The Splitter in DSL Applications What is it all about?

Telecom Division

Ronan Kelly, Field Applications Engineer

The Splitter in DSL Applications

Background:

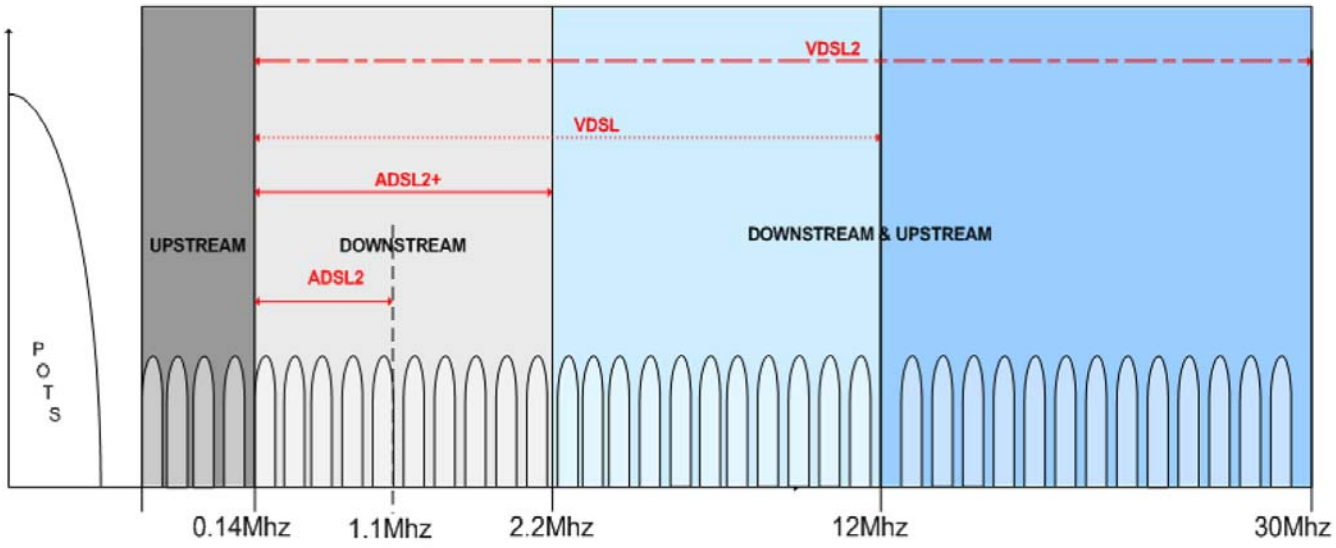
This white paper will focus on POTS (Plain Old Telephone Service) applications. In POTS, the telephone analog frequency uses only a small proportion of the bandwidth on a line i.e. up to 4KHz. The maximum amount of data that any basic dial-up modem can transmit through a POTS system is 56Kbps, therefore using this system to send data creates an absolute bottleneck.

The analog telephone frequency range has a limited bandwidth, so if data communication equipment is networked only very small amounts of information can be transmitted and received over the phone line at any one time. A wide band of frequencies is necessary if this system is to operate efficiently, to transmit information whether it is voice, data or video, in a given amount of time.

What is DSL and how many types are there?

DSL (Digital Subscriber Line) refers to the technology used between a customers premises and the telephone company, which enables more bandwidth over the already installed copper cabling than users have had traditionally. There are a few varieties of DSL (see Fig 1 below) which have key differences to suit the user (i.e. speed, line coding, no. of lines, and distance limit/reach).

