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VDSL2 technology

Introduction

VDSL2 stands for Very high-speed Digital Subscriber Line 2, the current latest development in DSL technology. The standard was approved by the International Telecommunication Union in 2006. In theory, VDSL2 can provide up to 200 Mbps for up- and downstream data rates, whereas ADSL2+ is limited to up to 24 Mbps downstream and 3.5 Mbps upstream.

Just like ADSL, ADSL2 and ADSL2+, VDSL2 uses DMT (Discrete Multitone) modulation to transfer data. This method involves splitting the frequency range into separate, independent DMT carriers. There are numerous advantages from this.

Firstly, narrow-bandwidth signals suffer from very low levels of dispersion in their transmission medium (which, for electromagnetic signals, increases with longer wavelengths). Narrow bandwidth signals thus reduce the number of corrections by the receiver, as each carrier is less influenced by neighboring signals. Secondly, interference can be handled more effectively as it does not affect the entire spectrum and impacts just a small number of carriers. Less data is transported by these carriers until the problem is resolved. The great improvement in VDSL2 performance is based on several factors, which are interdependent directly and indirectly. First of all, the working frequency of 2.208 MHz (ADSL2+) has been increased to up to 30 MHz with VDSL2.

The increased bandwidth available with VDSL2 provides a much larger number of individual carriers. Whereas ADSL2+ provides up to 512 carriers, VDSL2 works with up to 4,096 carriers. Accordingly, VDSL2 can transport much more information per second than ADSL2+.

Profiles and bandplans

There is a huge number of parameters for VDSL2 transceivers (transmitters/receivers in modems and DSLAMs) that make the technology both complex and expensive, and for this reason a number of profiles has been set down that specify a selection of these parameters. Thus manufacturers can produce standard-compliant transceivers that do not necessarily support all of the settings for VDSL2. Eight defined profiles offer different data rates, transmission powers and numbers of carriers.

VDSL2 Profiles (selection)

Description	8b	12b	17a	30a
Bandwidth (MHz)	8.83	12.0	17.66	30.0
Carriers	4,048	2,783	4,096	3,479
Carrier Bandwidth (KHz)	4.3125	4.3125	4.3125	8.625
Transmission Power (dBm)	+20.5	+14.5	+14.5	+14.5
Bandwidth (Mbps, bidirectional)	50	68	100	200

The 12-MHz profile (12b), for example, uses 2,783 carriers with an effective symbol rate of 4.3 kHz. This results in the following transmission capacity:

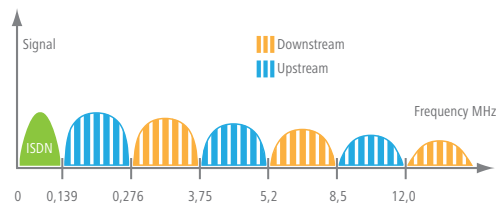
$$4315.5 \text{ DMT symbols/s} * 2783 \text{ carriers/DMT symbol} * 15 \text{ bit/carrier} = 180 \text{ Mbps}$$

This bandwidth can be shared between the up- and downstream directions. For a 12-MHz system, the standard requires a capacity for a bidirectional net data rate of 68 Mbps. However, it is important to consider that, in reality, the systems are affected by other factors that further reduce the performance. Depending on the infrastructure, portions of the frequency

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spectrum may need to be reserved for telephony and withheld from VDSL2 transmission; up to 138 KHz for ISDN and 25 KHz for POTS (analog telephony). Moreover, the allocation of the frequency range for upstream or downstream is less stringent for VDSL2 than for ADSL, where each direction is confined to a fixed contiguous band. For VDSL2, the available bandwidth is divided into multiple up-and downstream bands. This division and the reservation of frequency ranges for ISDN or POTS are implemented with bandplans. The decision as to which bandplan is to be used ultimately lies with the network operator. The bandplans are supplemented by PSD masks (Power Spectral Density), which specify the transmission power for each individual carrier.



Allotment of the frequency in the bandplan (Annex B: 998 B)

