IEEE P802.3dg Downshift/Upshift draft text

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1 Overview

This document provides draft text supporting the “Downshift” proposal described in <presentation name>.

This concept has been previously presented to the group:

- May 2024: IEEE 802.3dg 100BASE-T1L: Downshift - part 2
- May 2022: Downshift

1.1 Description

802.3 auto-negotiation for twisted paired PHYs is specified in 802.3 Clause 28 (BASE-T) and Clause 98 (BASE-T1).

The basic philosophy of auto-negotiation is during link startup:

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

Downshift is implemented by monitoring link failures. When link failures exceed given thresholds, and the Highest Common Denominator(HCD) speed is not equal to the Lowest Common Denominator(LCD), the HCD is removed from capability advertisements. Both link partners run the state machine independently. The process can be described as:

1. Auto-negotiation (AN) selects HCD speed.
2. Link training for selected speed.
3. Bring link up.
4. If the link does not come up, or if the link fails repeatedly in a short period, and HCD is not LCD, remove HCD rate from the AN advertisement and restart AN.

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

- If no valid AN signaling (`ability_match = false`) is received downshift is reset

This proposal includes the ability to “Upshift” after an extended period of link stability.

This document includes some “comment blocks” (see below for examples) that are intended to help the reviewed of the proposal, and not to be included in the 802.3dg standard itself.

```
/* This is a comment */
/*
  This is also a comment
*/
```

1.2 Change Log

- May 2025
  - Initial draft
- May 2025
  - Simplify draft for initial proposal, only consider link failures as trigger conditions.
  - Add Upshift

- June 2025
    - Additional changes to prepare for submission to 802.3dg
- July 2025
    - Add text to deal with
        - No valid AN signaling (`ability_match = false`)
        - The PMA does not bring the link up (`link_fail_inhibit_timer_[HCD]_done`)

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 Downshift

4.1 Outline

As outlined in 1.1, Downshift operates by monitoring the number of link failures over a set period. When the threshold is exceeded and the link is not running at the lowest rate supported by both link partners, either or both link partners remove the “current” rate from the Capabilities exchange to select the next lower rate supported by the link partners.

If the link is stable for an extended period, then the link partners can optionally add back the higher rates, and trigger auto negotiation by taking the link down and bringing it back up. This may require co-ordination between the link partners to avoid repeated link outages as the link partners move back up the speeds. If so, this may be done using LLDP, or adding some randomization to timer values.