Fig 1: POTS and DSL frequency spectrum



What is DSL and how many types are there? *(contd.)*

Type	Description	Data Rate Upstream Data Rate	Max Downstream Data Rate	Max Reach	POTS Support
HDSL	High Bit Rate - DSL	1.54Mbps	1.54Mbps	3650mtrs	No
ADSL	Asymmetric - DSL	800Kbps	8Mbps	5500mtrs	Yes
SDSL	Symmetric - DSL	2.3Mbps	2.3Mbps	6700mtrs	No
VDSL	Very High Bit Rate - DSL	16Mbps	52Mbps	1200mtrs	Yes
VDSL2	Very High Bit Rate - DSL (2nd Generation)	100Mbps	100Mbps	<1500mtrs	Yes

For the purpose of this document, to avoid confusion, the generic term DSL only will be used, which will encompass all types.

So how do we ensure that DSL does not interfere with POTS?

What is needed is a Splitter/filter. The main purpose of the DSL over POTS splitter, is to separate the transmission of POTS signals and DSL signals (see Fig 1), which enables the simultaneous transmission of both voice and data on the same twisted pair i.e. the POTS + DSL line. The splitter also provides isolation to the POTS signal from interference from DSL signals. Its also provides isolation for the DSL transmission to the POTS from transients generated during POTS signalling (i.e. dialling, ringing, ring trip, off-hook, on-hook etc.).

When DSL and PSTN (Public Switched Telephone Network) operate on the same line, the electronics inside a normal phone can be a problem for the high frequency DSL signal: the DSL signal can be attenuated (high capacitance on the telephone input, possible resonances inside the telephone, impedance mismatching) and DSL signals can be heard as noise on some phones (phone electronics demodulates high frequency signal outside its operating range to voice frequency noise). In order to keep these systems apart and stop them from interfering with each other it's necessary to separate the two components from the telephone line.

The DSL POTS Splitter/filter allows full advantage of the bandwidth of the copper line frequency spectrum to be taken, by stopping the telephone and DSL systems from interfering with each other.

The signal from the telephone output is generally just low-pass filtered so that voice frequencies (frequencies up to 3.4KHz, some say 4KHz) pass through without any issues, but higher frequencies are filtered. This filtering generally consists of an LC (L=Inductance, C=Capacitance) low-pass filter designed to some suitable operating frequency between 4 and 20 KHz (between voice and DSL bands). This kind of filter causes the high frequencies of the DSL signal to be severely attenuated (usually by at least 30dB with a good filter) so the signal reaching your telephone equipment does not contain such an amount of high frequency signals that could cause noise.

The Splitter in DSL Applications

The DSL POTS splitter is a series of coupled inductors and parallel capacitors forming a low pass filter that attenuates the higher frequency DSL data and permits only the voice frequencies to reach the telephone. The series inductor shows high impedance to high frequencies, so the DSL signals on the line are not attenuated.

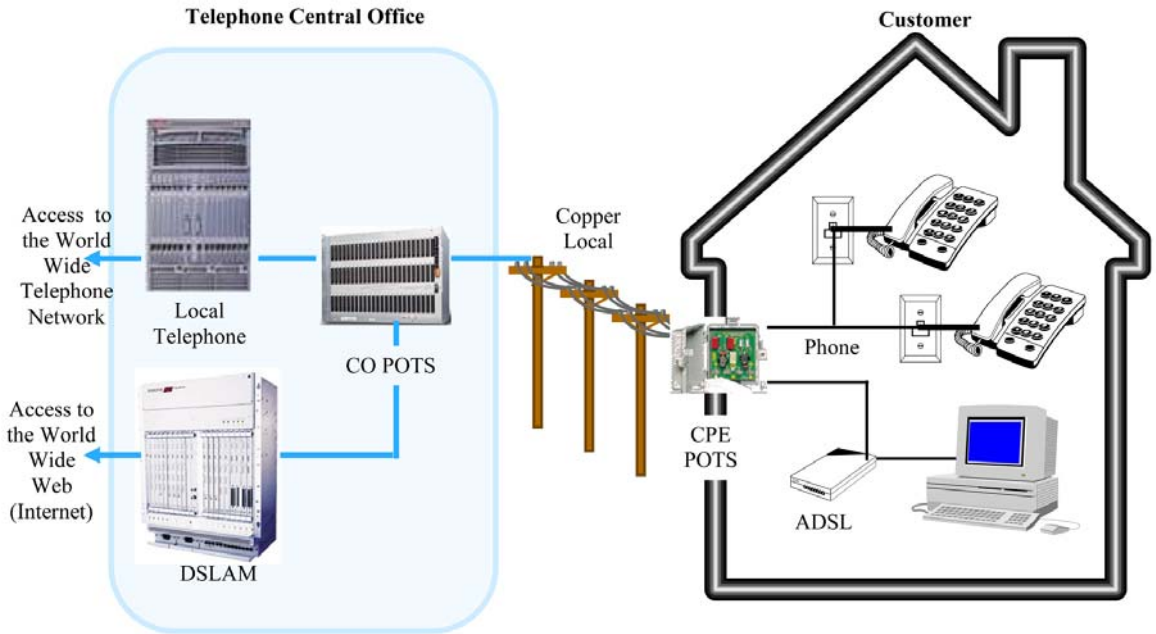
General design specifications for a DSL splitter are as follows:

