THE EFFECT OF LOOSE CONNECTORS ON SHIELDING EFFECTIVENESS

Asheridge Communications (A Teleste PLC Company) has undertaken a study to further understand the issues of RFI (Radio Frequency Interference) on CATV cable plant caused by loose F connectors. The study also touches on the issue of CPD within connectors, mainly relating to moisture ingress and contamination of the two connector mating parts. The information gathered within this paper is a result of many discussions with CATV operators across Europe, albeit the same issues effect every cable operator.

The study clearly concluded that all F connectors used over the past 20 + years suffered the same failing, resulting from Poor installation, Loosening through temperature variation, Vibration, Soft metals etc. The only way to resolve these issues is via complete hardening of the drop installation F port interconnect.

It is important to note that although the results of this study are European based, we believe the factors found affect F connectors on CATV plant worldwide.

Introduction

RFI shielding effectiveness of the cable plant is now becoming even more important, particularly in light of 4G LTE wireless, which currently operates in the 700-862MHz band. With possibilities of LTE even coming down to 600MHz in the future, it is paramount that cable operators take action now. In addition, the issues of Egress are becoming equally as important, with wireless authorities starting to clamp down on emissions from broadband cable plants, both from the network and within the home. Finally, there are of course the famous Ingress issues which affect a cable operator’s most valuable asset, his upstream; the real differentiator over most other copper technologies. The C/N or Carrier to Ingress as it can sometimes be called is the one of the key elements that affects the overall upstream performance. Maintaining good upstream C/N is a constant uphill battle for all cable
operators. With modulations schemes constantly improving, e.g. 16QAM to 64QAM to 256QAM and now talks of 1KQAM there is an even greater need for enhanced C/N.

In addition, the need for more symmetrical upstream speeds is becoming a must if cable operators are to compete head to head with the FTTH providers. This means expanding the upstream bandwidth, which currently is typically 65MHz. Docsis 3.1 is now becoming a reality and operators are now looking at upstream bandwidth up to 200MHz. The key word now for any cable operator looking to improve their plant in terms of Ingress is “FUTURE PROOFING”. Anything they do today should also be looking at the next generation upstream, both in terms of C/N and bandwidth. There are of course many things a cable operator can do, and is doing to enhance their upstream C/N, these include node segmentation, reducing node sizes, noise busting service teams who constantly working the cable plant and in-home in terms of terminating open connection, tightening loose connections etc.

One improvement that has been implemented is the introduction of the continuity F connector, which greatly reduces the RFI leakage of a loose F connector, particularly when the grounding between the two halves of the F connector become intermittently disconnected, making the centre conductor in to a super antenna. However, continuity connectors still leak RFI when loose, and will not maintain Class A shielding effectiveness once loose. Cumulatively, this will present a major issue to cable plants over time, as the connector thread lets in moisture and the metal to metal contact resistance between the connector thread and the F port thread deteriorates with corrosion etc. Another issue of loose continuity connectors relates to the fact the connectors can come loose and still maintain RF continuity, this means the operator can end up with leaking RF connectors and not know there is an RFI issue until they start to see major network issue. Originally, standard F connectors came loose and caused intermittent picture issues and broadband issues, the customer would then inform the operator who would then fix the problem by tightening up the connectors etc. In effect the connector told you there was a problem. All this assumes the connectors were tightened correctly in the first place, which again further enhances the issue. Now with continuity maintained, the picture and service continues to work, but as more and more connectors come loose they will cumulatively start to degrade the network C/N, and at this point it’s too late. Ensuring a continuity connector remains a minimum of finger tight and moisture free is imperative if these issue are to be avoided

Preventing the F connector from coming loose is essential, and this can be done with a simple fix, which this paper will now show in detail.

**Main**

In order to show the actual shielding effectiveness of closed and open continuity connectors, we tested many types of continuity connector using an Absorption Clamp RFI measurement system. The Absorption Clamp is a precision unit that has many sensitive
ferrite cores within its main body that can detect the RFI leakage on the outer braid of a coaxial cable. The leakage is seen as a voltage, which is then output from the clamp and measured on a network analyser. A highly screened cable is passed through the clamp, one end then goes to the DUT and the other end is terminated with a high quality 75 OHM terminator. The output of the clamp is then fed to the measurement port of the network analyser. The output from the analyser is set to 20dBm and sweeps 5-1000MHz and fed via a very highly screened coaxial cable to the input of the DUT. In our examples below we are using a 6” piece of RG6 quad shield cable with 99% braid, so very highly screened cable fitted with two standard F male continuity connectors. This cable is fitted as the DUT and connected to the test cable via two F61 splice adaptors.

The system is calibrated by taking the through loss curve of the Absorption Clamp, and then doing a simple Thru Cal on the network analyser with a Normaliser device, which is the exact inverse of the clamp loss. This is done without the clamp in circuit so that when you re-attach the clamp you are seeing a real-time RFI measurement, just as you would doing the same test in a G-Tem cell for example. An amplifier is fitted on the output of the clamp to compensate for the overall clamp loss.