4.1.1 Flow Chart

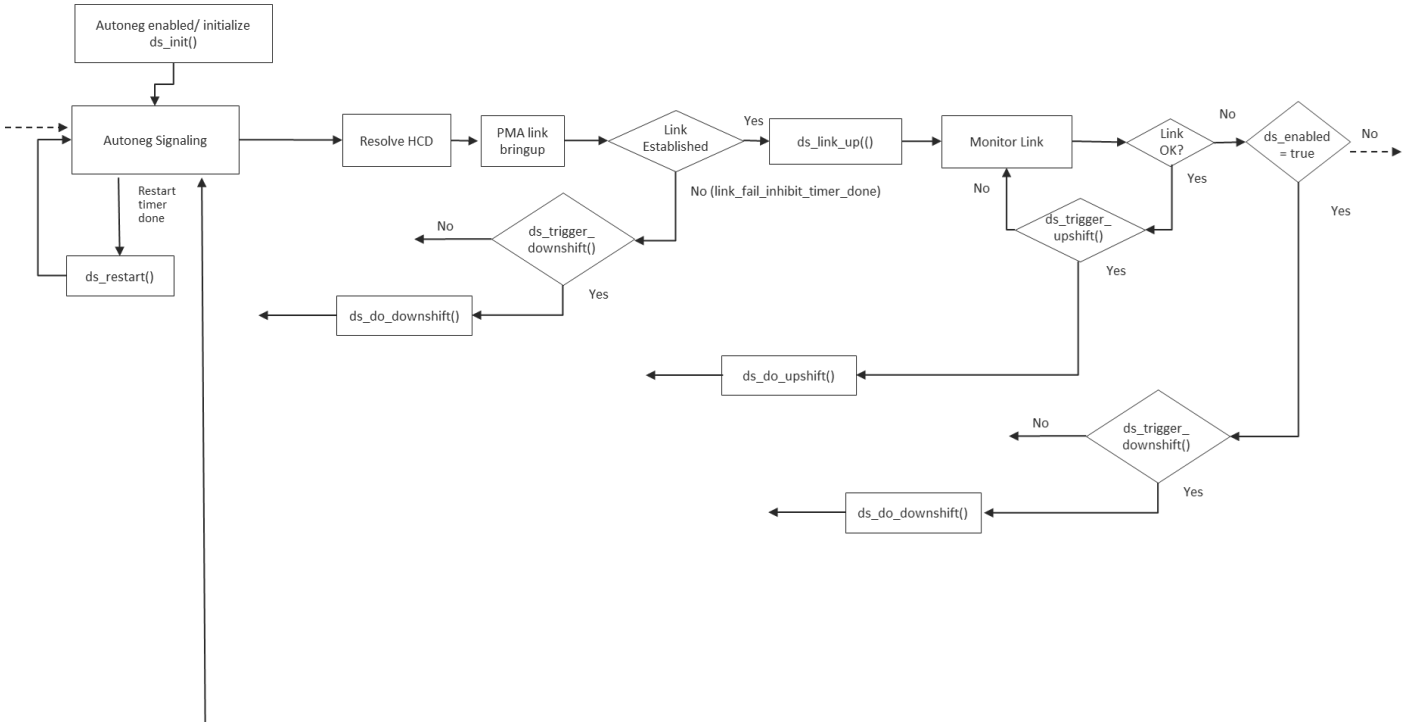

Figure 4-1: BASE-T1L Downshift Flow Chart

4.2 Clause 98 Modifications

4.2.1 Subclause 98.3

Insert the following rows into Table 98–7—State diagram variable to Single twisted-pair Auto-Negotiation 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 supported
mr_ds_upshift_supported	7.529.1 - 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

4.2.2 Subclause 98.5

Add the following sentence to the end of the only paragraph in 98.5 which finishes “diagrams, the state diagrams shall take precedence”.

```
The notation ++ after a counter or integer variable indicates that its value
is to be incremented.
```

4.2.3 Subclause 98.5.1

Insert the following variables into the list that begins with ‘— all’ and ends with ‘— 10GigT1’:

```
LCD; represents the single technology-dependent PMA chosen by Auto-
Negotiation as the lowest common denominator technology through the
Priority Resolution

InitialHCD; represents the single technology-dependent PMA chosen by Auto-
Negotiation as the highest common denominator technology through the
Priority Resolution before Downshift modifies mr_adv_ability.

NextHCD; represents the single technology-dependent PMA chosen by Auto-
Negotiation as the next highest common denominator technology through the
Priority Resolution before Downshift modifies mr_adv_ability.
```

Insert the following variables into the list that begins with ‘`ability_match`’ and ends with ‘`tx_link_code_word[64:1]`’:

```
mr_ds_downshift_enabled
  Is downshift enabled?
  Type:         boolean
  Default:      false

mr_ds_upshift_enabled
  Is upshift enabled?
  Type:         boolean
  Default:      false

mr_ds_downshift_supported
  Is downshift supported?
  Type:         boolean

mr_ds_upshift_supported
  Is upshift supported?
  Type:         boolean

mr_ds_fail_threshold
  The number of link failures within the downshift threshold period before
  downshift is triggered
  Type:         integer (0..255)
```

```
  Default:      8

mr_ds_period_downshift
  The downshift threshold period in seconds.
  Type:         integer (0..255)
  Default:      20

mr_ds_period_restart
  The restart threshold period in seconds
  Type:         integer (0..255)
  Default:      5

mr_ds_period_upshift
  The upshift threshold period in seconds
  Type:         integer (0..4095)
  Default:      255

ds_taf_initial
  The initial value of the Technology Ability Field bitmap as defined in Clause
  98.2.1.2.4 Technology Ability Field and Table 98B-1—Technology Ability Field
  bit assignments.
  Type:         bitmap

ds_trigger_restart
  Should the ds_restart_timer be started the next time the ABILITY DETECT state
  is entered?
  Type:         boolean
```

4.2.4 Subclause 98.5.2

Insert the following timers into the list that begins with ‘`backoff_timer_[HSM]`’ and ends with ‘`silent_timer_[LSM]`’:

```
ds_downshift_timer
  Timer used to evaluate downshift trigger conditions. The timer period is set
  in mr_ds_downshift_period.

ds_restart_timer
  Timer used to restart downshift/upshift when no valid signalling is being
  received. The timer period is equal to break_link_timer_[ANSP] +
  mr_ds_restart_period.

ds_link_upshift_timer
 Timer used to evaluate upshift trigger conditions. The timer period is set in
 mr_ds_link_upshift_period.
```

