# *IEEE P802.3dg Downshift/Upshift Proposal & Draft Text*

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# 1 Overview

This document provides draft text supporting my “Downshift/Upshift” proposal .

This concept has been previously presented to the group:

- July 2025: Downshift/Upshift (presentation), Proposed draft text
- May 2024: IEEE 802.3dg 100BASE-T1L: Downshift - part 2
- May 2022: Downshift

## 1.1 Description

802.3 Auto-Negotiation (AN) for twisted paired PHYs is specified in 802.3 Clause 28 (BASE-T) and Clause 98 (BASE-T1).

The basic philosophy of AN is during link startup:

- Exchange “capabilities”
- Resolve “best” capability values supported by both link partners.

BASE-T1 AN Priority Resolution has extra complexity compared to BASE-T. 98B.4 Priority Resolution specifies the following priority list:

- 10GBASE-T1
- 5GBASE-T1
- 2.5GBASE-T1
- 1000BASE-T1
- 100BASE-T1
- 10BASE-T1S full duplex
- 10BASE-T1S half-duplex
- 10BASE-T1L

This list does not consider the different possible operating voltages (e.g., see 146.6.4 and Table 98B–1 for 10BASE-T1L) can also affect link stability. It’s expected that the “Increased Transmit Level” be more resilient, but that may not always be the case. 146.6.4 specifies that Increased Transmit Level is preferred. This may not be the desired outcome, .e.g.,

- Preferring to run at the default Transmit Level for reduced energy consumption/emissions
- A line impairment (e.g., a SPoE Midspan) which limits supported voltages

Downshift specifies a separate list of preferred link settings. This starts with the list in 98B.4, and adds additional parameters, e.g., operating voltages, to create a configurable preferred link parameters list. The default list for BASE-T1L is as follows:

- 100BASE-T1L Increased Transmit Level
- 100BASE-T1L
- 10BASE-T1L Increased Transmit Level
- 10BASE-T1L

Downshift is implemented by monitoring link failures. When the link failure rate exceeds a threshold, and the current link parameters are not the least preferred supported by both peers , the advertised abilities are modified to remove the current link parameters, e.g., :

1. Auto-negotiation (AN) selects a set of link parameters (e.g., PHY ability, Increased Transmit Level) .
2. Link training.
3. Bring link up.
4. If the link does not come up or fails repeatedly, and the current link parameters are not the least preferred set supported by both peers , remove the current link parameters from the AN advertisement.

Upshift works in a similar fashion. If the link is stable for an extended period, and the current link parameters are not the most preferred set supported by both peers, add the next most preferred back into the AN advertisement.

Other conditions can trigger a downshift or reset the downshift process. These include:

- No valid AN signaling (`ability_match = false`) is received

# 1.2 Changes from July 2025

Detailed reviews showed several issues, and potentially a simpler approach to specify downshift/upshift.

## 1.2.1 Priority Resolution

In addition to the normal technology priority resolution specified in 98B.4 Priority Resolution, Downshift needs to take into account other abilities, e.g., 10BASE-T1L increased transmit (see Table 98B–1).

10BASE-T1L also supports two transmit voltages (2.4 Vpp and 1.0 Vpp). Clause 146.6.4 specifies how the transmit voltage is determined during the Auto-Negotiation process, but not as part of the Clause 98 Arbitration state diagram (Figure 98–7). While Clause 146.6.4 favors 2.4 Vpp over 1.0 Vpp, but this may not always be the desired outcome (e.g., when optimizing for lower power, or lower emissions).

To address these challenges, as part of downshift a new list will be specified to define the desired transitions between “operating modes” (e.g., speed, PHY type, voltage). This list will be part of Clause 45 and Clause 30 definitions and can be modified using these interfaces.

## 1.2.2 State Diagrams

There is a strong preference not to change the current Clause 98 Arbitration state diagram. A new annex will be specified with a state diagram (with variables, functions, etc) running “in parallel” with the current Figure 98–7—Arbitration state diagram state diagram.

