# CABLE-PLANT CONDITIONING: REDUCING PACKET LOSS AND IMPULSE NOISE

*Florin Hodis, Member of Technical Staff, Access Business Unit*

As telcos begin mass deployments of IPTV services, exceeding customers' current expectations is a key factor in acquiring and retaining market shares, since today's viewers are increasingly savvy and will accept no less than the highest-quality video transmissions. Taking this into consideration, this application note explores the need for cable-plant conditioning in xDSL access networks delivering IPTV services.

Typical telco access network environments use ADSL2+, VDSL2 or xPON architectures (physical layer), transport voice and high-speed Internet services, in addition to IPTV.

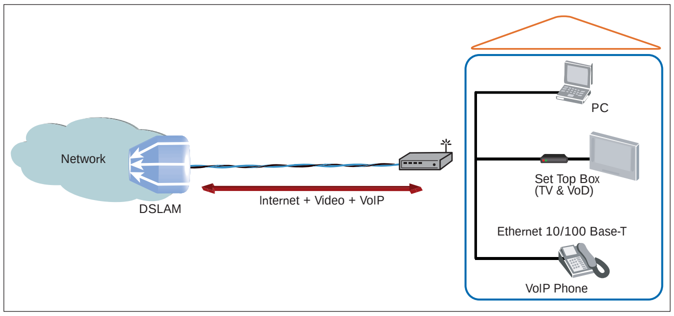


**Figure 1: IPTV access network.**

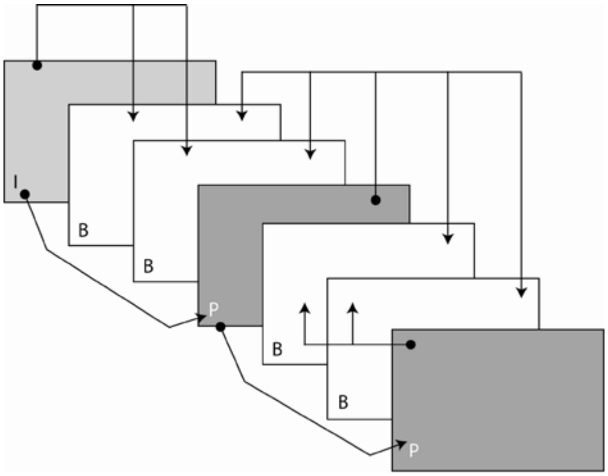


**Figure 2: MPEG GOP: I frames, P frames and B frames.**

## Packet Loss

Packet loss has a major impact on IPTV quality of service (QoS) and can occur for many reasons, including unexpected external events (e.g., electrical impulse noise, lightning, noise interference on DSL lines, system reconfigurations and/or traffic congestion).

IPTV packet loss leads to pixelization or blocking, freeze frame and/or set-top box lockup, and the degree of impact is dependent on the type of video frame that is affected. Through the IPTV video compression process, three types of frames are generated: I frames, P frames and B frames (i.e., intra frames, predicted frames and bipredictive frames).

I frames serve as the reference for all frames in a group of pictures (GOP).Therefore, loss of part or all of an I frame propagates and can persist for the entire GOP (typically 0.51 s ). Similarly, P and B frames can be referenced by other frames and similar issues could be experienced but usually to a lesser extent and shorter duration. The more flexible inter-picture prediction of H.264 can worsen this effect.

Packet loss can also create longer channel change times (zap time). During channel change, decoders wait for the next reference I-frame before presenting the image to the viewer; packet loss during this frame can cause the decoder to wait until the next good frame, thus significantly increasing channel-changing time.

Packet-loss performance requirements are defined in terms of loss period and loss distance. The loss period measures the duration of an error event, while the loss distance measures the time between packet losses. The DSL Forum recommendation TR-126 defines desirable loss distance as: one error in one hour for standard-definition (SD) programming and one error in four hours for high-definition (HD) programming, at loss periods of 16 ms.

At the xDSL physical layer, the most important contributors to packet loss are impulse noise, crosstalk and stationary noise. These interferences can be reduced, but not entirely eliminated, when access network conditioning operations are performed.

## Cable-Plant Conditioning Techniques for Enhanced IPTV Services

In order to implement cable-plant conditioning techniques effectively and achieve high-performance IPTV service delivery, there are several things to keep in mind. To begin with, cable pairs must show longitudinal balance. Twisted-pair telephone cables should be balanced and float equally with respect to ground. If the capacitance measured between tip and ground is different from that measured between ring and ground, it is likely that the conductor with the lower capacitance is cut at some point along the route or that either tip or ring (or both) are partially or completely grounded at some point. Most telephone companies prefer to measure longitudinal balance of the pair to analyze the effect that noise or crosstalk has on the pair. An equal-level signal is placed between ground to tip and ground to ring. To measure the balance, the amount of tip/ring signal is measured in dB with respect to the signal that was originally added. A good circuit has a balance of at least 40 dB with most being above 50 dB at 1.1 MHz for ADSL, and 2.2 MHz for ADSL2+. Longitudinal balance for voice band (1 kHz) should be better than 60 dB. If the cable is cut (open) or has a short, the best way to locate the fault is by using a time-domain reflectometer (TDR) measurement. The balance problem could also be caused by a partial short to ground. Locating this type of fault is best achieved by using a resistive fault location (RFL) measurement.

