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Definitions of Managed Object Extensions
for Very High Speed Digital Subscriber Lines (VDSL) Using
Single Carrier Modulation (SCM) Line Coding

Status of This Memo

This document specifies an Internet standards track protocol for the Internet community, and requests discussion and suggestions for improvements. Please refer to the current edition of the "Internet Official Protocol Standards" (STD 1) for the standardization state and status of this protocol. Distribution of this memo is unlimited.

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Abstract

This document defines a portion of the Management Information Base (MIB) module for use with network management protocols in the Internet community. In particular, it describes objects used for managing the Line Code Specific parameters of Very High Speed Digital Subscriber Line (VDSL) interfaces using Single Carrier Modulation (SCM) Line Coding. It is an optional extension to the VDSL-LINE-MIB, RFC 3728, which handles line code independent objects.

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1. The Internet-Standard Management Framework

For a detailed overview of the documents that describe the current Internet-Standard Management Framework, please refer to section 7 of RFC 3410 [RFC3410].

Managed objects are accessed via a virtual information store, termed the Management Information Base or MIB. MIB objects are generally accessed through the Simple Network Management Protocol (SNMP). Objects in the MIB are defined using the mechanisms defined in the Structure of Management Information (SMI). This memo specifies a MIB module that is compliant to the SMIV2, which is described in STD 58, RFC 2578 [RFC2578], STD 58, RFC 2579 [RFC2579] and STD 58, RFC 2580 [RFC2580].

2. Overview

This document describes an SNMP MIB module for managing the Line Code Dependent, Physical Medium Dependent (PMD) Layer of SCM VDSL Lines. These definitions are based upon the specifications for VDSL as defined in T1E1, European Telecommunications Standards Institute (ETSI), and International Telecommunication Union (ITU) documentation [T1E1311, T1E1011, T1E1013, ETSI2701, ETSI2702, ITU9931, ITU9971]. Additionally the protocol-dependent (and line-code dependent) management framework for VDSL lines specified by the Digital Subscriber Line Forum (DSL Forum) has been taken into consideration [DSLFT95] and [DSLFWT96].

The MIB module is located in the MIB tree under MIB-2 transmission.

The key words "MUST", "MUST NOT", "RECOMMENDED", and "SHOULD" in this document are to be interpreted as described in [RFC2119].

2.1. Relationship of this MIB Module to Other MIB Modules

The relationship of the VDSL Line MIB module to other MIB modules, in particular to the IF-MIB presented in RFC 2863 [RFC2863], is discussed in the VDSL-LINE-MIB, RFC 3728 [RFC3728]. This section outlines the relationship of this VDSL Line Extension MIB to the VDSL-LINE-MIB, RFC 3728 [RFC3728].

2.2. Conventions Used in the MIB Module

2.2.1. Naming Conventions

- A. Vtuc -- VDSL transceiver unit at near (Central) end of line
- B. Vtur -- VDSL transceiver unit at Remote end of line
- C. Vtu -- One of either Vtuc or Vtur
- D. Curr -- Current
- F. Atn -- Attenuation
- J. LCS -- Line Code Specific
- K. Max -- Maximum
- Q. Mgn -- Margin
- S. PSD -- Power Spectral Density
- T. Rx -- Receive
- T. Snr -- Signal to Noise Ratio
- U. Tx -- Transmit

2.3. Structure

The SCM VDSL Line Extension MIB contains the following MIB group:

- o vdslSCMGroup :

This group supports MIB objects for defining configuration profiles and for monitoring individual bands of Single Carrier Modulation (SCM) VDSL modems. It contains the following tables:

- vdslLineSCMConfProfileTxBandTable
- vdslSCMPhysBandTable

If the SCM VDSL Line Extension MIB is implemented then all objects in this group MUST be implemented.

Figure 1 below displays the relationship of the tables in the vdslSCMGroup to the vdslGroup and to the ifEntry:

```

ifEntry(ifType=97) ----> vdslLineTableEntry 1:(0..1)

    vdslLineTableEntry (vdslLineCoding=SCM)
        ----> vdslPhysTableEntry 1:(0..2)
            ----> vdslSCMPHysBandTable 1:(0..5)

    vdslLineConfProfileEntry(vdslLineConfProfileName)
        ----> vdslLineSCMConfProfileBandTable 1:(0..5)

```

Figure 1: Table Relationships

When the object `vdslLineCoding` is set to `SCM`, `vdslLineConfProfileName` is used as the index to `vdslLineSCMConfProfileBandTable`. The existence of an entry in any of the tables of the `vdslSCMGroup` is optional.

2.4. Persistence

All read-create objects defined in this MIB module SHOULD be stored persistently. Following is an exhaustive list of these persistent objects:

```

vdslLineSCMConfProfileBandId
vdslLineSCMConfProfileBandUsage
vdslLineSCMConfProfileBandCenterFrequency
vdslLineSCMConfProfileBandSymbolRate
vdslLineSCMConfProfileBandConstellationSize
vdslLineSCMConfProfileBandTransmitPSDLevel
vdslLineSCMConfProfileBandRowStatus
vdslLineSCMPHysBandId
vdslLineSCMPHysBandUsage
vdslLineSCMPHysBandCurrPSDLevel
vdslLineSCMPHysBandCurrSymbolRate
vdslLineSCMPHysBandCurrConstellationSize
vdslLineSCMPHysBandCurrCenterFrequency
vdslLineSCMPHysBandPerformanceBandId
vdslLineSCMPHysBandPerformanceBandUsage
vdslLineSCMPHysBandPerformanceBandSnrMgn
vdslLineSCMPHysBandPerformanceBandAtn

```

Note also that the interface indices in this MIB are maintained persistently. View-based Access Control Model (VACM) data relating to these SHOULD be stored persistently as well [RFC3415].

3. Conformance and Compliance

An SCM based VDSL agent does not have to implement this MIB to be compliant with RFC 3728 [RFC3728]. If the SCM VDSL Line Extension MIB is implemented then the following group is mandatory:

- vdslSCMGroup

4. Definitions

VDSL-LINE-EXT-SCM-MIB DEFINITIONS ::= BEGIN

IMPORTS

```

MODULE-IDENTITY,
OBJECT-TYPE,
Integer32,
transmission,
Unsigned32                FROM SNMPv2-SMI                -- [RFC2578]
TEXTUAL-CONVENTION,
TruthValue,
RowStatus                FROM SNMPv2-TC                -- [RFC2579]
MODULE-COMPLIANCE,
OBJECT-GROUP              FROM SNMPv2-CONF              -- [RFC2580]
ifIndex                  FROM IF-MIB                    -- [RFC2863]
vdslLineConfProfileName   FROM VDSL-LINE-MIB;            -- [RFC3728]

```

vdslExtSCMMIB MODULE-IDENTITY

LAST-UPDATED "200504280000Z" -- April 28, 2005

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DESCRIPTION

"The VDSL-LINE-MIB found in RFC 3728 defines objects for the management of a pair of VDSL transceivers at each end of the VDSL line. The VDSL-LINE-MIB configures and monitors the line code independent parameters (TC layer) of the VDSL line. This MIB module is an optional extension of the VDSL-LINE-MIB and defines objects for configuration and monitoring of the line code specific (LCS) elements (PMD layer) for VDSL lines using SCM coding. The objects in this extension MIB MUST NOT be used for VDSL lines using Multiple Carrier Modulation (MCM) line coding. If an object in this extension MIB is referenced by a line which does not use SCM, it has no effect on the operation of that line.

Naming Conventions:

Vtuc -- VDSL transceiver at near (Central) end of line
 Vtur -- VDSL transceiver at Remote end of line
 Vtu -- One of either Vtuc or Vtur
 Curr -- Current
 Atn -- Attenuation
 LCS -- Line Code Specific
 Max -- Maximum
 Mgn -- Margin
 PSD -- Power Spectral Density
 Rx -- Receive
 Snr -- Signal to Noise Ratio
 Tx -- Transmit

Copyright (C) The Internet Society (2005). This version of this MIB module is part of RFC 4069: see the RFC itself for full legal notices."