4.2.5 Subclause 98.5.3

Insert the following counters into the list that begins with ‘`remaining_ack_cnt`’ and ends with ‘`tx_bit_cnt`’:

```
mr_ds_downshift_attempts
  The number of downshift attempts.
  Type:    integer

mr_ds_restarts
  The number of times downshift was restarted.
  Type:    integer

mr_ds_upshift_attempts
  The number of upshift attempts.
  Type:    integer

ds_fail_count
  The number of link failures in the last downshift threshold period.
  Type:    integer
```

4.2.6 Subclause 98.5.4 Figure 98–7 Arbitration state diagram

Add the following functions:

see “spe ds code.txt” file

4.2.7 Subclause 98.5.5

4.2.7.1 Initialization

Add the following to `Auto-Negotiation ENABLE`.

```
if (mr_ds_downshift_enabled = true) then
 ds_init()
end
```

4.2.7.2 Ability Detect

Add the following to the `ABILITY DETECT` actions.

```
if (mr_ds_downshift_enabled = true & ds_trigger_restart = true) then
 ds_trigger_restart <= false
 start ds_restart_timer
end
```

Add a new `DS RESTART` state.

- entry condition from `ABILITY DETECT:` `ds_restart_timer_done`
- action:

  ```
  ds_do_restart()
  ```
- exit to `ABILITY DETECT: UCT`

4.2.7.3 Transmit Disable

The Arbitration state diagram enters `TRANSMIT DISABLE` for one of the following reasons:

- From `Auto-Negotiation ENABLE` because AN has restarted
- From `AN GOOD` because the `link_status` was `OK` and has changed to `FAIL`
- From `AN GOOD CHECK` because either:
  - There is no common speed (`incompatible_link`) was set
  - The PMA failed to bring the link up (`link_fail_inhibit_timer` expired and `link_status` = `FAIL`)

Add the following to `TRANSMIT DISABLE`.

```
if (mr_ds_downshift_enabled = true) then
  ds_link_down()
```

4.2.7.4 Upshift timeout

Add the following to `AN GOOD`.

- A new state action

  ```
  if (mr_ds_downshift_enabled = true) then
      ds_link_up()
  ```
- A new exit condition (`mr_ds_upshift_enabled` + `ds_trigger_upshift()`) that goes to a new state '`AN UPSHIFT`'

Add state '`AN UPSHIFT`' that contains the following:

- State action

  ```
  ds_do_upshift()
  ```
- Exit condition `UCT` to '`TRANSMIT DISABLE`'

4.2.8 Subclause 98.6

4.2.8.1 Subclause 98.6.4

Add the following information row after the row containing ‘G4:PHY support for Low-Speed Mode’.

Item	Feature	Sub clause	Value/Comment	Status	Support
*DNSFT	PHY support for Downshift	98.5		O	Yes [ ] No [ ]
*UPSFT	PHY support for Upshift	98.5		O: DNSFT	Yes [ ] No [ ]

4.2.8.2 Subclause 98.6.10a

Add the following subclauses after 98.6.10.

98.6.10a Downshift

Item	Feature	Sub clause	Value/Comment	Status	Support
DNSFT*N*	Downshift supported	98.5	`mr_ds_downshift_supported`	DNSFT:M	Yes [ ] No [ ]
DNSFT*N*	Downshift enabled	98.5	`mr_ds_downshift_enabled`	DNSFT:M	Yes [ ] No [ ]
DNSFT*N*	Downshift attempts	98.5	`mr_ds_downshift_attempts`	DNSFT:M	Yes [ ] No [ ]

DNSFT*N*	Downshift link attempts and link attempts threshold	98.5	`mr_ds_fail_threshold`
			`mr_ds_period_downshift`
			`ds_fail_count`
				DNSFT:M	Yes [ ]
					No [ ]

DNSFT*N*	Downshift reset when AN signal not detected	98.5	`mr_ds_period_restart`
			`mr_ds_restarts`
			`ds_trigger_restart`
				DNSFT:M	Yes [ ]
					No [ ]

98.6.10a Upshift

Item	Feature	Sub clause	Value/Comment	Status	Support
UPSFT*N*	Upshift supported	98.5	`mr_ds_upshift_supported`	UPSFT:M	Yes [ ] No [ ]
UPSFT*N*	Upshift enabled	98.5	`mr_ds_upshift_enabled`	UPSFT:M	Yes [ ] No [ ]

UPSFT*N*	Upshift timer	98.5	`mr_ds_period_upshift`	UPSFT:M	Yes [ ] No [ ]
UPSFT*N*	Upshift attempts	98.5	`mr_ds_upshift_attempts`	UPSFT:M	Yes [ ] No [ ]

4.3 Clause 45 Modifications

4.3.1 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 through 7.32767	Reserved	

4.3.2 BASE-T1 Downshift Control (Register 7.528)

Add subclause 45.2.7.28 with the following text.