System Setup showing test cable with continuity connectors fitted

Test Results

RFI Shielding effectiveness of Continuity connector tight then torque broken

The below RFI plot shows the continuity connector tight (Black Trace) then the continuity connector torque broken. Please note that the Blue Limit Lines show the RFI screening limits for Cenelec Class A screening. This is the minimum shielding limit you would expect, in fact, there are now new limits set which are Class A + which is 10dB down on Class A and also Class A++ which is 20dB down on Class A. At this point the connector is still around finger tight, but can easily be loosened with just fingers. Any amount of disturbance to the cable/connector assembly at this point would loosen the connector completely. As can be
seen from the plot, the shielding effectiveness at finger tight has degraded almost 20dB, but remains within the Class A limit.

**RFI Shielding effectiveness of Continuity connector tight then ¼ turn lose**

The below RFI plot shows the continuity connector tight (Black Trace) then the continuity connector ¼ turn lose. This time we are able to show the devastating effect of the connector actually working lose. As can be seen, the shielding effectiveness has now degraded by over 40dB from tight and 20dB worse than when the initial torque is broken. Taking in to account the recommended shielding effectiveness for 4G LTE is 95dB min you can see that the open connector shielding effectiveness in the 700-862MHz band is around -60dB. Also, please note that the low frequency RFI degrades badly from 50MHz upwards. This is major issue for the future upstream bandwidth enhancement where the upstream could expand up to 200MHz as operators move to Docsis 3.1

Another major issue relates to Egress, noise emitted from the cable plant through open and loose connections. More and more Governments are now putting legislation in place to control RFI emissions from cable plants, which will become a legal obligation and will results in heavy fines.
THE SOLUTION

As can be seen from the above testing, a tight connector has excellent RFI shielding effectiveness, and even when the connector torque is released to finger tight, the connector maintains adequate shielding. Keeping an F connector tight in reality is very difficult. Firstly, the mating F connector is made from either Zinc or Brass, both soft alloys. The continuity connector will slightly compress the mating connector when tightened then due to temperature changes and time; the two connector parts will lose their torque. At this point the connector will eventually work loose due to vibration from road side traffic, movement from overhead cabling and general disturbance.

All cable operators are fully aware of these issues and have constant maintenance programs to keep their F connections tight and RFI Ingress and Egress under control. In addition, once a connector comes lose, it is no longer water tight and will allow moisture and contaminates in to the connector. This will then cause oxidisation between the threads and various parts of the internal connector, which will result in the RFI screening degrading even further as the metal to metal contact resistance increases, but also equally as important can also lead to CPD issues.
There is a proven solution to all the above issue’s that will ensure the F connection never loosens more than finger tight, and will protect both halves of the F connection from moisture and corrosion. The solution is called Poly/Chemshrink, which is a special rubber that shrinks in air; no need for any heat, which itself creates issues. The rubber is specially formulated to remain durable and will shrink to 60% of its original inner diameter. Once the connection has been fitted with the Poly/Chemshrink, the complete F connection is water tight and more importantly, it is held firmly in place and cannot turn even after the torque force has eventually released. The end result is the RFI shielding will remain stable; the connection inner contact resistance will remain good and free from moisture and contamination and will maintain full integrity for a minimum of 10 years. This statement can be proven and can be backed up with statements from actual networks that have deployed the Poly/chemshrink on major outside plans, which have been monitored and are still performing well after a 10 year period.
See below a picture of a network passive fully connectorized and fitted with Poly/Chemshrink. This product had been in situ for 12 years.
Summary

The above pictures clearly show that it is possible to protect and maintain a CATV F type connection in perfect condition and free from moisture and corrosion whilst still maintaining RFI shielding effectiveness after extreme temperature cycling and vibration.

The F type continuity connectors rely totally on being tightened to the correct torque, and this torque being maintained throughout its life. In reality, this does not happen, and will at some point lose their torque and become loose due to environmental effects, or poor installation practices. At this point the connectors are open to moisture, contamination and their RFI shielding effectiveness will degrade. Over time the RF performance will degrade, intermittent faults will become inherent and then as we do today, we change out the connectors, time and time again. This goes to prove that environmental lab testing/environmental simulation does not replicate the real environment, no stand-alone F connector should be exposed to harsh environment, when for very little extra cost the connector assembly can be completely encapsulated, keeping the connection as new, and future proof.

Most connectors today cost more because of their construction to try ensure weather proofing and anticorrosion plating etc. It makes more sense to use a connector with excellent RF performance, adequate plating to ensure no dissimilar metals to avoid CPD and then enclose the connector assembly as above. It should be possible to reduce the cost of the connector and use this to off-set the additional cost of encapsulating the connector, which will provide clear long-term benefits, greatly reduce unnecessary truck rolls, and avoid continuous reconductorisation. The cost of ownership benefits include enhanced network reliability, reduced truck rolls and reduced maintenance costs.