- Should not alter voice band frequency response too much
- Should not have too high series resistance.
- Filter must pass the POTS tip-to-ring dc voltages (typically 0-72V)
- Filter must pass ring voltages well (40V to 80Vrms at any frequency from 15.3Hz to 68Hz with a DC component in the range from 0V to 72V)
- All requirements must be met in the presence of POTS loop currents (usually around 0-80 mA, can be up to 100mA in many cases or even 300mA in specific designs).

Where do these splitters exist?

When a DSL system is installed to the central office (CO), DSL splitters are installed on the CO end of the telephone wire. The splitters at the CO have basically the same functional needs as the home units, they need to be able to keep different signals separate, and separate those two signals to different outputs. Crosstalk and environmental conditions are two prerequisites, which need to be met for CO splitter filters, as opposed to CPE (Customer Premise Equipment) commercial offerings.

Fig 2: CO and CPE Splitter Location Diagram



Typical CO DSL splitter/filters are devices that have many filters built into one package. For each outgoing line there is one PSTN connection (goes to the CO telephone central equipment) and one for DSL connection (goes to Digital Subscriber Line Access Multiplexer (DSLAM) rack that terminates DSL connections). Typical DSL splitters in the central office have series capacitors (blocks telephone line DC well, attenuates ring signal considerably, and passes DSL signals well) between line and DSL output going to DSLAM. Because DSL splitter/filters connect directly to the subscriber's loop media, it must also provide some surge protection from externally induced voltage (lightning strike, power surges etc.) which could cause damage to any attached equipment or endanger humans interacting with the installed equipment. The DSL splitters in the central office typically include over-voltage protection components to protect the DSLAM against over-voltages on the line. Some filtered DSL outputs provide protection from the high frequency transient and impedance effect that occur during POTS operations (ringing transients, on-hook, off-hook transient and so on). This is an option that must not be omitted when considering what splitter/filter suits an application.

What is "Ring Transient Tripping"?

The local battery from the CO provides -48VDC in a telephone off-hook condition. The ringing signal from the CO is 90VAC RMS @ 20Hz and the peak voltage of the ringing signal is actually +127 Volts.If a subscriber picks up the phone at the negative peak of the ringing voltage an instantaneous voltage peak of -175 Volts (-48 from the CO battery + -127 Volts from the ringer) is received at the splitter. This condition is known as ring trip, because the ringing signal is being tripped or stopped when the end user picks up the telephone when it rings.

This is a common occurrence for VDSL2 applications. VDSL2 is the newest and most advanced standard of DSL broadband copper wire-line communications. It's designed to support the wide deployment of Triple Play services such as voice, video, data (triple play), high definition television (HDTV) and interactive gaming. IPTV (Internet Protocol Television) delivers television programming to households via a broadband connection using Internet protocols. Performance of the VDSL2 modems, and therefore IPTV quality, greatly depend on how well the splitter performs during the ring trip event.