Cable pairs must be free of any shorts, grounding and bridged taps (open cable pair). Any defective wire conditions must be identified and repaired.

Avoid using split pairs in the access network. In neighborhoods or business parks, where spare-pair wires have become scarce, telephone technicians have often turned to split pairs to deliver service. A split pair is created from two semi-defective loops, each of which contains a single broken conductor. By using the remaining good conductor from each pair, an additional pair is gained. Split pairs can be acceptable for short to medium distance voice-frequency applications. For xDSL applications, however, the increased amount of crosstalk, as compared to normal pairs, is unacceptable.

Identifying split pairs within cable bundles, which already have other DSL circuits within the same binder group, is quite simple. Since a split pair does not twist consistently between its two conductors, it acquires more crosstalk than normal pairs. Therefore, a comparative crosstalk measurement between several pairs will expose the split pair. Pairs that exhibit abnormally high crosstalk are most likely split or have a conductor that is partially or fully grounded. If the abnormal pair has a normal longitudinal balance, then the pair is split. It is more difficult to identify split pairs in bundles that contain no xDSL services. In these cases, a new practice is to place an artificial signal on one loop within the bundle, and then make a comparison to the crosstalk measured on several or all other pairs; this test is called a stressed noise test or four-wire crosstalk, in which a test tone is transmitted on one port, and the amount of crosstalk is measured on the other.

Proper bonding and grounding is an absolute must; although it does not eliminate AC interference, it does reduce impulse noise and interference from AM radio. Also, any disturbers such as T1 or HDSL must be placed in a separate 25-pair sub-unit. Once the cable-plant conditioning operation is complete, the line should be tested for impulse noise or disturber signals to ensure IPTV QoS.

## Access Network Equipment Settings

Network equipment used in xDSL-based IPTV deployments has various settings to help improve IPTV QoS. Namely, there are several parameters that help ensure that packet loss is kept to a minimum.

### *Noise-Margin Setting*

The common practice of increasing the xDSL noise-margin limit to allow more room for noise fluctuations has the disadvantage of decreasing bandwidth, which may limit the availability of IPTV services.

### *Virtual-Noise Setting*

Virtual noise, adopted in the ITU G.993.2 VDSL2 standard, provides additional protection against future noise interference with less bandwidth penalties, as compared to the noise-margin setting.

### *Interleaving and Forward Error Correction*

At the transmitter end, additional bits are added to the packet using the Reed-Solomon algorithm; at the receiver end, the additional bits enable error detection and, when possible, error correction. When the error rate exceeds the capacity of the protection mechanisms to correct the packet, the packet is flagged as corrupt; such packets are considered unusable or lost. Note that interleaving adds latency, which does not have a negative effect on IPTV.

### *Impulse-Noise-Protection Parameter*

ADSL2/2+ standards introduced the impulse-noise-protection (INP) parameter, which enables operators to select the maximum impulse length that the system can correct. The VDSL2 standard also supports the INP parameter. INP values can be set between 2 and 16 to perform error correction for intervals of time between 250 μs and 3.75 ms. The drawback of using the INP parameter is that it decreases usable bandwidth, which can limit the IPTV service deployment. The impact of bandwidth reduction is more significant for ADSL2/2+ than for VDSL2, where there is significantly more bandwidth available to begin with.

Due to the above-mentioned limitation of the INP methodology, new alternative methods are in the process of being defined by xDSL chipset vendors in order to provide a significant improvement in residual bit error rate (BER), as well as resistance against impulsive noise. These new techniques will become critical to ensure successful IPTV deployment.

## Conclusion

In order to deliver reliable IPTV service, it is extremely important to invest in the improvement of the access network infrastructure so as to minimize packet loss. Furthermore, implementing cable-plant conditioning techniques for IPTV services can eliminate a substantial number of potential subscriber complaints and, consequently, reduces the amount unnecessary truck rolls. Consideration should also be given to network equipment that incorporates new technologies enabling end-to-end error correction, which helps eliminate the remaining impairments that may be present in a well-conditioned cable plant.


EXFO Corporate Headquarters 400 Godin Avenue, Quebec City (Quebec) G1M 2K2 CANADA Tel.: 1 418 683-0211 Fax: 1 418 683-2170 info@EXFO.com

Toll-free: 1 800 663-3936 (USA and Canada) | www.EXFO.com

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|---|---|---|---|---|
| **EXFO America** | 3701 Plano Parkway, Suite 160 | Plano, TX 75075 USA | Tel.: 1 800 663-3936 | Fax: 1 972 836-0164 |
| **EXFO Europe** | Omega Enterprise Park, Electron Way | Chandlers Ford, Hampshire S053 4SE ENGLAND | Tel.: +44 2380 246810 | Fax: +44 2380 246801 |
| **EXFO Asia** | 151 Chin Swee Road, #03-29 Manhattan House | SINGAPORE 169876 | Tel.: +65 6333 8241 | Fax: +65 6333 8242 |
| **EXFO China** | No. 88 Fuhua, First Road, Central Tower, Room 801 Futian District | Shenzhen 518048 P. R. CHINA | Tel.: +86 (755) 8203 2300 | Fax: +86 (755) 8203 2306 |
| | Beijing New Century Hotel Office Tower, Room 1754-1755 No. 6 Southern Capital Gym Road | Beijing 100044 P. R. CHINA | Tel.: +86 (10) 6849 2738 | Fax: +86 (10) 6849 2662 |


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