10 Mb/s Single Twisted Pair Ethernet

10BASE-T1L Auto-Negotiation

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Timing Values

- The following table shows possible timer values for a 625 kBit/s communication (a bit time is t_{bit} = 1600 ns, the maximum link segment delay time is t_{dly} = 8834 ns, blue are the numbers, which have changed or are new compared to the D1.2 draft):

Timer	Min	Max	Unit	Remarks
blind_timer	17668	20868	ns	2 x t_{dly} → 2 x t_{dly} + 2 x t_{bit}
break_link_timer	205	215	ms	A 10BASE-T1L PHY tries for 200 ms ± 2 ms to recover the link before link_status = FAIL is set.
clock_detect_max_timer	1680	2000	ns	5 – 25 % more than time T2 (t_{bit})
clock_detect_min_timer	1200	1520	ns	5 – 25 % less than time T2 (t_{bit})
data_detect_max_timer	880	1200	ns	10 – 50 % more than time T3 (t_{bit} / 2)
data_detect_min_timer	400	720	ns	10 – 50 % less than time T3 (t_{bit} / 2)
interval_timer	799.96	800.04	ns	800 ns ± 0.005 % (t_{bit} / 2)
link_fail_inhibit_timer	3030	3090	ms	3060 ms ± 30 ms (3030 ms is the maximum time for link training of a 10BASE-T1L PHY)
page_test_max_timer	128000	131200	ns	80 t_{bit} → 82 t_{bit} (a nominal DME frame is 78 bit long)
receive_DME_timer	145668	148868	ns	page_test_max_timer + 2 x t_{dly}
rx_wait_timer	300	340	µs	Time after which at least a new DME frame has to be received before going into receive IDLE state (time to handle the half-duplex state diagram plus headroom).
silent_timer	20868	24068	ns	2 x t_{dly} + 2 x t_{bit} → 2 x t_{dly} + 4 x t_{bit}

- backoff_timer:

  if T[4] bit is 1 then the duration is set as (145668 ns to 148868 ns) + (random integer from 0 to 15) x (20868 ns to 24068 ns)

  (this is equal to: receive_DME_timer + (random integer from 0 to 15) x silent_timer)

  if T[4] bit is 0 then the duration is set as (156902 ns to 160102 ns) + (random integer from 0 to 15) x (20868 ns to 24068 ns)

  (this is equal to: receive_DME_timer + t_{dly} + 3 t_{bit} / 2 + (random integer from 0 to 15) x silent_timer)

Technology Ability Field

- Clause 98 auto-negotiation supports point-to-point link segments only, no mixing segments, thus there will be **no auto-negotiation for the mixing segment using multidrop PHYs**.

- Clause 98 auto-negotiation provides 27 bits (A0 to A26) within the Technology Ability Field.
- Currently bit A0 is reserved for a 100BASE-T1 PHY and bit A2 is reserved for a 1000BASE-T1 PHY.

- Additionally to these bits the following bits are intended to be defined for a 10BASE-T1L PHY:

Technology Ability Field Bit	Description
A4	10BASE-T1L PHY
A6	10BASE-T1S PHY
A22	Full Duplex Support (10BASE-T1S only): 0 = PHY does only support half-duplex operation 1 = PHY does support half-duplex and full-duplex operation
A24	Increased Transmit/Receive Level (10BASE-T1L, 10BASE-T1S): 0 = PHY only supports 1.0 V_{pp} (10BASE-T1L and 10BASE-T1S) 1 = PHY supports 2.4 V_{pp} (10BASE-T1L) / 2.0 V_{pp} (TBD) (10BASE-T1S)
A26	EEE advertising (10BASE-T1L, 10BASE-T1S): 0 = PHY has no EEE capability 1 = PHY has EEE capability

- Master/Slave relation ship can be decided identically to the existing Clause 98 auto-negotiation procedure.
- The selector field encoding can also be identical to the existing Clause 98 auto-negotiation.

10BASE-T1L Transmit Level Negotiation

- The default transmit/receive level of a 10BASE-T1L PHY is 1.0 V_{pp}:
  - All 10BASE-T1L PHYs shall support a transmit level of 1.0 V_{pp}.
  - All 10BASE-T1L PHYs shall support a receive level of 1.0 V_{pp}.

- For a 10BASE-T1L PHY a transmit level of 2.4 V_{pp} is optional.
- If a 10BASE-T1L PHY supports a transmit level of 2.4 V_{pp}, it also shall support a receive level of 2.4 V_{pp}.

- During auto-negotiation, only if both 10BASE-T1L PHYs connected to the link segment support a transmit/receive level of 2.4 V_{pp}, the resulting transmit level for both PHYs is set to 2.4 V_{pp}.
- In all other cases, the resulting transmit level for both PHYs is set to 1.0 V_{pp}.