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 0 = disabled	R/W
7. 528.0	Downshift enabled	1 = enabled 0 = disabled	R/W

4.3.2.1 Downshift Enabled

Setting bit 7. 528.0 enables or disables Downshift. This is recommended to be done when the link is down, or

auto-negotiation is disabled.

4.3.2.2 Upshift Enabled

Setting bit 7. 528.1 enables or disables Upshift. This is recommended to be done when the link is down, or auto-negotiation is disabled.

4.3.3 BASE-T1 Downshift Status (Register 7.529)

Add subclause 45.2.7.29 with the following text.

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

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

Bit(s)	Name	Description	R/W
7.529.2:15	Reserved	Value always 0	RO
7. 529.1	Upshift supported	1 = supported 0 = not supported	RO
7. 529.0	Downshift supported	1 = supported 0 = not supported	RO

4.3.3.1 Downshift Supported

Bit 7.529.0 reports whether Downshift is supported.

4.3.3.2 Upshift Supported

Bit 7.529.1 reports whether Upshift is supported.

4.3.4 BASE-T1 Downshift Parameters (Register 7.530)

Add subclause 45.2.7.30 with the following text.

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

4.3.4.1 Downshift Period

Setting 7.530.0:7 sets the period to evaluate the link failure count before triggering Downshift.

4.3.4.2 Downshift Threshold

Setting 7.530.8:15 sets the number of link failures within the trigger period before triggering Downshift.

4.3.5 BASE-T1 Downshift Restart Parameters (Register 7.531)

Add subclause 45.2.7.31 with the following text.

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

4.3.5.1 Restart Period

Setting 7.531.0:11 sets the period to evaluate before triggering Restart processing.

4.3.6 BASE-T1 Upshift Parameters (Register 7.532)

Add subclause 45.2.7.32 with the following text.

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

4.3.6.1 Upshift Period

Setting 7.532.0:11 sets the period to evaluate before triggering Upshift processing.

4.3.7 BASE-T1 Downshift Attempts (Register 7.533)

Add subclause 45.2.7.33 with the following text.

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

4.3.7.1 Downshift attempts

Bits 7.533.15:0 report the number of Downshift attempts since the last time Auto-Negotiation was enabled on the interface.

4.3.8 BASE-T1 Downshift Restarts (Register 7.534)

Add subclause 45.2.7.34 with the following text.

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

4.3.8.1 Downshift restarts

Bits 7.533.15:0 report the number of Downshift attempts since the last time Auto-Negotiation was enabled on the interface.

4.3.9 BASE-T1 Upshift Attempts (Register 7. 535)

Add subclause 45.2.7.35 with the following text.

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

4.3.9.1 Upshift attempts

Bits 7.535.15:0 report the number of Upshift attempts since the last time Auto-Negotiation was enabled on the interface.

4.4 Clause 30 Modifications

4.4.1 Table 30–1a—Capabilities

Insert the following row(s) to Table 30–1a—Capabilities in the "oAuto-Negotiation managed object class (30.6.1)" section after the row for aAutoNegReceivedSelectorAbility.

Name		Access	DTE	Reptr	MAU	AN package (mand.)	AN Downshift package (optional)
aAutoNegDownshiftSupported	ATTRIBUTE	GET					X
aAutoNegDownshiftAdminState	ATTRIBUTE	GET					X
aAutoNegUpshiftSupported	ATTRIBUTE	GET					X
aAutoNegUpshiftAdminState	ATTRIBUTE	GET					X
aAutoNegDownshiftThreshold	ATTRIBUTE	GET-SET					X
aAutoNegDownshiftPeriod	ATTRIBUTE	GET-SET					X
aAutoNegDownshiftRestartPeriod	ATTRIBUTE	GET-SET					X
aAutoNegUpshiftPeriod	ATTRIBUTE	GET-SET					X
aAutoNegDownshiftAttempts	ATTRIBUTE	GET					X
aAutoNegDownshiftRestarts	ATTRIBUTE	GET					X
aAutoNegUpshiftAttempts	ATTRIBUTE	GET					

Insert the following row(s) to Table 30–1a—Capabilities in the "oAuto-Negotiation managed object class (30.6.1)" section after the row for acAutoNegAdminControl.