Conventional splitters can saturate and/or allow high-voltage and high-frequency voltage transients to enter into the VDSL2 spectrum sent to the DSL modem, creating data corruption and packet loss. This was not a problem for high speed Internet access because, in the event of packet loss due to ring trip, the remote end would request a TCP/IP (Transmission Control Protocol/Internet Protocol, it's the basic communication language or protocol of the Internet), retransmit request from the host end.

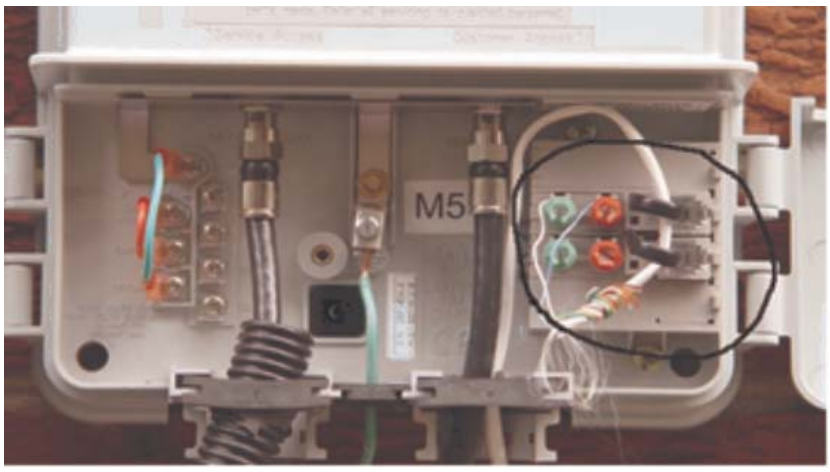
However, with streaming video, there is no TCP/IP packet retransmit request. The video frame has come and gone, and has already been viewed by the end user. This "bursty", versus streaming bit rate is a critical difference between data and video over broadband, making the VDSL2 splitter/filter very challenging from a design perspective.

What is the solution to "Ring Transient Tripping"?

A more practical and effective solution for a service provider and DSLAM manufacturer is to use high-quality video-grade splitters that significantly reduce the transient effects from ring trip and pass the error correction on to more complex upper layer protocols. The splitter works in conjunction with the DSL chipset in negating the ring trip effects.

Two types of splitters are needed: one outside the home in the Network Interface Device (NID), see Fig 3, and the other in the CO. A video-grade splitter is needed to determine the system level test requirements. Many system designers don't realize they have a problem because they have no way to test for it, and currently there is no standard or specification for testing the system to see how it's functioning. It isn't until the video severely degrades or dies that they realize there's a problem. If the problem can be identified, the service provider must design around it.

Fig 3: NID Splitter *Splitter installed in a NID*



Although some off-the-shelf products are available, most splitters have to be custom ordered due to the variation and specific requirements in CO splitter board dimensions. There is no standard for DSL splitter boards so each CO splitter board is unique. Because Pulse deals with these problems daily, we are experienced in selecting the best splitter and providing a configuration scheme to avoid ring trip issues. The new SmartER series of Pulse products meets the stringent requirements of VDSL2 and ring trip parameters in the smallest package in the industry.

For telcos to successfully compete with cable companies in providing video to the home, they will have to guarantee clear and uninterrupted programming. Before this can happen, they will have to deal with the ring trip issue. Industry standards committees are presently working to develop a way to test for voltage surge problems. In the meantime, the small investment for video grade splitters can save a system provider significant development and operational expenses, such as truck rolls, when deploying video services over VDSL2.

Can I use the same splitter worldwide?