REVISION "200504280000Z" -- April 28, 2005
 DESCRIPTION "Initial version, published as RFC 4069."
 ::= { transmission 228 }

vdslLineExtSCMMib OBJECT IDENTIFIER ::= { vds1ExtSCMMIB 1 }
 vds1LineExtSCMMibObjects OBJECT IDENTIFIER ::= { vds1LineExtSCMMIB 1 }

--

```
-- textual conventions used in this MIB
--
```

```
VdslSCMBandId ::= TEXTUAL-CONVENTION
```

```
    STATUS      current
```

```
    DESCRIPTION
```

```
        "This data type is used as the syntax for the VDSL SCM Band
        Identity.  Attributes with this syntax identify the SCM Band
        referred to.  Specified as an INTEGER, the possible values
        are:
```

```
        optionalBand (1)  -- the optional Band range [25kHz - 138kHz]
        firstDownstreamBand (2)  -- first Downstream Band
        firstUpstreamBand (3)    -- first Upstream Band
        secondDownstreamBand (4) -- second Downstream Band
        secondUpstreamBand (5)   -- second Upstream Band
        thirdDownstreamBand (6)  -- third Downstream Band
        thirdUpstreamBand (7)    -- third Upstream Band"
```

```
    SYNTAX      INTEGER      { optionalBand (1),
                                firstDownstreamBand (2),
                                firstUpstreamBand (3),
                                secondDownstreamBand (4),
                                secondUpstreamBand (5),
                                thirdDownstreamBand (6),
                                thirdUpstreamBand(7) }
```

```
--
-- Single carrier modulation (SCM) configuration profile tables
--
```

```
vdslLineSCMConfProfileBandTable OBJECT-TYPE
```

```
    SYNTAX      SEQUENCE OF VdslLineSCMConfProfileBandEntry
```

```
    MAX-ACCESS  not-accessible
```

```
    STATUS      current
```

```
    DESCRIPTION
```

```
        "This table contains transmit band descriptor configuration
        information for a VDSL line.  Each entry in this table
        reflects the configuration for one of possibly many bands
        of a single carrier modulation (SCM) VDSL line.  For each
        profile which is associated with a VDSL line using SCM
        line coding, five entries in this table will exist, one for
        each of the five bands.  Bands which are not in use will be
        marked as unused.  These entries are defined by a manager
        and can be used to configure the VDSL line.  If an entry in
```

this table is referenced by a line which does not use SCM,
it has no effect on the operation of that line."
::= { vdslLineExtSCMMibObjects 1 }

vdslLineSCMConfProfileBandEntry OBJECT-TYPE
SYNTAX VdslLineSCMConfProfileBandEntry
MAX-ACCESS not-accessible
STATUS current
DESCRIPTION

"Each entry consists of a list of parameters that
represents the configuration of a single carrier
modulation VDSL modem transmit band.

A default profile with an index of 'DEFVAL', will
always exist and its parameters will be set to vendor
specific values, unless otherwise specified in this
document.

All read-create objects defined in this MIB module SHOULD be
stored persistently."

INDEX { vdslLineConfProfileName,
vdslLineSCMConfProfileBandId }
::= { vdslLineSCMConfProfileBandTable 1 }

VdslLineSCMConfProfileBandEntry ::=

SEQUENCE

{	
vdslLineSCMConfProfileBandId	VdslSCMBandId,
vdslLineSCMConfProfileBandInUse	TruthValue,
vdslLineSCMConfProfileBandCenterFrequency	Unsigned32,
vdslLineSCMConfProfileBandSymbolRate	Unsigned32,
vdslLineSCMConfProfileBandConstellationSize	Unsigned32,
vdslLineSCMConfProfileBandTransmitPSDLevel	Unsigned32,
vdslLineSCMConfProfileBandRowStatus	RowStatus
}	