## 1.2.3 Clause 30 Definitions

Clause 30 definitions are pending based on the groups’ response to the proposals for Annex 98D and Clause 45.

# 1.3 Change Log

Plan B document

- August 2025
    - First draft of Plan B document

# 2 Contents

## 2.1 Table of Contents



## 2.2 Table of Figures

# 3 Definitions

**802.3:** IEEE Std 802.3-2022 as amended

**AN:** Auto-Negotiation

**BASE-T AN**: 802.3 Clause 28 - Physical Layer link signaling for Auto-Negotiation on twisted pair

**BASE-T1 AN**: 802.3 Clause 98 - Auto-Negotiation for single differential-pair media

**HCD:** Highest Common Denominator

**LCD:** Lowest Common Denominator

**MDIO**: 802.3 Clause 45 - Management Data Input/Output (MDIO) Interface

# 4 Proposed text changes

## 4.1 New Annex 98.D

Add the following new normative annex.

**Annex 98D**
**(normative)**
**Downshift/Upshift for Single Differential-Pair Media**

This annex specifies downshift/upshift for BASE-T1L PHYs that support this optional functionality.

**98D.1 Downshift/Upshift Sequence**

Downshift/Upshift uses an independent Downshift/Upshift Sequence to that defined in 98B.4. The 98B.4 list would include transitions that don't make sense (e.g., 100BASE-T1 to 10BASE-T1S). Each "family" of PHYs (e.g., BASE-T1L vs BASE-T1) defines it's own default sequence, but these can be modified using clause 45/30.

**98D.1.1 BASE-T1L Sequence**

The default Downshift/Upshift Sequence for the BASE-T1L PHYs is defined below:

- 100BASE-T1L
- 10BASE-T1L 1Vpp
- 10BASE-T1L 2.4Vpp

**98D.2 Detailed functions and state diagrams**

**98D.2.1 State diagram notation**

The notation used in the state diagrams follows the conventions of state diagrams as described in 21.5, along with the extensions described in 145.2.5.2. State diagram timers follow the conventions of 40.4.5.2. The notation ++ after a counter or integer variable indicates that its value is to be incremented.

Default initializations, unless specified, are left to the implementer

Variables of the form "mr_x", where x is a label, comprise a management interface that is intended to be connected to the Management function. However, an implementation-specific management interface may provide the control and status function of these bits. The mapping between state diagram variables and Single twisted-pair Auto-Negotiation MDIO registers is shown in Table 98D-1.

**98D.2.2 State diagram variables**

PreferredLinkList; The user configured list of link settings (e.g., technology-dependent PMA and PMA parameters) ordered from most preferred to least preferred.

MostPreferredLink; The most preferred link settings supported by both peers.

LeastPreferredLink; The least preferred link settings supported by both peers.

CurrentLink: The current link settings. Setting this changes mr_adv_ability and potentially other settings (e.g., 10BASE-T1L voltage).

NextHigherLink: The next link settings above CurrentLink.

NextLowerLink: The next link settings below CurrentLink

mr_ds_downshift_enabled
  Boolean variable indicating whether downshift is enabled.

mr_ds_upshift_enabled
  Boolean variable indicating whether upshift is enabled .

mr_ds_downshift_supported
  Boolean variable indicating whether downshift/upshift is supported.

mr_ds_fail_threshold
  The number of link failures within the downshift threshold period before downshift is triggered.
  Values: Integer number from 1 to 255

mr_ds_period_downshift
  The downshift threshold period in seconds.
  Values: Integer number from 1 to 255

mr_ds_period_restart
  The restart threshold period in seconds.

mr_ds_period_upshift
  The upshift threshold period in seconds.
  Values: Integer number from 1 to 4095

**98D.2.3 State diagram timers**

All timers operate in the manner described in 14.2.3.2 with the following additions:

- A timer is reset and stops counting upon entering a state where “stop timer” is asserted.
- While a timer is running x_timer_running is asserted

ds_downshift_timer
  Timer used to evaluate downshift trigger conditions.
  Duration: mr_ds_downshift_period seconds.

ds_restart_timer
  Timer used to restart downshift/upshift when no valid signaling is detected, i.e., being in Figure 98–7 ABILITY DETECT and not receiving any link codewords with good CRC16.
  Duration: break_link_timer_[ANSP] + mr_ds_restart_period.

ds_upshift_timer
  Timer used to evaluate upshift trigger conditions.
  Duration: mr_ds_link_upshift_period.