Name		Access	DTE	Reptr	MAU	AN package (mand.)	AN Downshift package (optional)
aAutoNegDownshiftAdminControl	ACTION						X
aAutoNegUpshiftAdminControl	ACTION						X

4.4.2 Downshift attributes

Add the following after '30.6.1.1.10 aAutoNegReceivedSelectorAbility' and before '30.6.1.2 Auto-Negotiation actions'.

```
30.6.1.1.11 aAutoNegDownshiftSupported
      ATTRIBUTE

      APPROPRIATE SYNTAX:
            An ENUMERATED VALUE that has one of the following entries:
            true
            false

      BEHAVIOUR DEFINED AS:
            Reports if an interface supports Downshift.;

30.6.1.1.12 aAutoNegUpshiftSupported
      ATTRIBUTE

      APPROPRIATE SYNTAX:
            An ENUMERATED VALUE that has one of the following entries:
            true
            false

      BEHAVIOUR DEFINED AS:
            Reports if an interface supports Upshift.;

30.6.1.1.13 aAutoNegDownshiftThreshold
      ATTRIBUTE

      APPROPRIATE SYNTAX:
            INTEGER
      BEHAVIOUR DEFINED AS:
            The number of link failures within the trigger period that will
            trigger Downshift.

30.6.1.1.14 aAutoNegDownshiftPeriod
      ATTRIBUTE

      APPROPRIATE SYNTAX:
            INTEGER
      BEHAVIOUR DEFINED AS:
            The period used to evaluate the number of link failures to trigger
            Downshift.

30.6.1.1.15 aAutoNegDownshiftRestartPeriod
      ATTRIBUTE

      APPROPRIATE SYNTAX:
            INTEGER
```

BEHAVIOUR DEFINED AS:
The period used to evaluate triggering Downshift restart.

30.6.1.1.16 aAutoNegUpshiftPeriod
ATTRIBUTE

APPROPRIATE SYNTAX:
INTEGER
BEHAVIOUR DEFINED AS:
The period used to evaluate triggering Upshift.

30.6.1.1.17 aAutoNegDownshiftAttempts
ATTRIBUTE

APPROPRIATE SYNTAX:
INTEGER
BEHAVIOUR DEFINED AS:
The number of Downshift attempts on the interface.

30.6.1.1.18 aAutoNegDownshiftRestarts
ATTRIBUTE

APPROPRIATE SYNTAX:
INTEGER
BEHAVIOUR DEFINED AS:
The number of Downshift restarts on the interface.

30.6.1.1.19 aAutoNegUpshiftAttempts
ATTRIBUTE

APPROPRIATE SYNTAX:
INTEGER
BEHAVIOUR DEFINED AS:
The number of Upshift attempts on the interface.

4.4.3 Downshift actions

Add the following after 30.6.1.2.2 `acAutoNegAdminControl` and before 30.7 Management for Link Aggregation.

```
30.6.1.2.2 aAutoNegDownshiftAdminControl
     ATTRIBUTE

     APPROPRIATE SYNTAX:
          Same as aAutoNegDownshiftAdminState

     BEHAVIOUR DEFINED AS:
          This action is used to enable or disable Downshift.;

30.6.1.2.3 aAutoNegUpshiftAdminControl
     ATTRIBUTE

     APPROPRIATE SYNTAX:
          Same as aAutoNegUpshiftAdminState

     BEHAVIOUR DEFINED AS:
          This action is used to enable or disable Upshift.;
```

End of Document

Appendix Notes:

Current text bugs

- 30.6.1.1.7 aAutoNegReceivedTechnologyAbility
  - For Clause 98 Auto-Negotiation, this attribute maps to bits ***D10-D13 and*** D21-D47 of the last received link codeword Base Page (see 98.2.1.2).
    - Looks wrong, 98.2.1.2 says D[47:21] contains the Technology Ability Field.
    - D[11:10] contains capability bits to advertise capabilities not related to the PHY. C[1:0] is used to advertise pause capability. D[12] is the force MASTER-SLAVE bit (see 98.2.1.2.5). D[15:13] contains the RF, Ack, and NP bits. <snip> D[47:21] contains the Technology Ability Field.

98.5.1 State diagram variables

Why does the "A variable with "_[x]" appended" list include the 1Gps+ phys, but not the lower speed ones?

Notes: