Supported by:	DDW-220	DDW-221	DDW-222	DDW-120

Scope

This white paper provides background information about DSL technology and more detail about the functionality of the Wolverine family. 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 Wolverine family, 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 might 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.

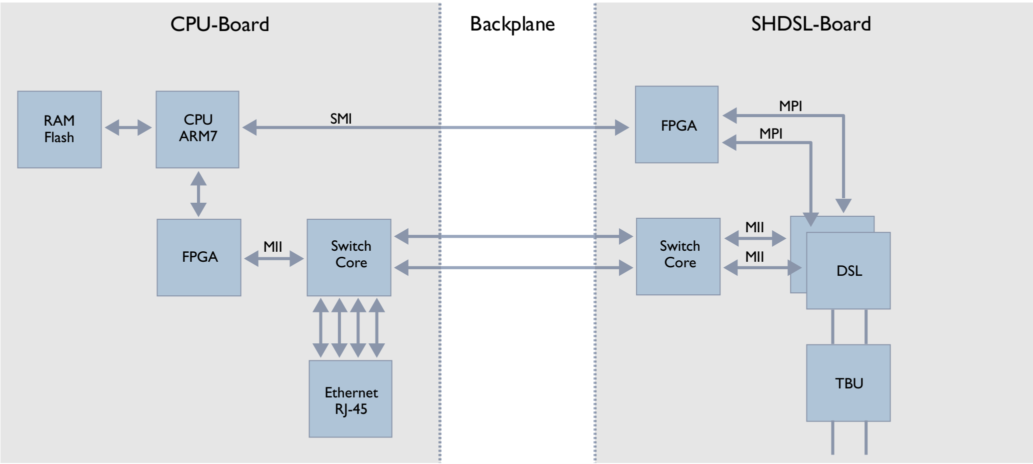
Standard part of 991.2	Data rates in kbit/s	TC-PAM level
Standard SHDSL	192 to 2312	16
SHDSL bis	192 to 3840	16
SHDSL bis	768 to 5696	32

Supported by:	DDW-220	DDW-221	DDW-222

DDW-2xx

Industrial Ethernet Extender

The DDW-2xx 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-2xx makes it possible to communicate over 10 km (6.2 miles) on twisted pair cable.
The DIN rail mounted DDW-2xx 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-2xx system description

The DDW-2xx 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-2xx 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.

Supported by:	DDW-220	DDW-221	DDW-222

Latency and throughput

Latency

The term latency describes the time it takes for data packets to travel through the DDW-2xx 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.

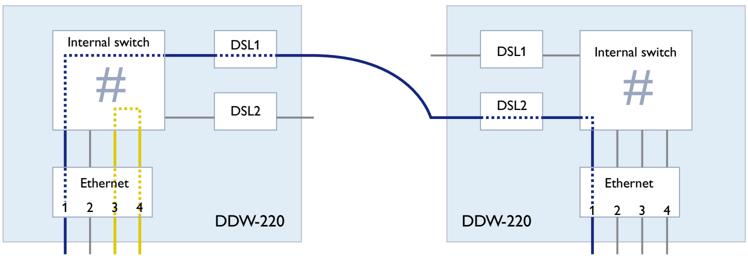
Throughput

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-2xx will discard incoming packets from the Ethernet side as by default flow control is disabled in the DDW-2xx 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)



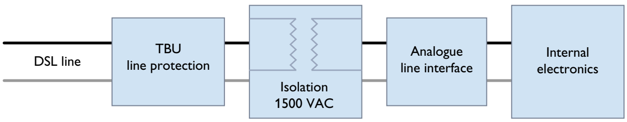
Supported by:	DDW-220	DDW-221	DDW-222	DDW-120

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-2xx and DDW-120 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-2xx and DDW-120 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-2xx and DDW-120 excellent performance even with noise on the line.
This also means that no external line protection is necessary when using the DDW-2xx and DDW-120 unit.

DSL line testing

The DDW-2xx and DDW-120 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-2xx and DDW-120 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

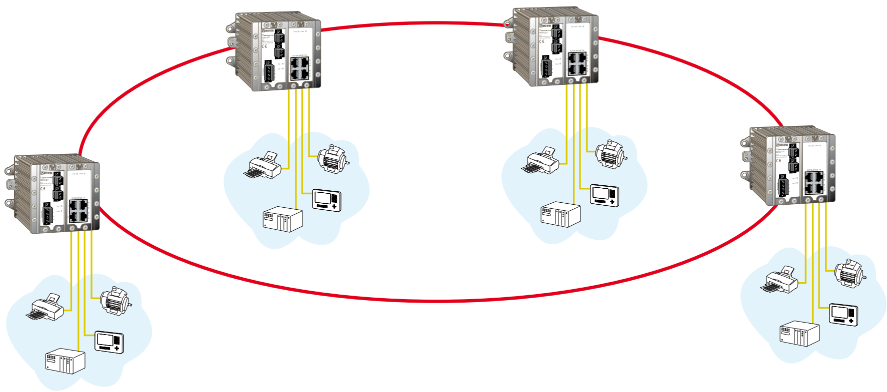
Supported by:	DDW-221	DDW-222

FRNT

The Ethernet extenders, DDW-221 and DDW-222 are available with redundant ring technology. This eliminates network failure caused by communication failures on the ring ports. In a ring application one unit must be configured as focal point, all other units will be configured as members.

Event based principle

A FRNT topology change event packet will be sent directly to the focal point in case of a topology change (e.g. a link loss or a link establishment). The focal point will then generate a topology change command. This packet is sent



to each member in the ring. The time it takes from the occurrence of a topology change until the corresponding topology change event packet is received on the focal point depends on if FRNT is configured on the SHDSL line or on the Ethernet switch.

Connection oriented protocol

The member to focal point communication is based on a connection-oriented protocol. This means that the protocol will handle packet loss of FRNT control packets. Packet loss is very unlikely in a normal scenario due the excellent Bit Error Rate (BER) properties of wired Ethernet (copper or fibre).

Full immunity vs. any type of network load

The loss of FRNT packets due to a network overload situation is not an issue for the FRNT control protocol. Thus, any unicast-, multicast- or broadcast network load can be generated on the network without any FRNT packet loss. An overload situation in this context means that the interface to the switch CPU is a network bottleneck. I.e. important control packets must compete vs. other packet to the CPU. Broadcast load is for all practical purposes the most critical network load in this context. The FRNT protocol is, however, protected against such an overload scenario.

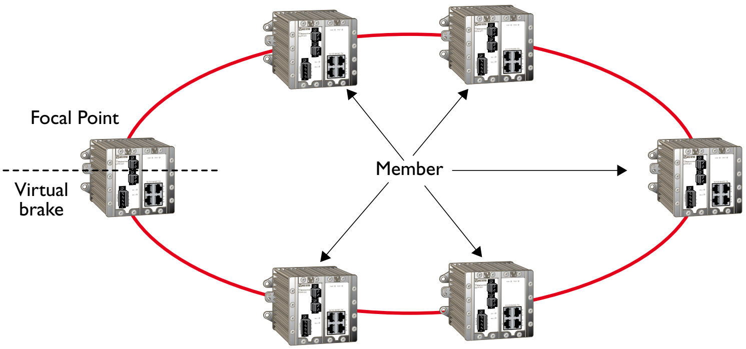
Similar proprietary network redundant protocols from other vendors are in most cases based on polling instead of event controlled handling of a topology change. This will introduce a slower establishment of a new topology. The FRNT protocol is also based on polling as a supplementary function to the event based part of the protocol.

