Scope

This white paper provides background information about DSL technology and more detail about the functionality of the DDW-220. The overview starts with the family of DSL standards and then provides further details of SHDSL in particular.
The product information focuses on technical descriptions about the functionality of the DDW-220, starting with a block diagram of the unit. This white paper will evolve over time with more information being added when new features are implemented.

xDSL technology

Digital Subscriber Line (DSL) technology gives us the ability to use existing copper cables in applications where bandwidth previously was a limitation. In the DSL family there are a number of different technologies used for different types of application:

Asymmetrical Digital Subscriber Line

(ADSL) offers differing upload and download speeds.

HDSL (high data rate DSL)

This variety created in the late 1980s delivers symmetric service at speeds up to 2.3 Mbit/s in both directions.

HDSL2 (2nd generation HDSL)

This variant delivers 1.5 Mbit/s service each way, supporting voice, data, and video using ATM.

SDSL (symmetric DSL)

SDSL is a vendor-proprietary version of symmetric DSL that may include bit-rates to and from the customer ranging from 128 kbit/s to 2.32 Mbit/s.

SHDSL

Is state-of-the-art, industry standard symmetric DSL SHDSL equipment conforms to the ITU recommendation G.991.2, also known as G.shdsl, approved by the ITU-T in February 2001. SHDSL achieves 20% better loop-reach than older versions of symmetric DSL. It causes much less crosstalk into other transmission systems occupying the same cable bundle and multi-vendor interoperability is facilitated by the standardization of this technology.

VDSL (very high bit rate DSL)

VDSL is a technology that promises high data rates, up to 55 Mbit/s over relatively short distances.

VDSL2 (second generation VDSL)

ITU Recommendation G.993.2 specifies symmetric transmission on loops over twisted copper cables with speed up to 100 Mbit/s. VDSL2 implementations will also interoperate with existing ADSL equipment.

G.SHDSL

Combines the positive aspects of existing copper-based, high-speed communications with the benefits of increased data rates, longer reach and less noise.

Four factors are driving the interest in G.SHDSL

1. Standardization

The industry needs a higher-speed digital transport service for business applications. HDSL was never adopted as an international standard. Symmetric DSL – introduced as the DSL service for businesses in the late 1990s – never became a standard and interfered with the residential ADSL service because it was spectrally incompatible (very noisy). G.SHDSL is positioned for deployment in Internet and T-1/E-1 infrastructure applications because of its international standardization.

2. Improved data rate

G.SHDSL offers a two-wire standard operating at 2.3 Mbit/s and four-wire standard operating at 4.6 Mbit/s.

3. Improved reach

G.SHDSL generally provides 20% to 30% increase in reach over HDSL at the same deliverable data rates.

4. Spectral compatibility

G.SHDSL is spectrally compatible with ADSL, causing little noise or crosstalk between cables. Therefore, G.SHDSL services can be mixed with ADSL in the same cables without much – if any – interference.

