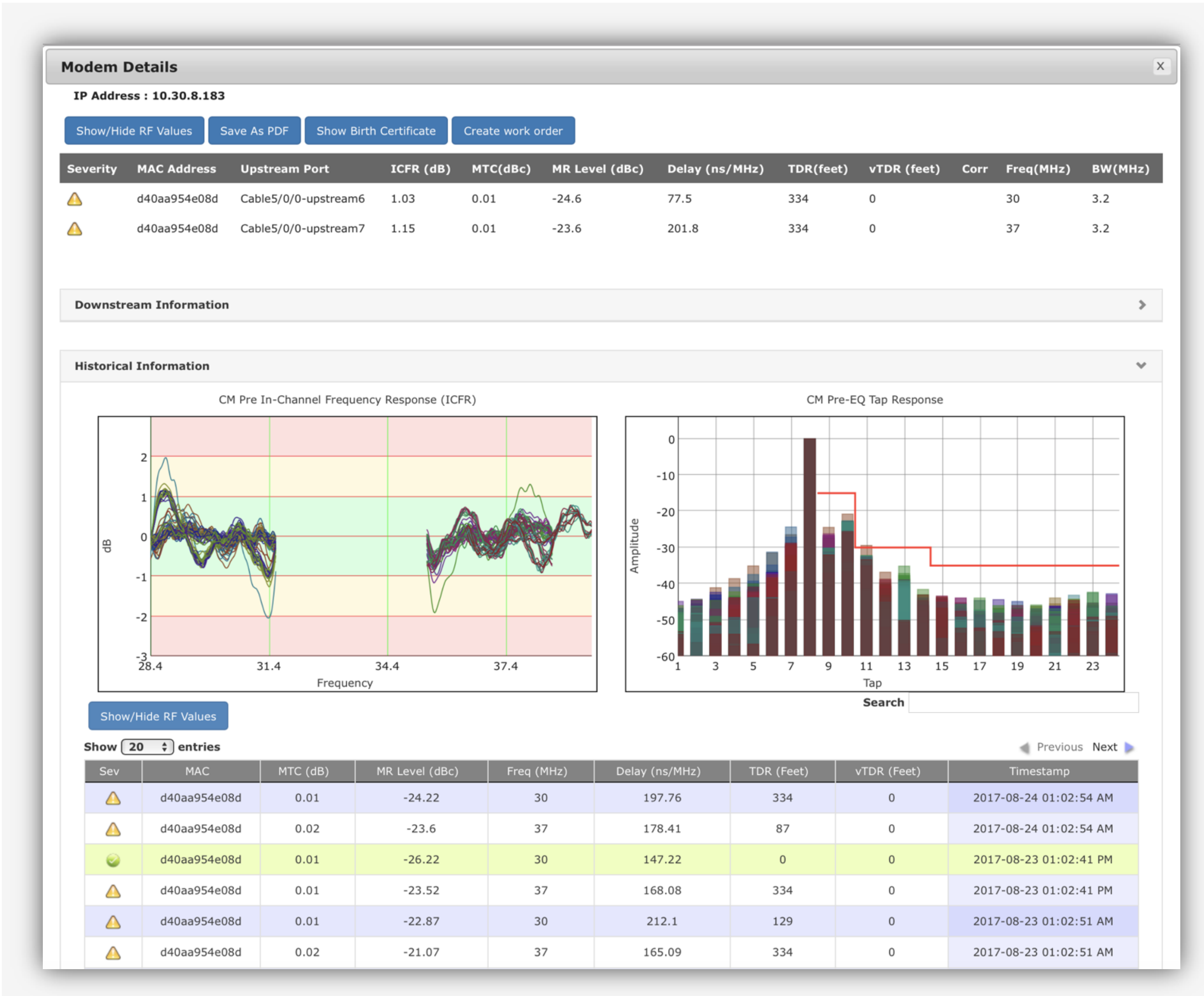


Figure 49: Subscriber 15 Before repair

Subscriber 15 exhibited problems of intermittent upstream, FM ingress and tilt in the downstream.

Problems found in crimp on connectors, a defective multiport splitter and a house amp that was not needed. Repaired all problems found which dramatically improved the return path channel response and returned the modem to a green status.