Link qualification based on data link layer protocol, LHP

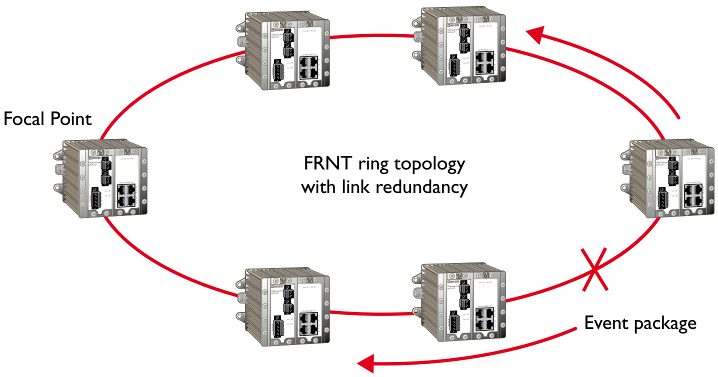
A major problem with most network redundancy protocols is the probability for having a network loop where a potential storm can be generated only in one direction (not both directions), and where this is not detected by the root (master) switch. This problem can only be handled if the switches support a link layer protocol that is used in order to qualify a link. The FRNT protocol has support for such a protocol. This Westermo protocol is referred to as the Link Health Protocol (LHP). The LHP makes sure that packets can be both sent and received on a trunk port before the link is properly qualified.

Fault in the ring

In a FRNT ring the focal point is the master of the ring, note that there can only be one unit configured as focal point, all other units must be configured as members. When everything is working, the focal point acts as a virtual brake in the ring. The virtual brake prevents a loop causing a broadcast storm in the ring.

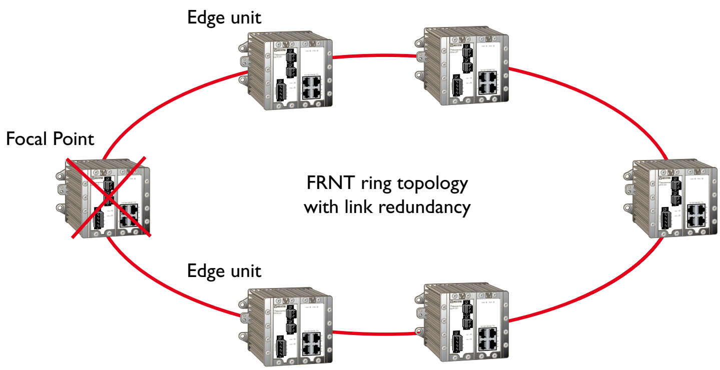


When a fault occurs, the unit closest to the fault, indicate an error, the first level of detection is link detection, the second level is, lost health packages (according to LHP, see above). If the LHP is lost the unit will indicate this as a fault and send an error package to the focal point. The focal point then will re-configure the topology of the network and remove the virtual brake since here is a "real" brake somewhere else in the system.



What happens if the focal point fails

Since the focal point is the master of the ring this unit has the important function to control the complete application, but what happens if there is a fault in the focal point?
Since the unit closest to the focal point will not receive LHP traffic from the focal point, they will become "edge units" and take over all operations from the focal point.



FRNT and DDW-200 series

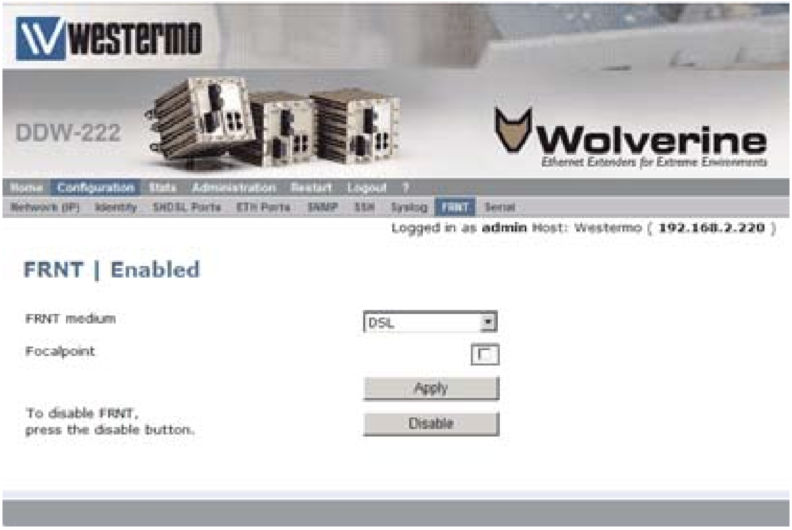
FRNT is implemented in the DDW-221 and DDW-222 models. The DDW-200 series support FRNT on both Ethernet and SHDSL. Using the web interface the operator can choose between FRNT on Ethernet or on SHDSL-lines. Note that it is not possible to mix FRNT on these interfaces.

Reconfiguration time on FRNT

- FRNT on Ethernet support 20 ms re-configuration time and is compatible with the Lynx series, making it possible to mix DDW-200 units and LYNX units in a FRNT ring.
- FRNT on SHDSL support 1000 ms re-configuration time. The SHDSL medium takes longer time to discover link changes.

Setting up the FRNT is easily made using the web interface. The user sets up which medium the FRNT should use (Ethernet or SHDSL) and also which unit should be the focal point in the ring. No other settings are necessary when configuring a redundant ring.

LED indicators on each unit show the status on the FRNT ring and also show the focal point in the ring.
The web interface also support FRNT diagnostic that helps the user to see the FRNT status, number of topology changes and other parameters.



FRNT setup using the web interface

FRNT diagnostic using the web interface

Statistic	Possible values	Description
Ring mode	MEMBER / FOCAL POINT	If unit is set up as member or focal point
Ring status	OK / BROKEN	Current ring status
Ring port 1 / 2	UP / DOWN	Current status on FRNT ports
Ring stat changes counter		Number of times the ring has changed state since last power on
Ring state change time		Time since ring last topology change

Supported by: **DDW-120**

LFF Functionality

General

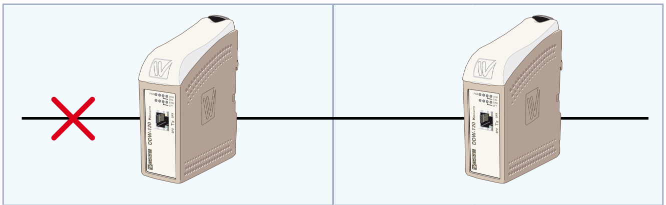
The Link Fault Forward (LFF) functionality in DDW-120 forwards information about the Ethernet link status, this is sent over the SHDSL link between two DDW-120 units. In many applications it is a requirement to disconnect the link on the other side of the SHDSL link if the primary Ethernet link goes down.

The LFF function uses bits in the SHDSL overhead frame and does not affect the data bandwidth. The opposite unit then reads the bits and the link status will be changed depending on the received status information.

The user can see the LFF status on the LED's in the front of the unit.

LFF disabled

LFF disabled will be indicated with the LFF LED off. No information about the Ethernet link will be sent over the SHDSL interface.

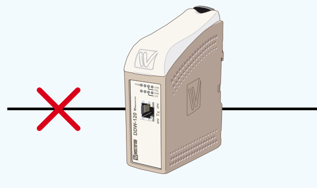


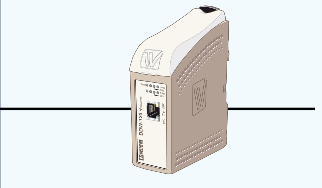
PWR	ON (green)	PWR	ON (green)
LFF	OFF	LFF	OFF
ERR	OFF	ERR	OFF
LINK	OFF	LINK	ON (green)
SPEED	OFF	SPEED	ON (green)
DUPLEX	OFF	DUPLEX	ON (yellow)
DSL	ON (green)	DSL	ON (green)

LFF enabled

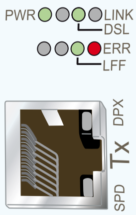
The LFF LED indicating green LFF is enabled. Information about Ethernet status will then be sent over the SHDSL interface. The ERR LED gives information about the Ethernet status and can be used for fault finding in the application.
LFF will control the link status on the connected units, if the link status is changed on one unit the remote interface will follow.