vdslLineSCMConfProfileBandId OBJECT-TYPE
SYNTAX VdslSCMBandId
MAX-ACCESS not-accessible
STATUS current
DESCRIPTION
"The BandId for this entry, which specifies which band
is being referred to."
::= { vdslLineSCMConfProfileBandEntry 1 }


```
vdslLineSCMConfProfileBandInUse OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS   read-create
    STATUS       current
    DESCRIPTION
        "Indicates whether this band is in use.
         If set to True this band is in use."
    ::= { vdslLineSCMConfProfileBandEntry 2 }

vdslLineSCMConfProfileBandCenterFrequency OBJECT-TYPE
    SYNTAX      Unsigned32
    UNITS        "Hz"
    MAX-ACCESS   read-create
    STATUS       current
    DESCRIPTION
        "Specifies the center frequency in Hz"
    REFERENCE    "T1E1.4/2000-011R3"      -- Part 2, SCM
    ::= { vdslLineSCMConfProfileBandEntry 3 }

vdslLineSCMConfProfileBandSymbolRate OBJECT-TYPE
    SYNTAX      Unsigned32
    UNITS        "baud"
    MAX-ACCESS   read-create
    STATUS       current
    DESCRIPTION
        "The requested symbol rate in baud."
    REFERENCE    "T1E1.4/2000-011R3"      -- Part 2, SCM
    ::= { vdslLineSCMConfProfileBandEntry 4 }

vdslLineSCMConfProfileBandConstellationSize OBJECT-TYPE
    SYNTAX      Unsigned32 (0..16)
    UNITS        "log2"
    MAX-ACCESS   read-create
    STATUS       current
    DESCRIPTION
        "Specifies the constellation size."
    REFERENCE    "T1E1.4/2000-011R3"      -- Part 2, SCM
    ::= { vdslLineSCMConfProfileBandEntry 5 }
```

```

vdslLineSCMConfProfileBandTransmitPSDLevel OBJECT-TYPE
    SYNTAX      Unsigned32
    UNITS       "-0.25 dBm/Hz"
    MAX-ACCESS   read-create
    STATUS      current
    DESCRIPTION
        "The requested transmit power spectral density for the VDSL
        modem. The Actual value in -0.25 dBm/Hz."
    REFERENCE   "T1E1.4/2000-011R3"      -- Part 2, SCM
    ::= { vdslLineSCMConfProfileBandEntry 6 }

```

```

vdslLineSCMConfProfileBandRowStatus OBJECT-TYPE
    SYNTAX      RowStatus
    MAX-ACCESS   read-create
    STATUS      current
    DESCRIPTION
        "This object is used to create a new row or modify or
        delete an existing row in this table.

        A profile activated by setting this object to 'active'.
        When 'active' is set, the system will validate the profile.

        None of the columns in this row may be modified while the
        row is in the 'active' state.

        Before a profile can be deleted or taken out of
        service, (by setting this object to 'destroy' or
        'notInService') it must be first unreferenced
        from all associated lines."

    ::= { vdslLineSCMConfProfileBandEntry 7 }

```

```

--
-- SCM physical band
--

```

```

vdslLineSCMPhysBandTable OBJECT-TYPE
    SYNTAX      SEQUENCE OF VdslLineSCMPhysBandEntry
    MAX-ACCESS   not-accessible
    STATUS      current
    DESCRIPTION
        "This table provides one row for each SCM Vtu band. This
        table is read only as it reflects the current physical
        parameters of each band. For each ifIndex which is
        associated with a VDSL line using SCM line coding, five
        entries in this table will exist, one for each of the
        five bands. Bands which are not in use will be marked
        as unused."

```

```

 ::= { vdslLineExtSCMMibObjects 2 }

vdslLineSCMPhysBandEntry OBJECT-TYPE
    SYNTAX      VdslLineSCMPhysBandEntry
    MAX-ACCESS   not-accessible
    STATUS      current
    DESCRIPTION
        "An entry in the vdslLineSCMPhysBandTable."
    INDEX { ifIndex,
            vdslLineSCMPhysBandId  }
    ::= { vdslLineSCMPhysBandTable 1 }

VdslLineSCMPhysBandEntry ::=
    SEQUENCE
    {
        vdslLineSCMPhysBandId                      VdslSCMBandId,
        vdslLineSCMPhysBandInUse                    TruthValue,
        vdslLineSCMPhysBandCurrCenterFrequency      Unsigned32,
        vdslLineSCMPhysBandCurrSymbolRate          Unsigned32,
        vdslLineSCMPhysBandCurrConstellationSize    Unsigned32,
        vdslLineSCMPhysBandCurrPSDLevel            Unsigned32,
        vdslLineSCMPhysBandCurrSnrMgn              Integer32,
        vdslLineSCMPhysBandCurrAtn                 Unsigned32
    }

vdslLineSCMPhysBandId OBJECT-TYPE
    SYNTAX      VdslSCMBandId
    MAX-ACCESS   not-accessible
    STATUS      current
    DESCRIPTION
        "The BandId for this entry, which specifies which band
         is being referred to."
    ::= { vdslLineSCMPhysBandEntry 1 }

vdslLineSCMPhysBandInUse OBJECT-TYPE
    SYNTAX      TruthValue
    MAX-ACCESS   read-only
    STATUS      current
    DESCRIPTION
        "Indicates whether this band is in use.
         If set to True this band is in use."
    ::= { vdslLineSCMPhysBandEntry 2 }