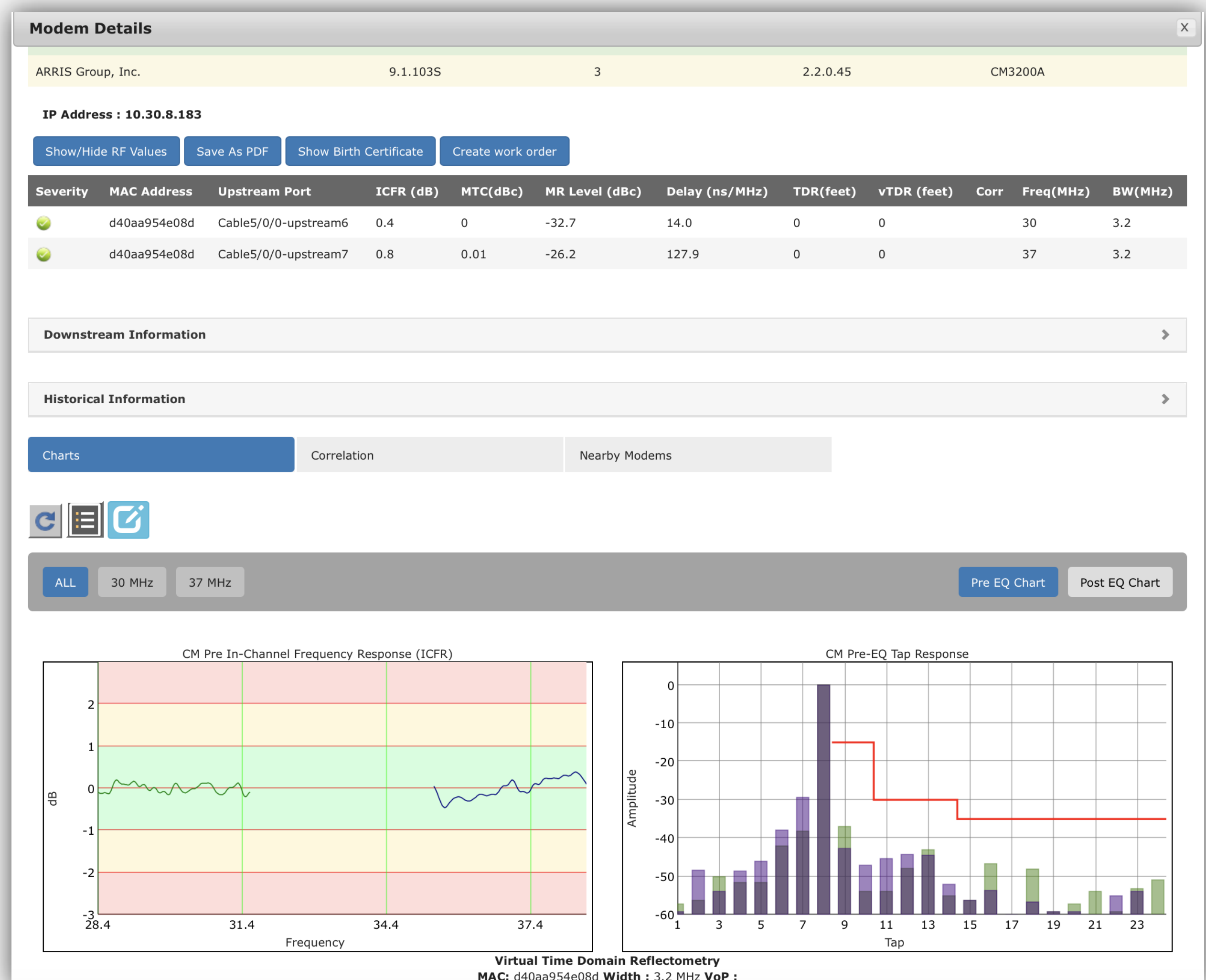


Figure 50: Subscriber 15 After Repair

SUMMARY BEST PRACTICES:

Best Practice #1: Avoid crimp-on F-connectors. Always use approved outdoor rated compression F-connectors to minimize future water ingress and corrosion, which will cause subscriber issues. It is recommended to avoid splices when possible. Further, do not count on your waterproof splice enclosure to protect your inline splices. **They will eventually fail.**

Best Practice #2: Avoid splices in drops when at all possible. Whether aerial or buried, splices will eventually fail due to environmental conditions causing unnecessary degraded subscriber quality of experience or even an outage resulting in a truck roll and the splice being replaced.

Best Practice #3: Avoid splices in buried drops. Not only are buried splices difficult to find, but unless they are in a very dry location, water ingress will almost always cause these to fail over time resulting in the splices to be replaced.

Best Practice #4: If you live in an area where lightning is prevalent be sure to check traps, filters and terminators for lightning damage. Most of these devices have small components which will fail if lightning strikes nearby the drop or mainline coax cable, causing micro-reflections.

Best Practice #5: Never use twist-on F-connectors. It is not possible to sustain an effective ground connection over long or even relatively short periods of time with twist-on F-connectors such as those shown in Figure 17.

Best Practice #6: Locate all splitters in a weather protected house box or inside the subscriber's home or MDU (multi-dwelling unit). Unprotected splitters will rust and corrode causing premature failure and micro-reflections. Be sure to weatherproof all outdoor F connectors, even those installed in house boxes.

👉**Pro Tip:** Just because a cable looks good from the outside does not mean it is good. Often micro-cracks, radial cracks, melted dielectric and other non-visible impairments can cause problems. PNM can show which homes have these problems and leakage tools will lead to the exact location of the problems.

Best Practice #7: Finger tight is never tight enough for F-connectors. The male “F” pin type connector shall withstand a minimum tightening torque of 60 lb-in., without damage when measured per ANSI/SCTE 98 2004. Be sure to always use a 7/16” or appropriate wrench when tightening all F-connectors. Note: In practice, the recommended tightening torque on mating interfaces such as tap ports, splitters, and ground/bond blocks, is typically in the 20 to 30 lb-in range, although some interfaces may use less torque. Consult the connector manufacturer. Connectors should NOT be tightened this much on CPE in the home (including TVs, VCRs, etc.) because of possible damage that may occur.

REFERENCES

[1] CableLabs PNM Best Practices

[2] Youtube Video of Twist on F-Connector: https://www.youtube.com/watch?v=LLOTdxs9VkA
Notice in the comments – Do Not Use These Connectors!

[3] Volpefirm.com

[4] Nimblethis.com