No, official standards have been officially issued by the ETSI (European Telecommunications Standards Institute), ANSI (American National Standards Institute), ITU-T (International Telecommunication Union), BT-SIN (BT-ADSL delivered services) and other local regulatory authorities, to describe the requirements and test methods for the low pass filtering of DSL over POTS/ISDN. These splitters are installed at the network side of the local loop which exists either at the local exchange or in a remote cabinet, or at the user side, i.e. those used at the demarcation point of the customer premises.

Before choosing which splitter needs to be used, there are two fundamental questions one needs to ask:

1) What country/network is the splitter to be operated?

2) What electrical specification is the finished product to be in compliance with?

Pulse has developed a full library of splitter/filter designs to cover all major applications worldwide. They can be used as off-the-shelf standard modules or re-designed under a specific form factor to correlate with the particular needs of the customers.

PULSE and what we can offer!

Pulses splitter families fulfill market demands and customers needs. At Pulse we work closely with our customers, and incorporate all country specific requirements in all of our designs. Together with our huge knowledge base of the various applications we turn each design into a high performing product for our customers. We can meet your needs, whether it's a sole splitter function, or whether you want us to incorporate your blocking capacitors, add relays, surge protectors, over-current protection, chokes, extended temperature operation, etc.

Figure 4 (back page) shows our complete standard product offerings, and if you have any queries on custom products or need more information on our catalog range, please contact our customer support team at:

prodinfo_telecom@pulseeng.com

DSL Splitter Guide

SmartER SPLITTER™ MODULES		
Part No.	**Application**	**Impedance Standard**
B8802NL	xDSL/POTS	ANSI complex impedance (US) - CPE ITU Spec 992.1 Annex E2
B8813NL	xDSL/POTS	ANSI complex impedance (US) - CO ITU Spec 992.1 Annex E2
B8817NL	xDSL/POTS	China MII relaxed spec
B8841NL	xDSL/POTS	600Ω ETSI real impedance
B8842NL	xDSL/POTS ISDN	Combo ISDN 2B1Q 135Ω + 4B3T 150Ω ETSI Spec. TS 101-952-1-3
B8845NL	xDSL/POTS	ISDN 4B3T 150Ω + DT Complex Impedance - ETSI Spec. TS 101-952-1-4
B8846NL	xDSL/POTS	BT SIN-346 Complex Impedance (UK) + ETSI101-952-1-1 optionB
B8849NL	xDSL/POTS	ETSI Complex Impedance (Europe) Option A of ETSI Spec. TS 101-952-1-1
B8850NL	xDSL/POTS	ETSI Complex Impedance (Europe) Option A of ETSI Spec. TS 101-952-1-1 fully compliant 300 mA saturating current
B8859NL	xDSL/POTS	ETSI Complex Impedance (Europe) Option A of ETSI Spec. TS 101-952-1-1 fully compliant

SMART SPLITTER™ MODULES		
Part No.	**Application**	**Impedance Standard**
B8041	ADSL/POTS	600Ω ETSI real impedance
B8042	ADSL/ISDN	135Ω Line Impedance, ISDN 2B1Q (Europe), ETSI Spec. TS 101-952-1-3
B8045	ADSL/ISDN	150Ω Line Impedance, ISDN 4B3T DT Complex Impedance
B8245	ADSL/ISDN	150Ω Line Impedance, ISDN 4B3T, DT Complex Impedance – Compliant (Germany)
B8546	ADSL/POTS	BT SIN-346 Complex Impedance (UK)
B8216	ADSL/POTS	BT SIN-346 Complex Impedance (UK) With protections (K20 compliant)
B8049	ADSL/POTS	ETSI Complex Impedance (Europe) Option A of ETSI Spec. TS 101-952-1-1
B8549	ADSL/POTS	ETSI Complex Impedance (Europe) Option A of ETSI Spec. TS 101-952-1-1
B8120	ADSL/POTS	ANSI complex impedance (US) ITU Spec 992.1 Annex E2
B8120A	ADSL/POTS	ANSI complex impedance (US) ITU Spec 992.1 Annex E2
BX8214	ADSL/POTS	ANSI complex impedance (US), ITU G992.1 Annex E2 (B804x 12 mm package)
BX8270	ADSL/POTS	ITU G992.1 Annex E2 for Korea CPE (B8120 package)
BX8296	ADSL/POTS	ANSI T.421 standard

Pulse Offerings:

*Excelsus Customer Premise Equipment (CPE) Filters

*Excelsus is a brand of Pulse.