```

```
vdslLineSCMPhysBandCurrCenterFrequency OBJECT-TYPE
    SYNTAX      Unsigned32
    UNITS        "Hz"
    MAX-ACCESS   read-only
    STATUS       current
    DESCRIPTION
        "The current center frequency in Hz for this band."
    REFERENCE    "T1E1.4/2000-011R3"      -- Part 2, SCM
    ::= { vdslLineSCMPhysBandEntry 3 }

vdslLineSCMPhysBandCurrSymbolRate      OBJECT-TYPE
    SYNTAX      Unsigned32
    UNITS        "baud"
    MAX-ACCESS   read-only
    STATUS       current
    DESCRIPTION
        "The current value of the symbol rate in baud for this
        band."
    REFERENCE    "T1E1.4/2000-011R3"      -- Part 2, SCM
    ::= { vdslLineSCMPhysBandEntry 4 }

vdslLineSCMPhysBandCurrConstellationSize OBJECT-TYPE
    SYNTAX      Unsigned32 (0..16)
    UNITS        "log2"
    MAX-ACCESS   read-only
    STATUS       current
    DESCRIPTION
        "The current constellation size on this band."
    REFERENCE    "T1E1.4/2000-011R3"      -- Part 2, SCM
    ::= { vdslLineSCMPhysBandEntry 5 }

vdslLineSCMPhysBandCurrPSDLevel        OBJECT-TYPE
    SYNTAX      Unsigned32
    UNITS        "- 0.25 dBm/Hz"
    MAX-ACCESS   read-only
    STATUS       current
    DESCRIPTION
        "The transmit power spectral density for the
        VDSL modem."
    REFERENCE    "T1E1.4/2000-011R3"      -- Part 2, SCM
    ::= { vdslLineSCMPhysBandEntry 6 }
```

```

vdslLineSCMPhysBandCurrSnrMgn OBJECT-TYPE
    SYNTAX      Integer32
    UNITS       "0.25 dB"
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "Noise margin as seen by this Vtu and band with respect
         to its received signal in 0.25 dB."
    ::= { vdslLineSCMPhysBandEntry 7 }

vdslLineSCMPhysBandCurrAtn OBJECT-TYPE
    SYNTAX      Unsigned32 (0..255)
    UNITS       "0.25 dB"
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
        "Measured difference in the total power transmitted by
         the peer Vtu on this band and the total power received
         by this Vtu on this band in 0.25 dB."
    ::= { vdslLineSCMPhysBandEntry 8 }

-- conformance information

vdslLineExtSCMConformance OBJECT IDENTIFIER ::=
    { vdslLineExtSCMMib 2 }
vdslLineExtSCMGroups OBJECT IDENTIFIER ::=
    { vdslLineExtSCMConformance 1 }
vdslLineExtSCMCompliances OBJECT IDENTIFIER ::=
    { vdslLineExtSCMConformance 2 }

vdslLineExtSCMMibCompliance MODULE-COMPLIANCE
    STATUS      current
    DESCRIPTION
        "The compliance statement for SNMP entities which
         manage VDSL interfaces."

    MODULE -- this module

    MANDATORY-GROUPS
    {
        vdslLineExtSCMGroup
    }

    ::= { vdslLineExtSCMCompliances 1 }

```

-- units of conformance

```

vdslLineExtSCMGroup      OBJECT-GROUP
    OBJECTS
        {
            vdslLineSCMConfProfileBandInUse,
            vdslLineSCMConfProfileBandTransmitPSDLevel,
            vdslLineSCMConfProfileBandSymbolRate,
            vdslLineSCMConfProfileBandConstellationSize,
            vdslLineSCMConfProfileBandCenterFrequency,
            vdslLineSCMConfProfileBandRowStatus,
            vdslLineSCMPhysBandInUse,
            vdslLineSCMPhysBandCurrPSDLevel,
            vdslLineSCMPhysBandCurrSymbolRate,
            vdslLineSCMPhysBandCurrConstellationSize,
            vdslLineSCMPhysBandCurrCenterFrequency,
            vdslLineSCMPhysBandCurrSnrMgn,
            vdslLineSCMPhysBandCurrAtn
        }
    STATUS      current
    DESCRIPTION
        "A collection of objects providing configuration
        information for a VDSL line based upon single carrier
        modulation modem."
    ::= { vdslLineExtSCMGroups 1 }

END