### 98D.2.4 State diagram counters

mr_ds_downshift_attempts
The number of downshift attempts since auto-negotiation was enabled.

mr_ds_restarts
The number of times downshift was restarted since auto-negotiation was enabled.

mr_ds_upshift_attempts
The number of upshift attempts since auto-negotiation was enabled.

ds_fail_count
The number of link failures in the last downshift threshold period.

### 98D.2.6 State diagram

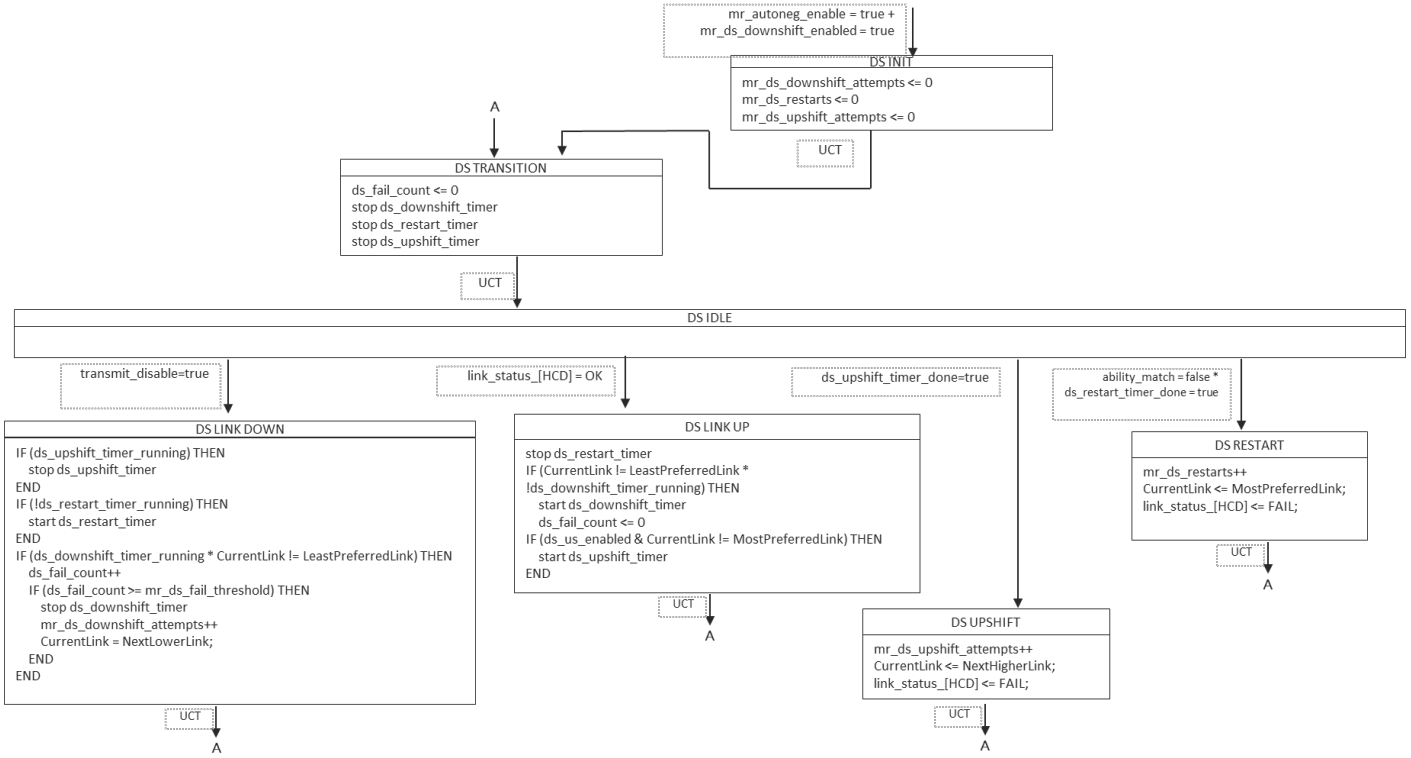


**Figure 1 Downshift state diagram**

**98D.2.7 State diagram variable to MDIO register mapping**

Table 98D-1 specifies the state diagram variable to MDIO register mapping.

Table 98D-1—State diagram variable to MDIO register mapping

| State diagram variable | Description / MDIO register mapping |
|---|---|
| mr_ds_downshift_enabled | 7.528.0 - Downshift enabled |
| mr_ds_upshift_enabled | 7.528.1 - Upshift enabled |
| mr_ds_downshift_supported | 7.529.0 – Downshift/Upshift supported |
| mr_ds_fail_threshold | 7.530.8:15 – Downshift threshold |
| mr_ds_period_downshift | 7.529.0:7 – Downshift period |
| mr_ds_period_restart | 7.531.0:7 – Restart period |
| mr_ds_period_upshift | 7.532.0:11 –Upshift period |
| mr_ds_downshift_attempts | 7.533.15:0 - Downshift attempts |
| mr_ds_restarts | 7.534.15:0 - Restarts |
| mr_ds_upshift_attempts | 7.535.15:0 - Upshift attempts |