Resulting Transmit Level	**Second PHY 1.0 V_{pp}**	**Second PHY 1.0 V_{pp} / 2.4 V_{pp}**
First PHY 1.0 V_{pp}	1.0 V_{pp}	1.0 V_{pp}
First PHY 1.0 V_{pp} / 2.4 V_{pp}	1.0 V_{pp}	2.4 V_{pp}

10BASE-T1S Transmit Level Negotiation

- The default transmit/receive level of a 10BASE-T1S PHY is 1.0 V_{pp}:
  - All 10BASE-T1S PHYs shall support a transmit level of 1.0 V_{pp}.
  - All 10BASE-T1S PHYs shall support a receive level of 1.0 V_{pp}.

- For a 10BASE-T1S PHY a transmit level of 2.0 V_{pp} (TBD) is optional.
- If a 10BASE-T1S PHY supports a transmit level of 2.0 V_{pp} (TBD), it also shall support a receive level of 2.0 V_{pp} (TBD).

- During auto-negotiation, only if both 10BASE-T1S PHYs connected to the link segment support a transmit/receive level of 2.0 V_{pp} (TBD), the resulting transmit level for both PHYs is set to 2.0 V_{pp} (TBD).
- In all other cases, the resulting transmit level for both PHYs is set to 1.0 V_{pp}.

Resulting Transmit Level	Second PHY 1.0 V_{pp}	Second PHY 1.0 V_{pp} / 2.0 V_{pp}
First PHY 1.0 V_{pp}	1.0 V_{pp}	1.0 V_{pp}
First PHY 1.0 V_{pp} / 2.4 V_{pp}	1.0 V_{pp}	2.0 V_{pp} (TBD)

10BASE-T1S Half-/Full-Duplex Negotiation

- The default (basic) mode for a 10BASE-T1S PHY is half-duplex:
  - All 10BASE-T1S PHYs shall support half-duplex transmitting.
  - All 10BASE-T1S PHYs shall support half-duplex receiving.

- For a 10BASE-T1S PHY full-duplex mode is optional.
- If a 10BASE-T1S PHY supports full-duplex transmitting, it shall also support full-duplex receiving.

- During auto-negotiation, only if both 10BASE-T1S PHYs support full-duplex mode, full-duplex transmission is activated.
- In all other cases, both PHYs operate in half-duplex mode.

Resulting Mode	Second PHY Half-Duplex	Second PHY Half-/Full-Duplex
First PHY Half-Duplex	Half-Duplex	Half-Duplex
First PHY Half-/Full-Duplex	Half-Duplex	Full-Duplex