```

5. Acknowledgments

This document contains many definitions taken from an early version of the VDSL MIB [RFC3728]. As such, any credit for the text found within should be fully attributed to the authors of that document.

6. Security Considerations

There are a number of management objects defined in this MIB module with a MAX-ACCESS clause of read-create. Such objects may be considered sensitive or vulnerable in some network environments. The support for SET operations in a non-secure environment without proper protection can have a negative effect on network operations. These are the tables and objects and their sensitivity/vulnerability:

```

vdslLineSCMConfProfileBandTable
vdslLineSCMConfProfileBandInUse,
vdslLineSCMConfProfileBandTransmitPSDLevel,
vdslLineSCMConfProfileBandSymbolRate,

```

```
vdslLineSCMConfProfileBandConstellationSize,  
vdslLineSCMConfProfileBandCenterFrequency,  
vdslLineSCMConfProfileBandRowStatus
```

VDSL layer connectivity from the Vtur will permit the subscriber to manipulate both the VDSL link directly and the VDSL embedded operations channel (EOC) for their own loop. For example, unchecked or unfiltered fluctuations initiated by the subscriber could generate sufficient notifications to potentially overwhelm either the management interface to the network or the element manager.

Additionally, allowing write access to configuration data may allow an end-user to increase their service levels or affect other end-users in either a positive or negative manner. For this reason, the tables and objects listed above should be considered to contain sensitive information.

Some of the readable objects in this MIB module (i.e., objects with a MAX-ACCESS other than not-accessible) may be considered sensitive or vulnerable in some network environments. It is thus important to control even GET and/or NOTIFY access to these objects and possibly to even encrypt the values of these objects when sending them over the network via SNMP. These are the tables and objects and their sensitivity/vulnerability:

```
vdslLineSCMPhysBandInUse,  
vdslLineSCMPhysBandCurrPSDLevel,  
vdslLineSCMPhysBandCurrSymbolRate,  
vdslLineSCMPhysBandCurrConstellationSize,  
vdslLineSCMPhysBandCurrCenterFrequency,  
vdslLineSCMPhysBandCurrSnrMgn,  
vdslLineSCMPhysBandCurrAtn
```

Read access of the physical band parameters may provide knowledge to an end-user that would allow malicious behavior, for example the application of an intentional interference on one or all of the physical bands in use.

SNMP versions prior to SNMPv3 did not include adequate security. Even if the network itself is secure (for example by using IPSec), even then, there is no control as to who on the secure network is allowed to access and GET/SET (read/change/create/delete) the objects in this MIB module.

It is RECOMMENDED that implementers consider the security features as provided by the SNMPv3 framework (see [RFC3410], section 8), including full support for the SNMPv3 cryptographic mechanisms (for authentication and privacy).

Further, deployment of SNMP versions prior to SNMPv3 is NOT RECOMMENDED. Instead, it is RECOMMENDED to deploy SNMPv3 and to enable cryptographic security. It is then a customer/operator responsibility to ensure that the SNMP entity giving access to an instance of a MIB module is properly configured to give access to the objects only to those principals (users) that have legitimate rights to indeed GET or SET (change/create/delete) them.

7. IANA Considerations

The IANA has assigned the transmission value 228 to VDSL-LINE-EXT-SCM-MIB.

8. References

8.1. Normative References

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- [DSLFWT96] DSL Forum WT-096, "SCM Specific Managed Objects In VDSL Network Elements".
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- [ETSI2702] ETSI TS 101 270-2 V1.1.1, "Transmission and Multiplexing (TM); Access transmission systems on metallic access cables; Very high speed Digital Subscriber Line (VDSL); Part 1: Transceiver specification", February 2001.
- [ITU9931] ITU-T G.993.1, "Very-high-speed digital subscriber line foundation", November 2001.
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