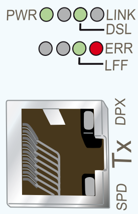
Ethernet error example





PWR	ON (green)	PWR	ON (green)
LFF	ON (green)	LFF	ON (green)
ERR	ON (red)	ERR	Flash (red)
LINK	OFF	LINK	OFF
SPEED	OFF	SPEED	OFF
DUPLEX	OFF	DUPLEX	OFF
DSL	ON (green)	DSL	ON (green)

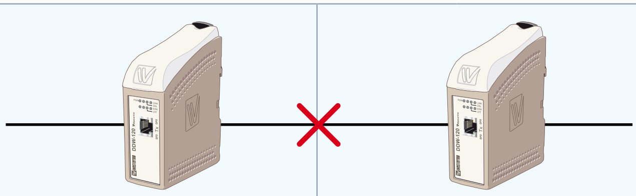
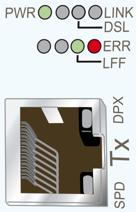
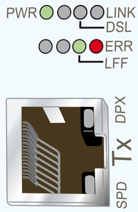




ERR indicates red indicating a local error on the Ethernet interface. This information is sent over the SHDSL interface.

ERR flashes red indicating a remote error on the Ethernet interface. The DDW-120 disconnects the Ethernet interface to indicate a problem to the connected equipment.

SHDSL error example

<table>
<tr><td colspan="4"></td></tr>
<tr><td>PWR</td><td>ON (green)</td><td>PWR</td><td>ON (green)</td></tr>
<tr><td>LFF</td><td>ON (green)</td><td>LFF</td><td>ON (green)</td></tr>
<tr><td>ERR</td><td>Flash (red)</td><td>ERR</td><td>Flash (red)</td></tr>
<tr><td>LINK</td><td>OFF</td><td>LINK</td><td>OFF</td></tr>
<tr><td>SPEED</td><td>OFF</td><td>SPEED</td><td>OFF</td></tr>
<tr><td>DUPLEX</td><td>OFF</td><td>DUPLEX</td><td>OFF</td></tr>
<tr><td>DSL</td><td>OFF</td><td>DSL</td><td>OFF</td></tr>
<tr><td colspan="2">
</td><td colspan="2">
</td></tr>
<tr><td colspan="2">ERR flashes red indicating a remote error on the Ethernet interface.
The DDW-120 disconnects the Ethernet interface to indicate a problem to the connected equipment.</td><td colspan="2">ERR flashes red indicating a remote error on the Ethernet interface.
The DDW-120 disconnects the Ethernet interface to indicate a problem to the connected equipment.</td></tr>
</table>

Supported by:	DDW-220	DDW-221	DDW-222	DDW-120

Performance on different loop types

Introduction

This document reports the performance of the Westermo SHDSL products based on the Infineon Socrates-4e family chipset.

Scope

Test Case ID	Description
Reach loop 2 16-TCPAM	Maximum reach on a noise-free 0.4 mm^2 cable with TCPAM-16 modulation
Reach loop 2 32-TCPAM	Maximum reach on a noise-free 0.4 mm^2 cable with TCPAM-32 modulation
Reach G.991.2 annex B TC-PAM16, Noise	Maximum reach on G-991.2 annex B, 0.4 mm^2 and 0.8 mm^2 cable is used with 16-TCPAM modulation
Reach G.991.2 annex G TC-PAM32, Noise	Maximum reach on G.991.2 annex G, 0.4 mm^2 with 32-TCPAM modulation

Noise models

The tests are conducted with different levels of applied noise. The mode models are described below.

Four noise models have been defined for SHDSL

Type A noise models

Represents a high load scenario where the SHDSL system is placed in a big cable bundle, up to hundreds of wire pairs, which are using other (potentially incompatible) transmission technologies.

Type B noise models

Represents a medium load scenario where the SHDSL system is using a cable (>= 10 wire pairs), which are using other (potentially incompatible) transmission technologies.

Type C noise models

Represents a legacy load scenario where the SHDSL system is using a cable (>= 10 wire pairs), which are using older transmission technologies such as ISDN-PRI in addition to the scenario of noise model B.

Type D noise models

Represents a model that simulates a cable filled with only SHDSL techniques.

Loop models

The different loop models are specified in G991.2.

Test loop 2

This loop consists of a 0.4 mm^2 cable from CO to CPE

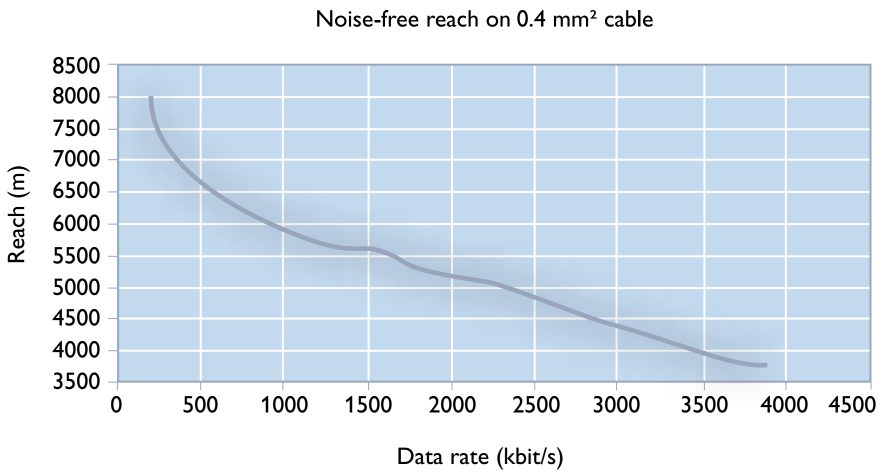
Test loop 5

This loop consists of a 0.8 mm^2 cable from the CO to the CPE

Maximum reach on 0.4 mm^2 cables with noise free communication

Test properties	
Wire type	2-wire
Modulation	16-TCPAM
Power Backoff	0 dB
Loop Properties	
Test Loop	2
Used cable	0.4 mm^2
Noise Type	Noise Free

The table and graph below shows the maximum reach for each data rate.

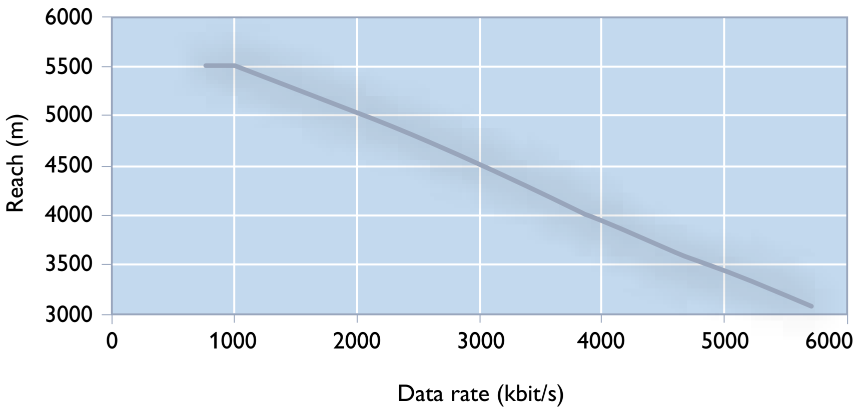


Maximum reach on 0.4 mm² cables with noise free communication

Test properties	
Wire type	2-wire
Modulation	32-TCPAM
Power Backoff	0 dB
Loop Properties	
Test loop	2
Used cable	0.4 mm^2
Noise type	Noise Free

The table and graph below shows the maximum reach for each data rate.

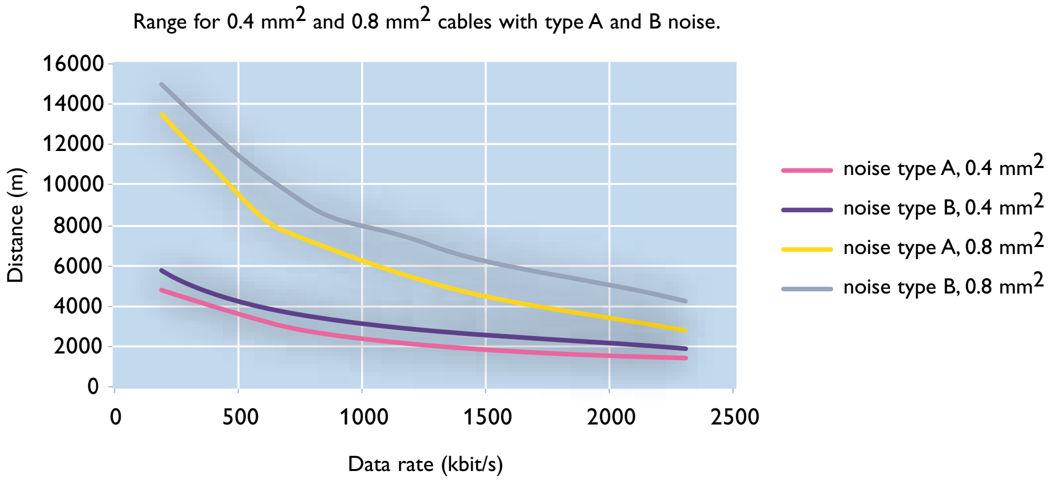
Noise-free reach on 0.4 mm² cable



Maximum reach on 0.4 mm² and 0.8 mm² cables with noise level 4 dB, data rate up to 2304 kbit/s

Test properties	
Wire type	2-wire
Modulation	16-TCPAM
Power Backoff	0 dB
Loop Properties	
Test loop	2
Used cable	0.4 mm² and 0.8 mm²
Noise type	C-2304
Noise level	4 dB

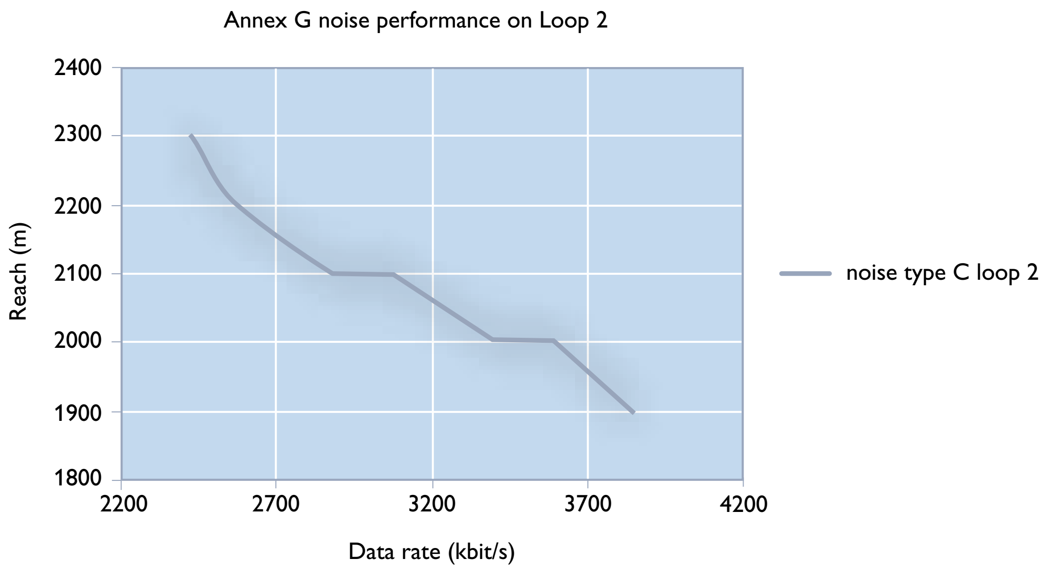
The table and graph below shows the maximum reach for each data rate.



Maximum reach on 0.4 mm² and 0.8 mm² cables with noise level 4 dB, data rate 2432 to 3840 kbit/s

Test properties	
Wire type	2-wire
Modulation	16-TCPAM
Power Backoff	0 dB
Loop Properties	
Test loop	2
Used cable	0.4 mm^2
Noise type	C-2304
Noise level	4 dB

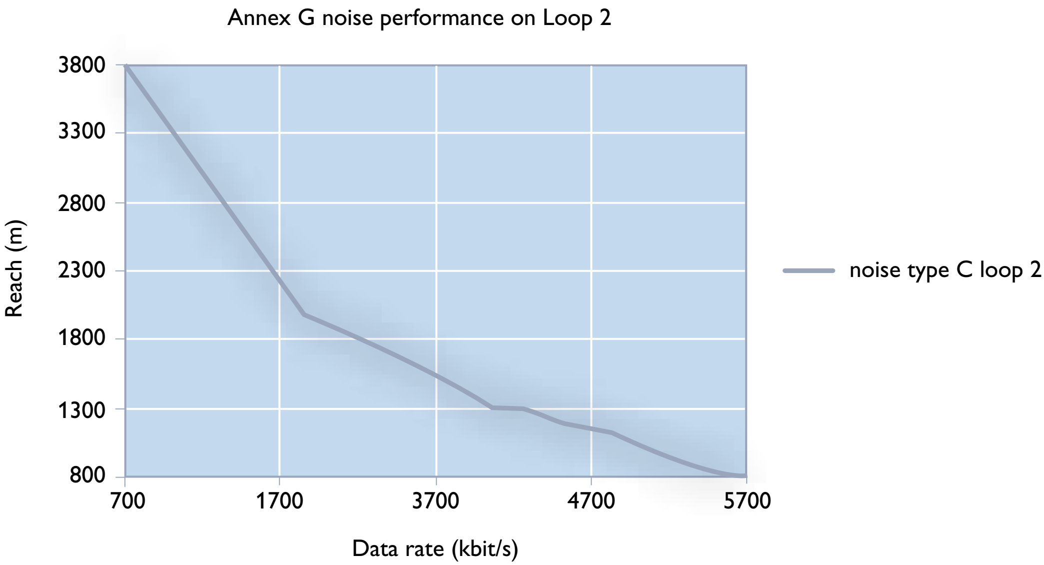
The table and graph below shows the maximum reach for each data rate.



Maximum reach on 0.4 mm^2 cables with noise level 4 dB

Test properties	
Wire type	2-wire
Modulation	32-TCPAM
Power Backoff	0 dB
Loop Properties	
Test loop	2
Used cable	0.4 mm^2
Noise type	C-2304
Noise level	4 dB

The table and graph below shows the maximum reach for each data rate.



Supported by:	DDW-220	DDW-221	DDW-222

SHDSL SNMP

Introduction

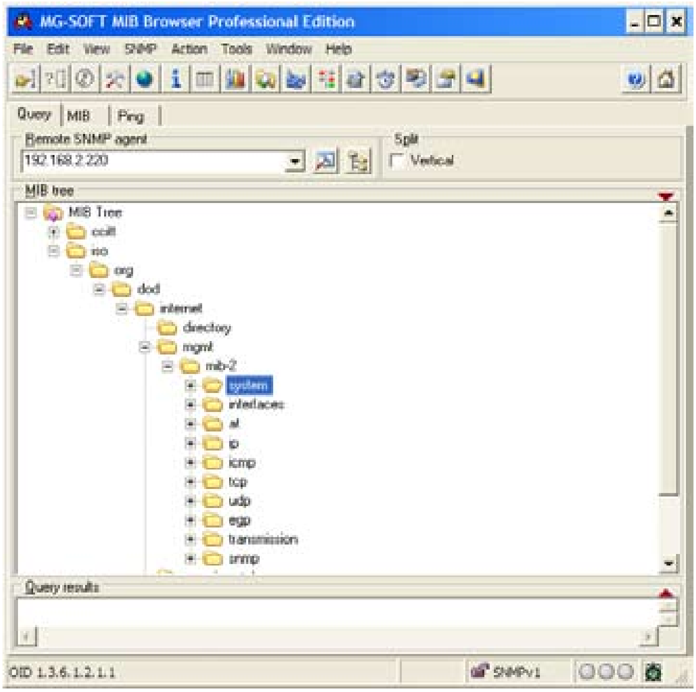
This document describes the SHDSL specific SNMP support of the Westermo SHDSL products.
The information is valid for the Westermo SHDSL products that support SNMP:

Scope

The unit supports MIB-II and relevant sub nodes in the MIB-II tree structure. The standard nodes used for a switch (MIB-II.system, -interfaces, -ip, -tcp, -udp and -snmp) are initially described briefly and the SHDSL interface specific node under MIB-II.transmission are described more in detail down to the end node.

The use of a MIB browser software simplifies the work with SNMP MIBs and is highly recommended. The only action needed before the user can take full SNMP control over the unit is to install the SMNP MIB browser software and to load the MIB-II.

Screenshots from the MG-Soft MIB-Browser software has been used to visualize the tree structure and where the different nodes are located. Any MIB-browser can of course be used instead of the one mentioned above.



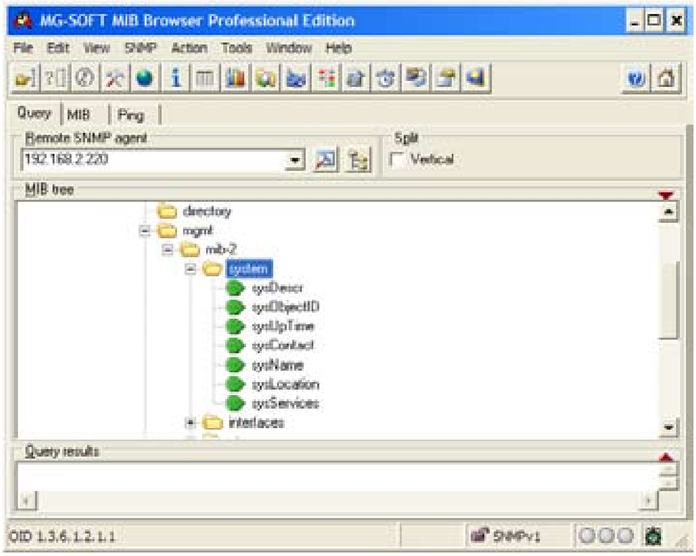
Supported nodes below MIB-II

This is a list of each sub tree that is supported.