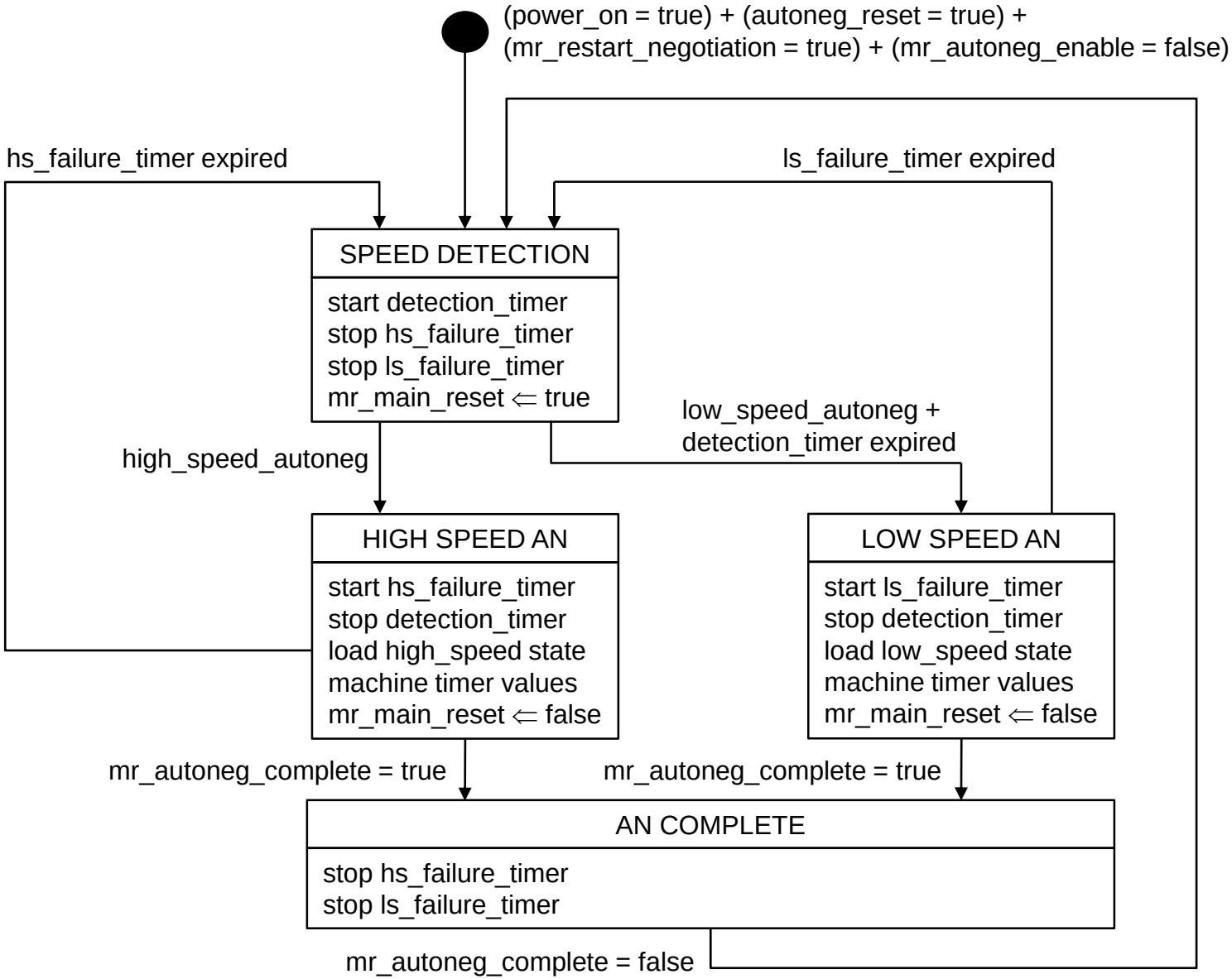
PHY Priority Resolution

- As Clause 98 only supports point-to-point link segments, auto-negotiation for mixing segments will not be supported.
- For a multi-protocol PHY the priority resolution is suggested to be (from highest priority to lowest priority):

  (1000BASE-T1L, potentially later PHY type)
  1000BASE-T1
  (100BASE-T1L, potentially later PHY type)
  100BASE-T1
  10BASE-T1L
  10BASE-T1S

- Using the above auto-negotiation priorities, higher communication speeds will be prioritized over lower communication speeds and long distance PHYs will be prioritized over short distance PHYs.
- The intention behind that is, that a long reach PHY will also support a short reach link segment, but not the other way round, thus providing a „higher“ ability and therefore leading to a higher priority.
- This priority resolution will work well, if later on 1000BASE-T1L and 100BASE-T1L PHY types are available or if a multi-type PHY IC only supports short reach or long reach PHY types, not both within the same PHY IC.
- If a PHY IC supports both, short and long reach PHY types and not all long reach PHY types are available, then negotiating to a higher speed short distance PHY type will not lead to a reliable link at longer links segments.
- Therefore building a multi-type PHY IC will rely on having an additional configuration option to directly set the PHY IC to the intended PHY type and only negotiate the remaining parameters (e.g. by adding an additional bit to the BASE-T1 PMA/PMD control register (1.2100) allowing to directly set the PHY type using the lower 4 bits, even if auto-negotiation is enabled).

Rate Adaption



Rate Adaption

- Modify state machine in figure 98-11 according to the previous slide, remove figure 98-12 (remove energy detection state as valid signals are detected by implementation of functions “high_speed_autoneg“ and “low_speed_autoneg“).
- Modify text in clause 98.5.6 for PHYs only supporting one auto-negotiation speed, to use the appropriate timer values and implement the auto-negotiation state machines according to figures 98-7, 98-8, 98-9 and 98-10 without any further change.

- Set auto-negotiation speed detection timer (detection_timer) value to 2.5 ms + random value between (0 to 15) * 0.5 ms.
- Set high speed auto-negotiation failure timer (hs_failure_timer) value to 200 ms ± 2 ms.
- Set low speed auto-negotiation failure timer (ls_failure_timer) value to 4000 ms ± 40 ms.

- Add additional reset signal (“autoneg_reset”), which is triggered by the management entity, if dual speed auto-negotiation is being used, to restart the auto-negotiation process as replacement signal for “mr_main_reset” of the state machines described in figures 98-7, 98-8, 98-9 and 98-10, as the signal “mr_main_reset” is triggered by the speed selection state machine in figure 98-11, when supporting two different auto-negotiation speeds.

- Describe the „load“ function in the state machine on the previous slide.

- Add the descriptions for the new relevant variables “power_on“, „mr_restart_negotiation“, „mr_autoneg_enable“, “mr_main_reset“, and “mr_autoneg_complete“.

Thank You