Further increased speed

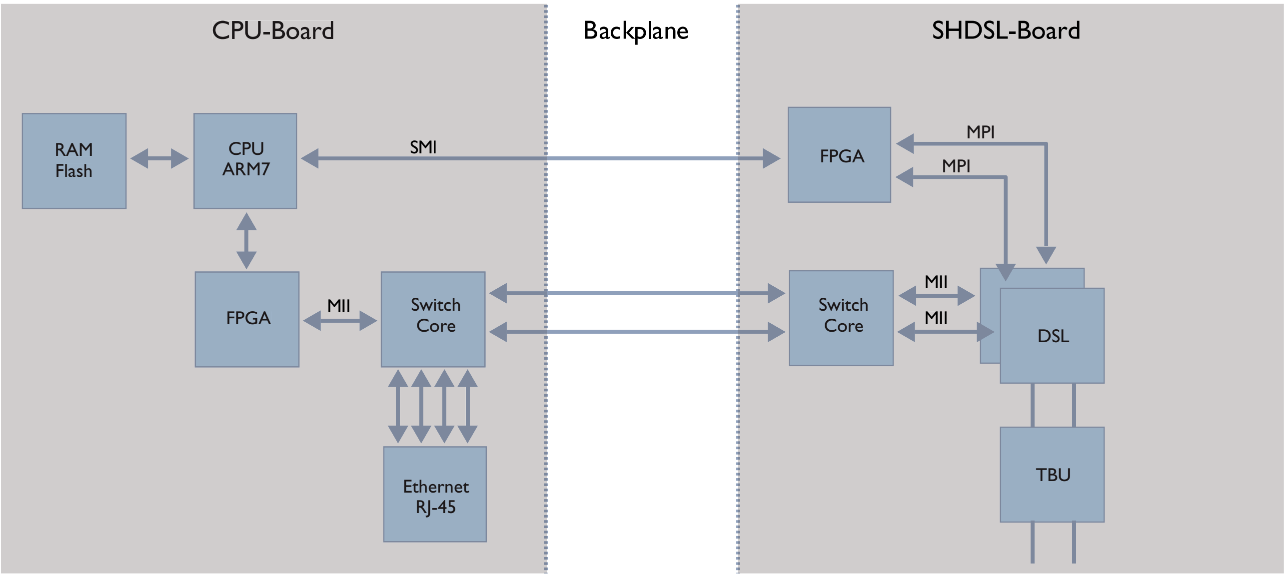
An extended version of SHDSL called G.SHDSL.bis is also available. This extended version uses an enhanced coding algorithm (TC-PAM) to increase the symmetric data rate to 5.7 Mbit/s while still complying with spectral compatibility requirements. The G.SHDSL.bis standard was adopted by the Ethernet in the First Mile (EFM) committee, which developed the IEEE 802.3ah EFM standard.

Standard part of 991.2	Data rates in kbit/s	TC-PAM level
Standard SHDSL	192 to 2312	16
SHDSL bis	192 to 3840	16
SHDSL bis	768 to 5696	32

DDW-220

Industrial Ethernet Extender

The DDW-220 is an Industrial Ethernet SHDSL extender with a built-in Ethernet switch. It is designed as a transparent Ethernet Extender for 10/100BaseTX networks.
SHDSL represents the best of several symmetric DSL technologies. This unit provides the ability to reuse existing twisted copper pair with data rates from 192 kbit/s to 5.7 Mbit/s in both directions. The DDW-220 makes it possible to communicate over 10 km (6.2 miles) on twisted pair cable.
The DIN rail mounted DDW-220 is designed for harsh environments and can be used in industrial and railway applications. It can be powered from two separate supplies and handle an operating voltage range of 16 – 60 VDC.



DDW-220 system description

The DDW-220 is built around 4 different circuit boards. The backplane connects to a power board, CPU board and a DSL board. All communication between the boards are made via the backplane. The power board converts the external voltage (16 – 60 V) to internal voltage levels. The power board also has a high level of protection circuits to handle power disturbances in a harsh environment.
The DSL board consists of two separate SHDSL lines with state of the art DSL chip technology. Each DSL chip supports G.SHDSLbis making it possible to communicate at up to 5.7 Mbit/s over long distances. Each DSL line interface is protected using an over-voltage / over-current protecting circuit (TBU) making it possible to deal with noise on the DSL lines and still maintain communication.
The CPU board handles all communication within the DDW-220 and also controls all switching between Ethernet ports and DSL ports. The switchcore mounted on the CPU board supports wire speed communication between all Ethernet ports. The complete unit is encased in a high quality housing making it possible to handle harsh EMI environments and extreme climatic conditions.

Latency and throughput

Latency

The term latency describes the time it takes for data packets to travel through the DDW-220 unit.
Measurements have been taken on data going between the following ports.

- DSL1 to DSL2
- Ethernet to Ethernet

The latency will depend on both data path and packet size as the unit uses the store and forward technique for data transfer.
This means a packet is received in its entirety, stored in the unit and checked for errors before it is transferred to an outbound port.
In all tests Ethernet traffic is 100 Mbit/s and SHDSL link speed is 5.7 Mbit/s.
Measured latency is within a single unit. In a network with several DDW-200, latency introduced by each unit needs to be added to get a theoretical value for the total latency in the system.