**98D.2.8 Downshift Preference List Enumerations**

Downshift makes use of a configurable list of link settings to specify the preferred order used in downshift/upshift. Table 98D-2 specifies enumerations for these link settings.

The enumerations have two components, following the "Clause 98 Technology Ability Field" proposal from Curren etc al (affiliated with ADI)." The enumerations are 8 bits, comprised of a 3 bit Technology Category (as proposed in the presentation) and a 5 bit type within Technology Category.

**Table 98D-2— Link Setting Enumerations**

| **Technology Category** | **Value** | **Name** | **Value** | **What** |
|---|---|---|---|---|
| None | 0 | None | * | Unused values. |
| BASE-T1 | 1 | BASE-T1 | * | Reserved for future used |
| BASE-T1L | 2 | BASE-T1L | | |
| | | 10BaseT1L | 0 | 10BASE-L |
| | | 10BaseT1LItl | 1 | 10BASE-L Increased Transmit Level |
| | | 100BaseT1L | 2 | 100BASE-T1L |
| | | 100BaseT1LItl | 3 | 10BASE-L Increased Transmit Level |
| Reserved | 3-8 | | | Reserved |

## 98D.3 Protocol implementation conformance statement (PICS) proforma for Annex 98D, Downshift/Upshift for Single Differential-Pair Media

### 98D.3.1 Introduction

The supplier of a protocol implementation that is claimed to conform to Annex 98D, Downshift/Upshift for Single Differential-Pair Media, shall complete the following protocol implementation conformance statement (PICS) proforma. A detailed description of the symbols used in the PICS proforma, along with instructions for completing the PICS proforma, can be found in Clause 21.

