10 Mb/s Single Twisted Pair Ethernet

10BASE-T1L Transmit Amplitude (Comments #567, #671)

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- A 10BASE-T1L PHY supports two different operating modes:
  - 2.4 V_{pp} (optional) and
  - 1.0 V_{pp} (mandatory).

- Each PHY which is able to transmit in 2.4 V_{pp} operating mode must also be able to receive in 2.4 V_{pp} operating mode (even if there is only a short cable with no attenuation).

- The actual status of the 2.4 V_{pp} operating mode selection in Draft D2.0 is the following:

  - **Bit 1.2294.12 in 10BASE-T1L PMA control register is used to select the 2.4 V_{pp}** (if the bit is set to a one) **or 1.0 V_{pp} operating mode** (if the bit is set to a zero).
  - Annex 98B.3 (Auto-Negotiation) states that Bit A24 (in the base page) shall contain a one, if the PHY is supporting and advertising 2.4 V_{pp} operating mode. **If both PHYs then advertise the ability to support the 2.4 V_{pp} operating mode, then this mode shall be enabled for both PHYs and the bit in 1.2294.12 shall be set accordingly by the Auto-Negotiation implementation.**

- **As this behavior may lead to a higher energy consumption and RF radiation than needed, this presentation suggests another approach.**

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- There are different requirements for different applications:
  - For PHYs operating in environments with a relatively low noise environment, energy saving and reduction of RF interference may be the main goal.
  - For PHYs operating in more severe noise environments, a higher transmit level at the expense of spending more energy for the transmitter would be beneficial.
  - For PHYs which only support a limited signal amplitude, as it is the case e.g. in intrinsically safe applications, a limited transmit amplitude is required.

- To handle these different conditions the idea is to advertise two different pieces of information about the operating mode during Auto-Negotiation:
  - 2.4 V_{pp} mode is supported (bit A24, as it is currently in Draft D2.0).
  - 2.4 V_{pp} mode is preferred (additional bit (e.g. bit A25), which is advertised during Auto-Negotiation).

- Depending on how to handle the 2.4 V_{pp} preferred bit, there are two possible ideas:
  - **Option 1:** If at least one PHY sets the 2.4 V_{pp} mode preferred bit, then both PHYs switch to the 2.4 V_{pp} operating mode. This keeps both PHYs in sync related to the transmit amplitude.
  - **Option 2:** If one PHY sets the 2.4 V_{pp} mode preferred bit, then the only the remote PHY switches to the 2.4 V_{pp} operating mode. This allows to use different transmit amplitudes on both sides.

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- The following table gives an overview about how to handle the different application requirements for **Option 1** (the 2.4 V_{pp} mode preferred bit activates the 2.4 V_{pp} mode on both PHYs):

Application	AN Advertising	Result
Normal EMC environment, e.g. office/building **(default behavior)**	2.4 V_{pp} mode is supported: Yes (Master and Slave) 2.4 V_{pp} mode is preferred: No (Master and Slave)	Even if both PHYs support the 2.4 V_{pp} operating mode, **both PHYs start-up in 1.0 V_{pp} operating mode**; if during the training at **least one PHY detects, that it is running at a link with high insertion loss** (implementation specific), the **PHY may drop the link** and **Auto-Negotiation will restart the PHY**. In this case the management entity of the PHY **enables the "2.4 V_{pp} mode preferred bit"** and in the **next Auto-Negotiation attempt** then the link will come up **using the 2.4 V_{pp} operating mode**.
More severe EMC environment, long links, e.g. trunk in industrial applications	2.4 V_{pp} mode is supported: Yes (Master and Slave) 2.4 V_{pp} mode is preferred: Yes (Master or Slave)	If both PHYs support the 2.4 V_{pp} operating mode and at least one PHY prefers to run in 2.4 V_{pp} operating mode, then both **PHYs start-up in 2.4 V_{pp} operating mode and stay there**.
Limited signal amplitude, e.g. powered intrinsically safe applications, spurs in industrial applications	2.4 V_{pp} mode is supported: No (Master or Slave) 2.4 V_{pp} more is preferred: Not relevant.	If at least one PHY does not support the 2.4 V_{pp} mode, both **PHYs start-up in 1.0 V_{pp} operating mode and stay there**.

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- The following table gives an overview about how to handle the different application requirements for **Option 2** (the 2.4 V_{pp} mode preferred bit activates the 2.4 V_{pp} mode only on the remote PHY):

Application	AN Advertising	Result
Normal EMC environment, e.g. office/building **(default behavior)**	2.4 V_{pp} mode is supported: Yes (Master and Slave) 2.4 V_{pp} mode is preferred: No (Master and Slave)	**Both PHYs start-up in 1.0 V_{pp} operating mode**; if during the training a **PHY detects, that it is running at a link with high insertion loss**, the **PHY may drop the link** and **Auto-Negotiation will restart the PHY**. The management entity of the PHY **enables the "2.4 V_{pp} mode preferred bit"** and in the **next Auto-Negotiation attempt** the remote PHY will come up **using the 2.4 V_{pp} operating mode**.
Mixed operating mode	2.4 V_{pp} mode is supported: Yes (Master and Slave) 2.4 V_{pp} mode is preferred: Only one side (Master or Slave)	**The remote PHY** of the PHY having the 2.4 V_{pp} mode preferred bit set, **starts-up in 2.4 V_{pp} operating mode and stays there**. If this PHY detects during training, that the other PHY also needs to go into 2.4 V_{pp} operating mode, **it may drop the link, set the "2.4 V_{pp} mode preferred bit"** and **Auto-Negotiation will bring up the other PHY in 2.4 V_{pp} operating mode**.
More severe EMC environment, long links, e.g. trunk in industrial applications	2.4 V_{pp} mode is supported: Yes (Master and Slave) 2.4 V_{pp} mode is preferred: Yes (Master and Slave)	If both PHYs support the 2.4 V_{pp} operating mode and both PHYs prefer to run in 2.4 V_{pp} operating mode, then both **PHYs start-up in 2.4 V_{pp} operating mode and stay there**.
Limited signal amplitude, e.g. powered intrinsically safe applications, spurs in industrial applications	2.4 V_{pp} mode is supported: No (Master or Slave) 2.4 V_{pp} more is preferred: Not relevant.	If at least one PHY does not support the 2.4 V_{pp} mode, both **PHYs start-up in 1.0 V_{pp} operating mode and stay there**.

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- Adding an additional „2.4 V_{pp} operating mode preferred“ bit into the Clause 98 Auto-Negotiation Base Page (and also adding an associated bit in the 10BASE-T1L Configuration Register space) allows to better control the negotiation of the required transmit signal amplitude.
- The **suggested default setting**, which supports a start-up at a lower transmit amplitude, **will allow to conserve some energy and to reduce the RF emissions** for link segments, where a higher transmit amplitude is not necessary (which likely will be the case for most link segments), while providing a simple method of switching to a higher transmit amplitude, where it is required, e.g. if the insertion loss of the link segment is high.
- Having the **possibility to prefer the 2.4 V_{pp} operating mode**, **supports applications**, where a higher transmit amplitude is desired, e.g. if there is a **more severe noise environment**, even if the link segment length does not extend to the maximum reach.
- Having the ability to tell the remote PHY, that the local PHY does **only support a 1.0 V_{pp} operating mode**, allows also the **use of a universal PHY in intrinsically safe applications**, where the transmit amplitude has to be limited.
- Two different options exist, on how to set the operational mode of the PHY, depending on the 2.4 V_{pp} mode preferred bit. **A decision by the task force is required, which option to use.**

Thank You