MIB-II.System

Full Path:
iso.org.dod.internet.mgmt.mib-2.system

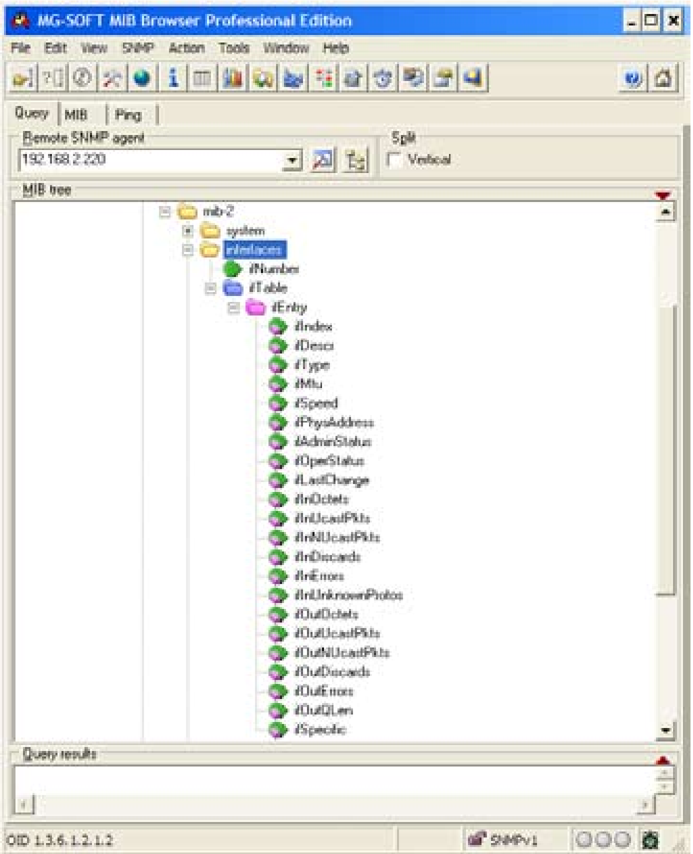
OID:
1.3.6.1.2.1.1



MIB-II.Interfaces

Full Path:
iso.org.dod.internet.mgmt.mib-2.interfaces

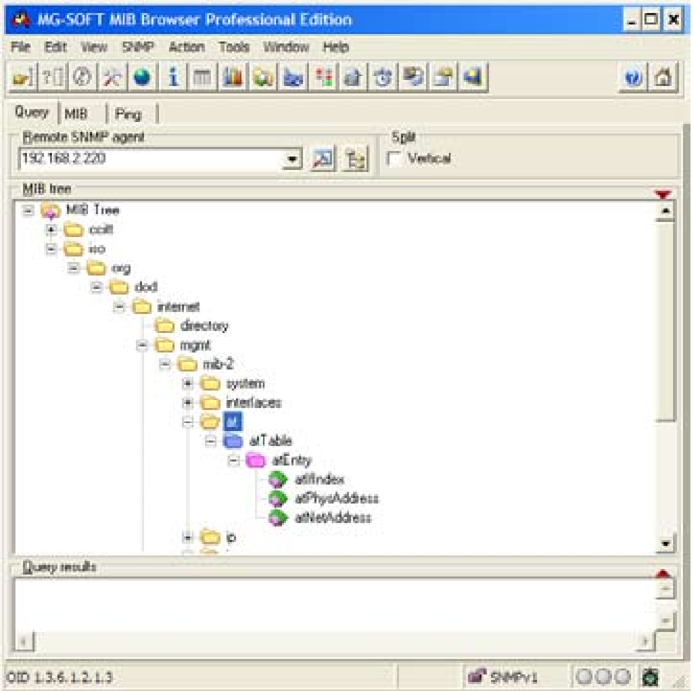
OID:
1.3.6.1.2.1.2



MIB-II.at

Full Path:
iso.org.dod.internet.mgmt.mib-2.at

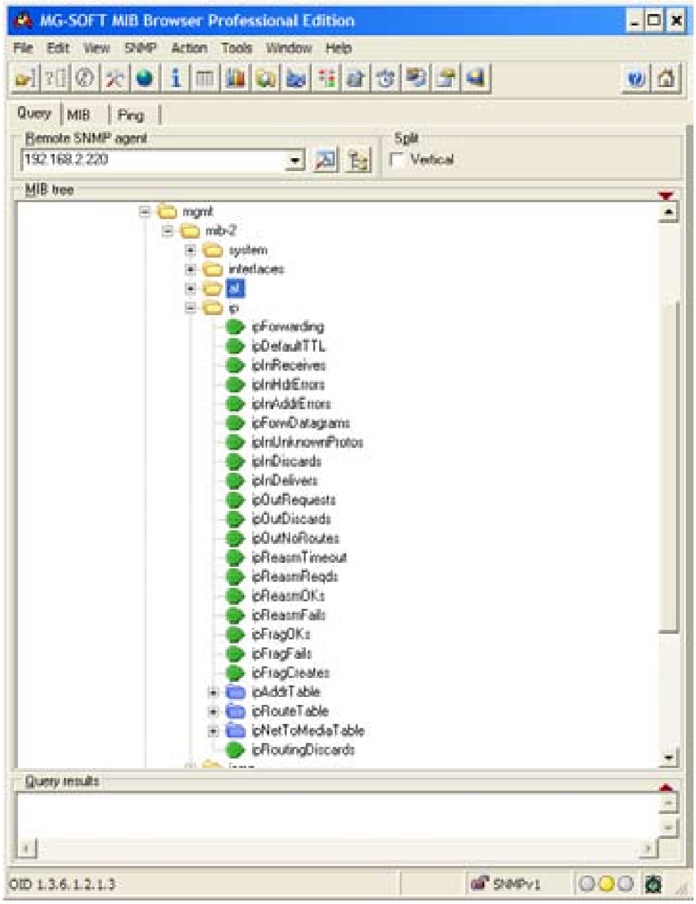
OID:
1.3.6.1.2.1.3



MIB-II.ip

Full Path:
iso.org.dod.internet.mgmt.mib-2.ip

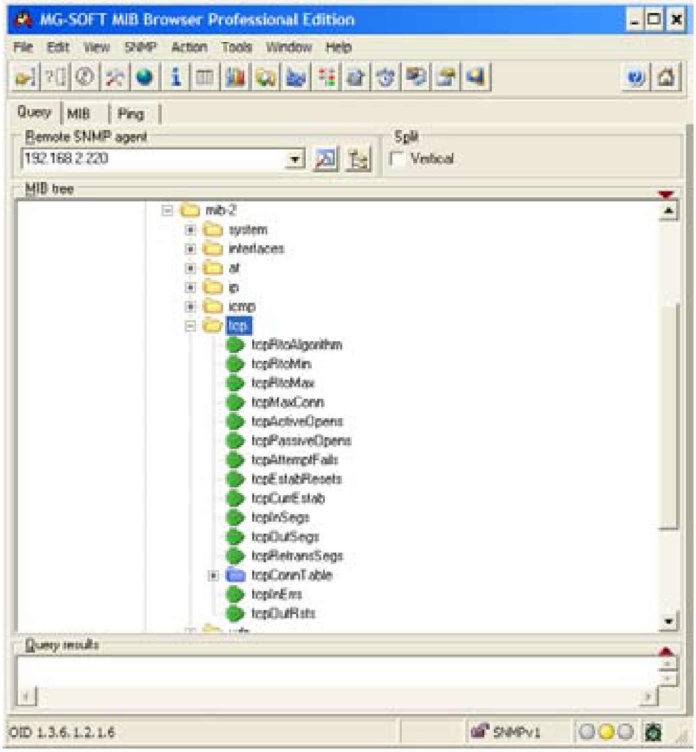
OID:
1.3.6.1.2.1.4



MIB-II.tcp

Full Path:
iso.org.dod.internet.mgmt.mib-2.tcp

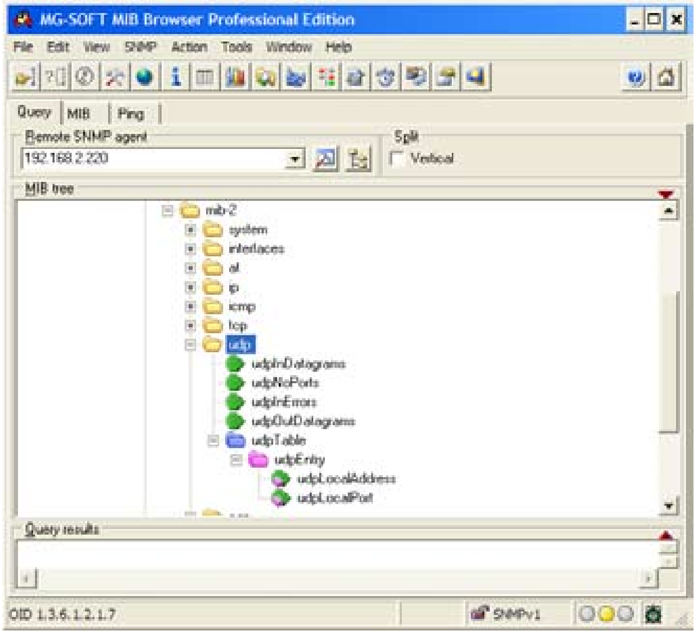
OID:
1.3.6.1.2.1.6



MIB-II.udp

Full Path:
iso.org.dod.internet.mgmt.mib-2.udp

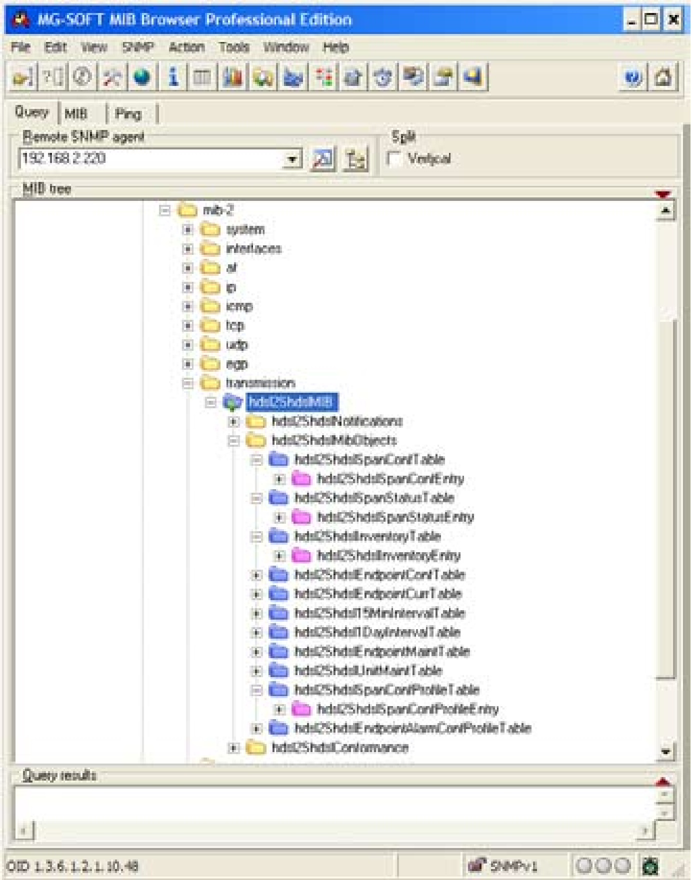
OID:
1.3.6.1.2.1.7



MIB-II.transmission

Full Path:
iso.org.dod.internet.mgmt.mib-2.transmission

OID:
1.3.6.1.2.1.10



The transmission node of the MIB-II tree is pointed to from a many different MIB:s that contains groups that use different transmission technologies. From a Westermo Wolverine point of view, the MIB of interest in this node is the hdsl2ShdslMIB.

The full Path of this module is
iso.org.dod.internet.mgmt.mib-2.transmission.hdsl2ShdslMIB

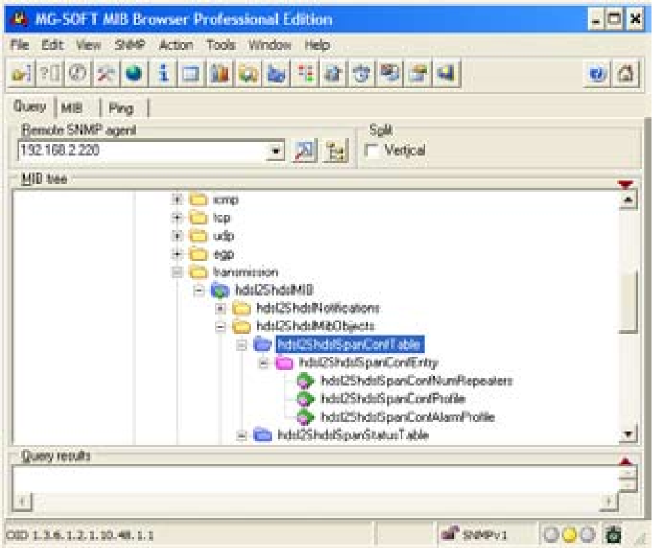
The OID to this node is:
1.3.6.1.2.1.10.48

Below this level are three branches of the tree:
hdsl2ShdslNotifications (1.3.6.1.2.1.10.48.0), hdsl2ShdslMibObjects (1.3.6.1.2.1.10.48.1) and hdsl2ShdslConformance (1.3.6.1.2.1.10.48.2).
Only the, hdsl2ShdslMibObjects (1.3.6.1.2.1.10.48.1) is supported in the Westermo Wolverine series.

The OIDs in this node are very useful for status diagnostics on the SHDSL interface.
Each OID is described below in detail. For more information, please refer to the hdsl2ShdslMIB.

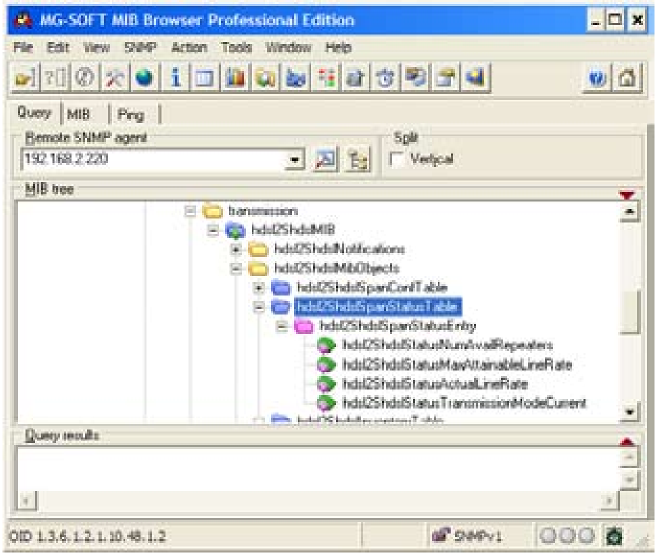
hdsl2ShdslSpanConfTable (OID: 1.3.6.1.2.1.10.48.1.1)

Description:
This table supports overall SHDSL Spans. Entries in this table MUST be maintained in a persistent manner.



hdsl2ShdslSpanStatusTable OID: 1.3.6.1.2.1.10.48.1.2

Description:
This table provides overall status information of SHDSL spans. This table contains live data from equipment. As such, it is NOT persistent

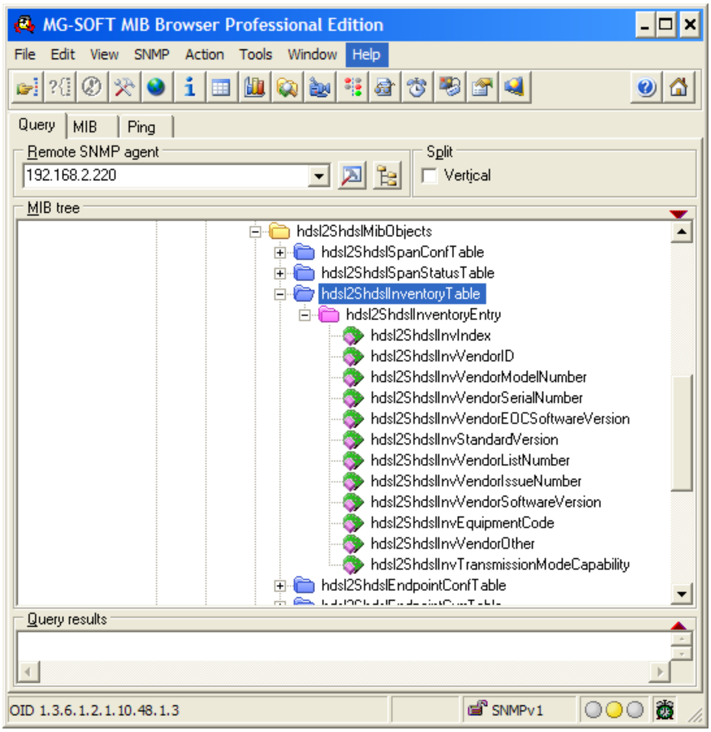


hdsl2ShdslInventoryTable OID: 1.3.6.1.2.1.10.48.1.3

Description:
This table supports retrieval of unit inventory information available via the EOC from units in a SHDSL line. Entries in this table are dynamically created during the line discovery process.
The life cycle for these entries is as follows:

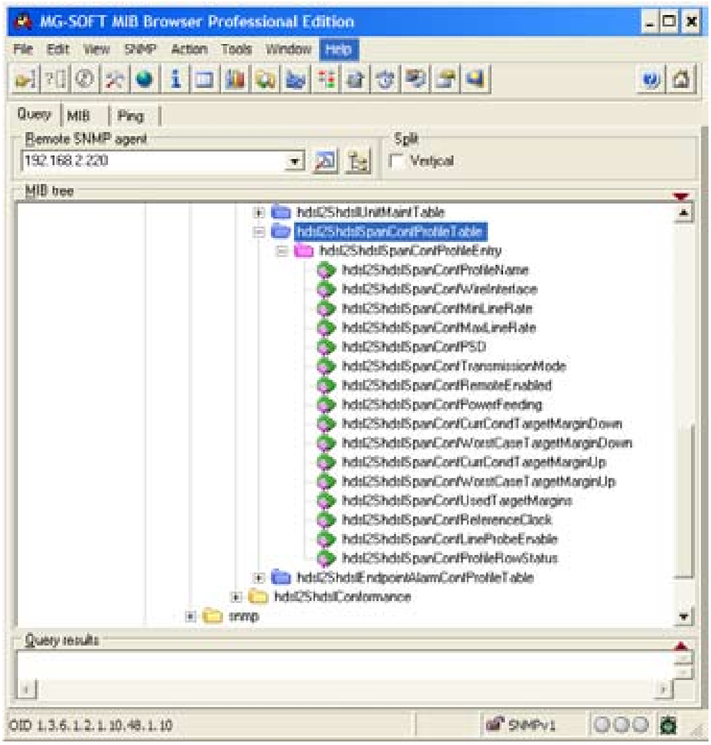
- xtu discovers a device, either a far-end xtu or an xru
- an inventory table entry is created for the device
- the line goes down for whatever reason
- inventory table entries for unreachable devices are destroyed.

As these entries are created/destroyed dynamically, they are NOT persistent.



hdsl2ShdslSpanConfProfileTable, OID: 1.3.6.1.2.1.10.48.1.10

Description:
This table supports definitions of span configuration profiles for SHDSL lines
This table MUST be maintained in a persistent manner



Supported by:	DDW-220	DDW-221	DDW-222

What is explosion protection?

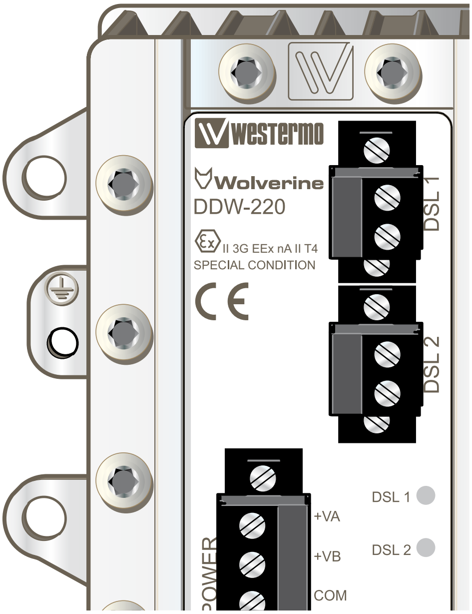
Atex and Class1Division2 are approvals intended for products intended for use in potentially explosive atmospheres. The ATEX Directive 94/9/EC was adopted by the European Union (EU) to facilitate free trade in the EU and the EEA by aligning the technical and legal requirements in the member states, Class1Division2 is the corresponding US approval. Harmonized design standards are used for conformity to this New Approach Directive. Although the ATEX directive was originally developed by the European Union, and Class1div2 for the US market both is now being applied all over the world.

The concept of explosion protection is used for equipments, electrical and mechanical, which shall be used in explosive atmospheres. As explosive atmospheres are areas where substances of gas, mist, vapour and dust may occur in such concentration that it would become explosive in normal oxygen environment and be ignited by hot surfaces, mechanical or electrical generated sparks, corrosion, lightning, electrostatic discharge, ionizing- and optical radiation, acoustic energy, radio and electromagnetic waves, stray electric and leakage currents, shock waves or adiabatic compression, exothermic reactions, flames and heat gases.
It shall be avoided in the first place that an explosive atmosphere appears, but if it's not possible the appearance shall be minimized and if it's not possible to avoid completely any potential ignition sources in the area shall not be able to ignite the atmosphere. If equipment with ignition sources is allowed these shall be constructed in such safe manner that any ignition of the surrounding atmosphere is eliminated.

Is Atex and Class1div2 needed?

The ATEX and Class1div2 Directives covers both Equipment and Protective Systems used in potentially explosive atmospheres. In this Directive, Equipment is considered to be any device that contains a potential ignition source and requires special measures to be incorporated in its design or application to prevent ignition. This includes safety or control devices outside a hazardous area but having an explosion protection function. A Protective System is considered to be any device, which is intended to halt an incipient explosion from spreading or causing damage. Application of the ATEX and Class1div2 Directive begins with an accurate definition of the atmosphere in which your products will be used. Zone 1 atmospheres drive greater costs and project schedule time than a Zone 2 environment. Similarly, specifying a Zone 2 environment where an explosive atmosphere is not present also i ncreases product cost and time. Be sure to properly state the atmosphere, gas groups, and environmental and media temperatures for proper classification of your product.