### 98D.3.2 Identification

#### 98D.3.2.1 Implementation identification

| | |
|---|---|
| Supplier | |
| Contact point for inquiries about the PICS | |
| Implementation Name(s) and Version(s) | |
| Other information necessary for full identification—e.g., name(s) and version(s) for machines and/or operating systems; System Name(s) | |
| NOTE 1—Only the first three items are required for all implementations; other information may be completed as appropriate in meeting the requirements for the identification.<br>NOTE 2—The terms Name and Version should be interpreted appropriately to correspond with a supplier's terminology (e.g., Type, Series, Model). | |

#### 98D.3.2.2 Protocol summary

| | |
|---|---|
| Identification of protocol standard | IEEE Std 802.3xx-202x, Annex 98D, Downshift/Upshift for Single Differential-Pair Media |
| Identification of amendments and corrigenda to this PICS proforma that have been completed as part of this PICS | |
| Have any Exception items been required? No [ ] Yes [ ]<br>(See Clause 21; the answer Yes means that the implementation does not conform to IEEE Std 802.3xx-202x,.) | |

### 98D.3.3 Major capabilities/options

| Item | Feature | Sub clause | Value/Comment | Status | Support |
|---|---|---|---|---|---|
| *DNSFT | PHY support for Downshift/Upshift | 98.5 | | M | Yes [ ]<br>No [ ] |

### 98D.3.4 PICS proforma tables for Downshift/Upshift for Single Differential-Pair Media

#### 98D.3.4.1 Downshift

| Item | Feature | Sub clause | Value/Comment | Status | Support |
|---|---|---|---|---|---|
| DNSFT*N* | Downshift supported | 98D.2 | mr_ds_downshift_supported | DNSFT:M | Yes [ ]<br>No [ ] |
| DNSFT*N* | Downshift enabled | 98D.2 | mr_ds_downshift_enabled | DNSFT:M | Yes [ ]<br>No [ ] |
| DNSFT*N* | Downshift attempts | 98D.2 | mr_ds_downshift_attempts | DNSFT:M | Yes [ ]<br>No [ ] |
| DNSFT*N* | Downshift link attempts and link attempts threshold | 98D.2 | mr_ds_fail_threshold<br>mr_ds_period_downshift<br>ds_fail_count | DNSFT:M | Yes [ ]<br>No [ ] |
| DNSFT*N* | Downshift reset when AN signal not detected | 98D.2 | mr_ds_period_restart<br>mr_ds_restarts<br>ds_trigger_restart | DNSFT:M | Yes [ ]<br>No [ ] |

#### 98D.3.4.2 Upshift

| Item | Feature | Sub clause | Value/Comment | Status | Support |
|---|---|---|---|---|---|
| UPSFT*N* | Upshift supported | 98D.2 | mr_ds_upshift_supported | DNSFT:M | Yes [ ]<br>No [ ] |
| UPSFT*N* | Upshift enabled | 98D.2 | mr_ds_upshift_enabled | DNSFT:M | Yes [ ]<br>No [ ] |
| UPSFT*N* | Upshift timer | 98D.2 | mr_ds_period_upshift | DNSFT:M | Yes [ ]<br>No [ ] |
| UPSFT*N* | Upshift attempts | 98D.2 | mr_ds_upshift_attempts | DNSFT:M | Yes [ ]<br>No [ ] |

# 4.2 Clause 45 Modifications

## 4.2.1 Table 45–378—Auto-Negotiation MMD registers

Change Table 45–378—Auto-Negotiation MMD registers by replacing the second last row (7.528 through 7.32767) as follows:

| Register address | Register name | Subclause |
|---|---|---|
| 7.528 | BASE-T1 Downshift Control | 45.2.7.28 |
| 7.529 | BASE-T1 Downshift Status | 45.2.7.29 |
| 7.530 | BASE-T1 Downshift Parameters | 45.2.7.30 |
| 7.531 | BASE-T1 Downshift Restart Parameters | 45.2.7.31 |
| 7.532 | BASE-T1 Upshift Parameters | 45.2.7.32 |
| 7.533 | BASE-T1 Downshift Attempts | 45.2.7.33 |
| 7.534 | BASE-T1 Restarts | 45.2.7.34 |
| 7.535 | BASE-T1 Upshift Attempts | 45.2.7.35 |
| 7.536 | BASE-T1 Downshift Preference List Entries 0 & 1 | 45.2.7.36 |
| 7.537 | BASE-T1 Downshift Preference List Entries 2 & 3 | 45.2.7.37 |
| 7.538 through 7.32767 | Reserved | |

## 4.2.2 Downshift MDIO registers

Add the following subclauses after 45.2.7.27 10BASE-T1 AN status register (Register 7.527)

**45.2.7.28 BASE-T1 Downshift Control (Register 7.528)**

The assignment of bits in the BASE-T1 Downshift control register is shown in Table 45-402a.