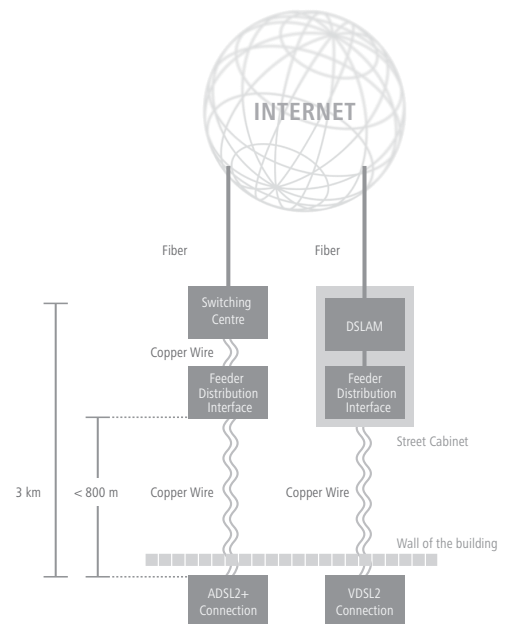
VDSL2 infrastructure

The increased bandwidth and the higher frequencies employed by VDSL2 bring new challenges. For example, the higher signal frequencies experience increased attenuation in the transport medium. This results in repeat transmissions and error corrections, which negatively impact the data throughput. Whereas ADSL can achieve ranges of up to three kilometers, the maximum range with VDSL2 over copper cable is about 800 meters. With transmission through optical fiber, attenuation is much lower and the range increases accordingly. However, to keep costs to a minimum, not all of the cabling will be switched to optical

fiber. The DSLAM (Digital Subscriber Line Access Multiplexer) is relocated from the central exchange directly to the street cabinet in order to bridge some of the distance to the user with fiber-optics and not with copper cable as with the current DSL standard. This limits the range to be covered by copper cable to the distance between the street cabinet and connection socket in the building. This type of infrastructure is referred to as „Fiber To The Curb (FTTC)“.

Compatibility and differences

The development of VDSL1, the forerunner of VDSL2, never reached the maturity required for large-scale deployment. The main reason for this was disagreement about the method to be used for data transmission. The choice was between QAM (quadrature amplitude modulation) and DMT. The VDSL2 standard uses DMT because of the performance it offers and its compatibility with existing DSL technologies. Anybody



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who talks about VDSL today is generally referring to VDSL2.

There are strong similarities between VDSL2, ADSL2+, ADSL2 and ADSL, and compatibility is a requirement of the ITU standard. However, there are some important differences. While the ADSL family uses ATM (Asynchronous Transfer Mode) as a transport protocol, and individual services are prioritized with PVC (Permanent Virtual Circuit), VDSL2 relies on Ethernet packets and VLAN tagging. Each Ethernet frame is given a 12-bit long VLAN ID and a further 3 bits are used for prioritizing the frames. Working with an ATM-free infrastructure means that ATM IP gateways can be dispensed with, so reducing costs significantly. ATM packets also have a larger overhead, and the transition to Ethernet means a further gain in speed of about ten percent. This technique is also used in ADSL, and is referred to as EFM (Ethernet First Mile).

International

When selecting a suitable VDSL router or modem, it is important to know whether the network operator uses ISDN or POTS as the underlying service. The actual local phone line is not necessarily a good indicator of this, because some providers provide VDSL over ISDN on a separate ISDN line, with an analog telephone line running parallel to it. For ADSL equipment, it was quite simple to tell the difference by the suffix Annex A (POTS) or Annex B (ISDN). For VDSL2, however, this distinction is not sufficient. Due to the fact that the ITU standard calls for backward compatibility, VDSL2 equipment can also be operated at ADSL connections. For this reason, devices with a VDSL2 modem may indicate the Annex. This may be used to indicate the ADSL specification for the VDSL2 modem. However, in relation to the VDSL2 standard from the ITU, Annex A and Annex B have different meanings than for ADSL:

Annex A describes the bandplan for North America, Annex B the bandplans for Europe and Annex C for Japan. Thus any information about the Annex for VDSL2 devices could lead to misunderstandings, and this should be questioned in case of doubt.

Consequently, there are various checks to be made: Are the VDSL2 services provided over ISDN or POTS, which profiles and bandplans are supported by the device, and which are on offer from the operator. There are also bandplans that use the full frequency range, meaning that there are no portions reserved for ISDN or POTS.

VDSL2 in the business environment

Even if one of the most highly advertised features of VDSL2, IP-TV, is of limited relevance in the business environment, VDSL2 offers many advantages for business users.

The significantly higher data rates in particular are attractive to enterprises. VDSL2 can be expected to offer downstream data rates of 50 Mbps and 10 Mbps upstream, although the speeds on offer differ from provider to provider. In comparison, SDSL and SHDSL indeed provide symmetrical up- and downstream data rates, but only of about 2 to 4 Mbps per copper-wire pair.

The high data rates of VDSL allow, for example, fast VPN-based access to data stored on the company network – even when a number of people dial-in to the network by VPN at the same time.

Given the high performance compared to previous DSL technologies and the lower price, VDSL2 is an interesting technology for all companies that want to use large bandwidths at low cost. Useful supplements to VDSL2 include UMTS to ensure cost-effective high availability, and ISDN for effective remote maintenance.