Classification of explosion-proof equipment



DDW-220, DDW-221 and DDW-222 are approved according to: **II 3G Eex nA IIT4 and Class1, Division2, Groups A,B,C &D.T4**

Description of approval denomination

”II”

-Group I: Electrical apparatus for places with an explosive gas atmosphere in mines

- Group II: Electrical apparatus for places with an explosive gas atmosphere other than mines

Areas and zoon classifications

Areas where an explosive atmosphere may occur are classified according to classification of hazardous areas standards and these areas are divided into different zones, according to the table 1 and figure 1.

Table 1.

Area classification	
Zoon 0 Gas Zoon 20 Dust	Flammable material present continuously or for long periods
Zoon 1 Gas Zoon 21 Dust	Flammable material present occasionally in normal operation
Zoon 2 Gas Zoon 22 Dust	Flammable material present in abnormal conditions and only for short periods

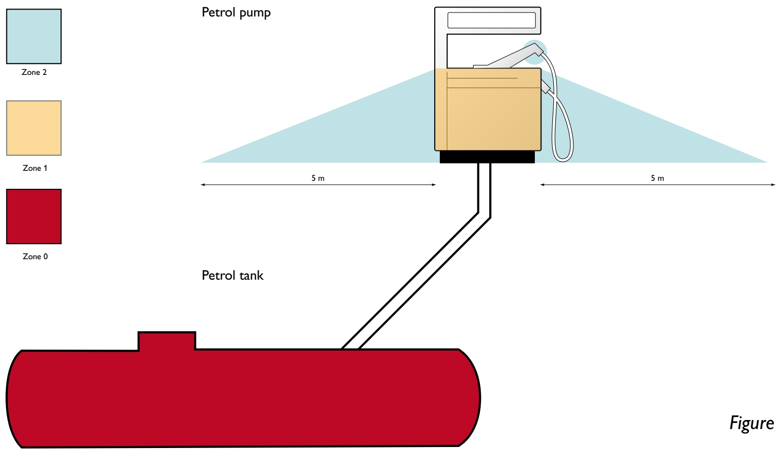


Figure 1

"3G"

3 = Category 3

Equipment intended for use in hazardous areas shall be divided into different categories depending on its use. Category 3 equipment can be self approved by the manufacturer.

G = concerning explosive atmospheres caused by gases, vapours or mists.

Area	Category of equpment to ATEX definitions	Precence of duration of explosive atmosphere	Level of protection Faults to allow for	Comparison with present practice
	1	Continous precence Long periods Frequent	Very high level of protection two types of protection or two independent faults	Group II **Zone 0** (gas) Zone 20 (dust)
Equipment Group II (surface industri)	**2**	Likely to occur	High level of protection: one type of protection. Habitual frequent malfunction	Group II **Zone 1** (gas) Zone 21 (dust)
	3	Unlikely to occur Present for a short period	Normal protection: Required level of protection	Group II **Zone 2** (gas) Zone 22 (dust)

"EEx"

E defines that the apparatus is approved according to EN standards.

Ex defines that it is according to Ex-standard

"nA"
Non-sparking device "nA". Device constructed to minimize the risk of occurrence of arcs or sparks (or hot temperatures) capable of creating an ignition hazard during normal conditions of normal operation.

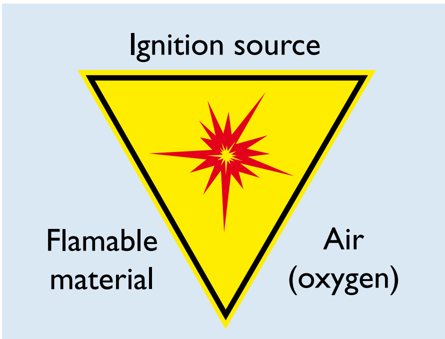
"II"
Equipment Group II, as above

"T4"
T4 is the temperature class this defined equipment surface temperature and the ignition temperature for the substances in the area. The temperatures are divided into six temperature classification and apply for both the equipment and the area. The temperature classification states the highest surface temperature the equipment can reach in its intended use and that the substances for a certain temperature. T4 defines 135 °C as maximum surface temperature of the equipment

Temperature class	Maximum upper surface temperature of the equipment	Ignition temperatures of combustible substances
T1	450 °C	> 450 °C
T2	300 °C	> 300 °C
T3	200 °C	> 200 °C
T4	135 °C	> 135 °C
T5	100 °C	> 100 °C
T6	85 °C	> 85 °C

Definitions of Explosion Protection
An explosion is a sudden increase in volume and release of energy in an extreme manner, usually with the generation of high temperatures and the release of gases, an explosion also creates a shock wave. The explosion is a reaction of a flammable substance together with oxygen. Flammable substances may be present in the form of gases, vapours, mists or dusts.

Explosion can only occur, when three factors come together
1. Flammable material (in ignitable quantities)
2. Oxygen (in the air)
3. Ignition source

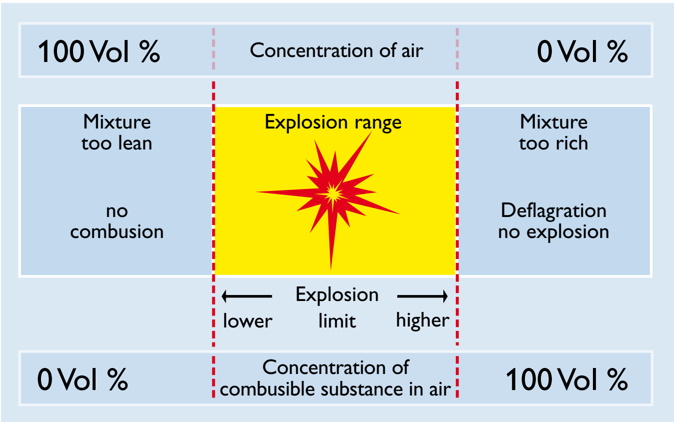


Flash point

The flash point of a flammable liquid is the lowest temperature at which it can form an ignitable mixture in air. If the flash point of a flammable liquid is well above the maximum temperatures that arise, an explosive atmosphere cannot be formed. The flash point of a mixture of various liquids may be lower than that of the individual components. The flash point of a liquid serves to classify liquids as highly flammable, easily flammable, and flammable liquids.

Designation of the flammable	at flash point and boiling point °C
Highly flamable	Flash point < 0 °C and boiling point <35 °C
Easily flammable	Flash point < 0 °C and boiling point < 35 °C or 0 °C < flash point < 21 °C
Flammable	21 °C < flash point < 55 °C

An explosion will be caused by the flammable substance and it must be present in a certain concentration.
If the concentration is too high (rich mixture) or too low (lean mixture), no explosion occurs.



Depending on the speed of combustion there will be a deflagration, explosion or detonation. An explosive environmental is described as hazardous or if there is danger to human life or property.

Ignition source

There might be different sources that can cause an explosion some examples are:

- Electrical installations
- Flames and hot gases
- Mechanically generated sparks
- Hot surfaces
- Static electricity
- Optical radiation
- Lightning
- Electromagnetic waves

Preventing explosions

The principle of integrated explosion protection requires all explosion protection measures to be carried out in a defined order. A distinction is made here between *primary* and *secondary* protective measures.
Primary explosion protection covers all measures that prevent.

What protective measures can be taken to ensure that the risk of an explosion will be minimized?

- Avoidance of combustible substances
- Improved ventilation
- Inerting (addition of nitrogen, carbon dioxide etc)
- Limitation of the concentration by means of natural or technical ventilation

Avoiding ignition of explosive atmospheres

To avoid the danger of explosions activities must be considered in the explosive areas. The hazardous areas are therefore divided into zones. For locations classified in this way, requirements must be met concerning the apparatus, which are approved for use in these locations. In addition, it is also necessary to prove that these requirements have been met.

Mitigation of the explosion effects

If hazardous explosive atmospheres cannot be safely avoided and their ignition cannot be excluded, then measures must be taken which limit the effect of explosions to a safe degree, e.g. by means of:

- Explosion pressure resistant construction
- Explosion relief devices
- Explosion suppression by means of extinguishers

The principle of integrated explosion protection requires following explosion protection measures in a certain sequence.