Table 45-402a—BASE-T1 Downshift control register bit definitions

| Bit(s) | Name | Description | R/W |
|---|---|---|---|
| 7. 528.2:15 | Reserved | Value always 0 | RO |
| 7. 528.1 | Upshift enabled | 1 = enabled<br>0 = disabled | R/W |
| 7. 528.0 | Downshift enabled | 1 = enabled<br>0 = disabled | R/W |

**45.2.7.28.1 Downshift Enabled**

Setting bit 7.528.0 enables or disables Downshift, see Table 98D-1 mr_ds_downshift_enabled.

**45.2.7.28.2 Upshift Enabled**

Setting bit 7.528.1 enables or disables Upshift, see Table 98D-1 mr_ds_upshift_enabled.

**45.2.7.29 Downshift Status (Register 7.529)**

The assignment of bits in the BASE-T1 Downshift status register is shown in Table 45-402b.

Table 45–402b—BASE-T1 Downshift status register bit definitions

| Bit(s) | Name | Description | R/W |
|---|---|---|---|
| 7.529.1:15 | Reserved | Value always 0 | RO |
| 7.529.0 | Downshift/Upshift supported | 1 = supported<br>0 = not supported | RO |

**45.2.7.29.1 Downshift/Upshift Supported**

Bit 7.529.0 reports whether Downshift/Upshift is supported, see Table 98D-1 mr_ds_downshift_supported.

**45.2.7.30 BASE-T1 Downshift Parameters (Register 7.530)**

The assignment of bits in the BASE-T1 Downshift Threshold register is shown in Table 45-402c.

Table 45–402c—BASE-T1 Downshift Threshold register bit definitions

| Bit(s) | Name | Description | R/W |
|---|---|---|---|
| 7.530.8:15 | Downshift threshold | The number of link failures used when evaluating Downshift trigger. | R/W |
| 7.530.0:7 | Downshift period | The period in seconds used when evaluating the Downshift trigger | R/W |

**45.2.7.30.1 Downshift Period**

Setting 7.530.0:7 sets the period to evaluate the link failure count before triggering Downshift, see Table 98D-1 mr_ds_period_downshift.

**45.2.7.30.2 Downshift Threshold**

Setting 7.530.8:15 sets the number of link failures within the trigger period before triggering Downshift, see Table 98D-1 mr_ds_fail_threshold.

**45.2.7.31 BASE-T1 Downshift Restart Parameters (Register 7.531)**

The assignment of bits in the BASE-T1 Downshift Restart Parameters register is shown in Table 45-402d.

Table 45–402d—BASE-T1 Upshift Parameters register bit definitions

| Bit(s) | Name | Description | R/W |
|---|---|---|---|
| 7.531.8:15 | Reserved | Value always 0 | RO |
| 7.531.0:7 | Restart period | The period in seconds used when evaluating the restart trigger | R/W |

**45.2.7.31.1 Restart Period**

Setting 7.531.0:11 sets the period to evaluate before triggering Restart processing, see Table 98D-1 mr_ds_period_restart.

**45.2.7.32 BASE-T1 Upshift Parameters (Register 7.532)**

The assignment of bits in the BASE-T1 Upshift Parameters register is shown in Table 45-402e.