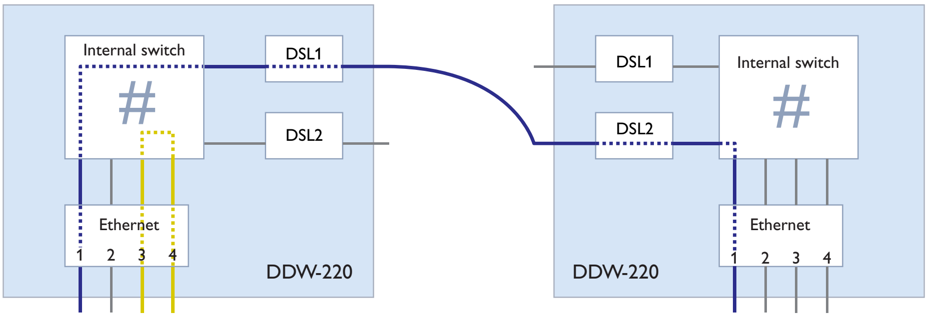
Throughput

The term throughout describes the maximum numbers of packets per second that can travel through the unit without any packet loss.
Measurements have been done on data going between the following ports.

- DSL1 to DSL2
- Ethernet to Ethernet

Throughput is depending on data path and also packet size. Small packets require more overhead and will hence decrease the data throughput.
In all tests Ethernet traffic is 100 Mbit/s and SHDSL link speed is 5.7 Mbit/s.
If maximum throughput capability on the DSL link is exceeded the DDW-220 will discard incoming packets from the Ethernet side as by default flow control is disabled in the DDW-220 unit.

Test	Packet size	Mesured latency	Measured throughput
DSL1 to DSL2	64	1.3 ms	4.9 Mbit/s
DSL1 to DSL2	1518	12.0 ms	5.5 Mbit/s
Ethernet to Ethernet	64	80 µs	100 Mbit/s (wire speed)
Ethernet to Ethernet	1518	200 µs	100 Mbit/s (wire speed)

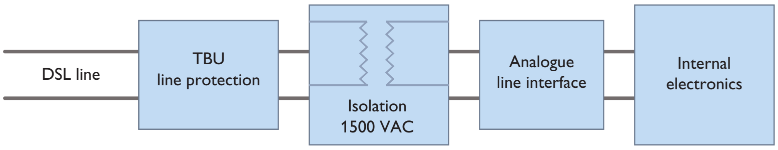


Line interface and line protection

General

In a demanding industrial applications reliability is a major factor. Equipment must be able to handle line disturbances and harsh environments.
The DDW-220 has been developed with increased protection on the DSL lines to be able to deliver a high degree of reliability to the customer.

DSL line interface



The DDW-220 relies on a TBU (transient blocking unit) on each DSL line. The TBU responds to both over-current and over-voltage faults on the line and can take care of indirect lightning, power induction and power crossing problems.
The TBU provides a high level of protection and also high speed performance, which gives the DDW-220 excellent performance even with noise on the line.
This also means that no external line protection is necessary when using the DDW-220 unit.

DSL line testing

The DDW-220 has been tested against IEC EN61000-6-2, which is the generic standard for immunity in industrial environments, and also against IEC EN 50121-4, which specifies demands for trackside railway applications. The DSL interface on the DDW-220 is compliant to both these standards. Westermo has also performed extended testing on the DSL line interface.

Table shows tests made on the DSL interfaces

Test	Generic standard / test level*	Simulates
EN61000-4-4, Electrical fast transient	EN61000-6-2 / 1 kV (criteria B) EN50121-4 / 2 kV (criteria A)	Arcing contacts in switches and relays with inductive loads. Normally capacitive coupling to signal cable
EN61000-4-5, Surge	EN61000-6-2 / 1 kV (criteria B) EN50121-4 / 2 kV (criteria B)	Lightning and switching of power system
EN61000-4-6, RF conducted	EN61000-6-2 / 10 V (criteria A) EN50121-4 / 10 V (criteria A)	Radio-frequency fields introduced in cables attached to the unit
EN61000-4-16, 50 Hz CM	Westermo / 100 V (criteria A)	50 Hz common mode disturbance
SS 436 15 03, 50 Hz DM	Westermo / 250 V (criteria A)	50 Hz differential mode disturbance
Isolation	Isolation level	
Isolation DSL to Power	2000 VAC, 50 Hz, 1min	
Isolation DSL to Ethernet	1500 VAC, 50 Hz, 1min	

*) Criteria A = no function loss during test
Criteria B = function loss accepted during test