Custom MDF Boards

EXCELSUS® CPE SPLITTERS & MICRO FILTERS			
EXCELSUS VIDEO GRADE SPLITTERS			
Region	**Application**	**Part Number**	**Specification**
Americas	xDSL/POTS	**CP-V413S** **CP-V413TJ45**	ANSI T1.413 ANSI T1.413
Europe	POTS POTS POTS and ISDN	**CP-401TJ45** **CP-V501TJ45** **CP-404TJ45**	ETSI TS 101 952-1-1 ETSI TS 101 952 2-1 ETSI TS 101 952-1-4
Country Specific			
Sweden	POTS	**CP-421SE**	Skanova Network's 304/1056-KDUA 101 110 Rev. D
Czechoslovakia	POTS and ISDN	**CP-404TJ11**	Cesky Telecom TPK 2092 C for ADSL2+
Norway	POTS and ISDN	**CP-404TJ45**	Telenor's specification for CPE splitters

EXCELSUS MICRO FILTERS	
Region	**Application**
North America	**Z-330PJ, Z-330P2J-A, Z-300TJ, Z-300LS**
South America	**Z-301LS-G**
Europe	**Z-230PJ, Z-300TJ Z-301LS** **Z-450UK, Z-420UKP2J, Z-350UK** **Z-471BE, Z-250IT, Z-250FR**
Middle East and Asia	**Z-301LS**
Australia	**Z-490TJ45**

EXCELSUS MDU		
Part No.	**Description**	**Application**
KHZ-023-6625FF	24 Port Splitter intergrated into a 66 Punch down block	VDSL2 and HPN

EXCELSUS HPNA PRODUCTS		
B-V175	Twisted Pair to Coaxial Balun	VDSL2 and HPN

NOTE: Custom circuits and mechanical designs available.

Pulse
A TECHNITROL COMPANY

B829.B (1/08)

© Copyright 2008, Pulse Engineering, Inc. All rights reserved.

For More Information:

Pulse Worldwide Headquarters
12220 World Trade Dr.
San Diego, CA 92128
U.S.A.
www.pulseeng.com

Tel: 858 674 8100
Fax: 858 674 8262

Pulse Europe
Einsteinstrasse 1
D-71083 Herrenberg
Germany

Tel: 49 7032 7806 0
Fax: 49 7032 7806 12

Pulse China Headquarters
B402, Shenzhen Academy of
Aerospace Technology Building
10th Kejinan Rd.
High-Tech Zone
Nanshan District, Shenzhen
P.R. China 518057

Tel: 86 755 33966678
Fax: 86 755 33966700

Pulse North China
Room 1503
XinYin Building
No. 888 YiShan Rd.
Shanghai 200233
China

Tel: 86 21 32181071
Fax: 86 21 32181396

Pulse South Asia
150 Kampong Ampat
#07-01/02
KA Centre
Singapore 368324

Tel: 65 6287 8998
Fax: 65 6280 0080

Pulse North Asia
No. 26
Kao Ching Rd.
Yang Mei Chen
Taoyuan Hsien
Taiwan, R. O. C.
32667

Tel: 886 3 4643715
Fax: 886 3 4641911

Performance warranty of products offered on this data sheet is limited to the parameters specified. Data is subject to change without notice. Other brand and product names mentioned herein may be trademarks or registered trademarks of their respective owners. © Copyright 2008. Pulse Engineering, Inc. All rights reserved.