Table 45-402e—BASE-T1 Upshift Parameters register bit definitions

| Bit(s) | Name | Description | R/W |
|---|---|---|---|
| 7.532.12:15 | Reserved | Value always 0 | RO |
| 7.532.0:11 | Upshift period | The period in seconds used when evaluating the link Upshift trigger | R/W |

**45.2.7.32 Upshift Period**

Setting 7.532.0:11 sets the period to evaluate before triggering Upshift processing, see Table 98D-1 mr_ds_period_upshift.

**45.2.7.33 BASE-T1 Downshift Attempts (Register 7.533)**

The assignment of bits in the BASE-T1 Downshift Attempts register is shown in Table 45-402f. All the bits in this register are read only; therefore, a write to the register shall have no effect.

Table 45-402f—BASE-T1 Downshift Attempts register bit definitions

| Bit(s) | Name | Description | R/W |
|---|---|---|---|
| 7.533.15:0 | Downshift attempts | The number of Downshift attempts on the interface. | RO |

**45.2.7.33.1 Downshift attempts**

Bits 7.533.15:0 report the number of Downshift attempts since the last time Auto-Negotiation was enabled on the interface, see Table 98D-1 mr_ds_downshift_attempts.

**45.2.7.34 BASE-T1 Downshift Restarts (Register 7.534)**

The assignment of bits in the BASE-T1 Downshift Restarts register is shown in Table 45-402g. All the bits in this register are read only; therefore, a write to the register shall have no effect.

Table 45-402g—BASE-T1 Downshift Restarts register bit definitions

| Bit(s) | Name | Description | R/W |
|---|---|---|---|
| 7.534.15:0 | Downshift restarts | The number of Downshift restarts on the interface. | RO |

**45.2.7.34.1 Downshift restarts**

Bits 7.533.15:0 report the number of Downshift attempts since the last time Auto-Negotiation was enabled on the interface, see Table 98D-1 mr_ds_restarts.

**45.2.7.35 BASE-T1 Upshift Attempts (Register 7. 535)**

The assignment of bits in the 4.3.9 BASE-T1 Upshift Attempts register is shown in Table 45-402h. All the bits in this register are read only; therefore, a write to the register shall have no effect.

Table 45-402h—10BASE-T1 Upshift Attempts register bit definitions

| Bit(s) | Name | Description | R/W |
|---|---|---|---|
| 7.535.15:0 | Upshift attempts | The number of Upshift attempts since Auto-Negotiation was enabled on the interface. | RO |

**45.2.7.35.1 Upshift attempts**

Bits 7.535.15:0 report the number of Upshift attempts since the last time Auto-Negotiation was enabled on the interface, see Table 98D-1 mr_ds_upshift_attempts.

**45.2.7.36 BASE-T1 Downshift Preference List Entries 0 & 1 (Register 7.536)**

The assignment of bits in the BASE-T1 Downshift Restart Parameters register is shown in Table 45-402d.

Table 45-402d—BASE-T1 Upshift Parameters register bit definitions

| Bit(s) | Name | Description | R/W |
|---|---|---|---|
| 7.536.8:15 | Entry 1 | Preference List Entry 1 | R/W |
| 7.536.0:7 | Entry 0 | Preference List Entry 0 | R/W |

**45.2.7.36.1**

This register contains Entry 0 and Entry 1 in the Downshift Preference List. The enumerations are specified in Table 98D-2.

**45.2.7.37 BASE-T1 Downshift Preference List Entries 2 & 3 (Register 7.537)**

The assignment of bits in the BASE-T1 Downshift Restart Parameters register is shown in Table 45-402d.

Table 45-402d—BASE-T1 Upshift Parameters register bit definitions

| Bit(s) | Name | Description | R/W |
|---|---|---|---|
| 7.536.8:15 | Entry 3 | Preference List Entry 1 | R/W |
| 7.536.0:7 | Entry 2 | Preference List Entry 0 | R/W |

**45.2.7.36.1**

This register contains Entry 2 and Entry 3 in the Downshift Preference List. The enumerations are specified in Table 98D-2.

## 4.3 Clause 30 Modifications

## *PENDING* – agreement on 98D and 45.7

# End of Document