Thoughts on Modified Clause 73 Auto-Negotiation for 1000BASE-T1

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OVERVIEW

- **Auto-negotiation should be defined for 1000BASE-T1 to provide**
  - PHY synchronization before training and
  - Capability of configuration information exchange
- **Clause 73 is a good starting point**
- **Some modification of Clause 73 is needed to operate over a single pair**
- **However, we have some concerns about details in Lo3pb_04_0314**

CONSTRAINTS

- **Start up time <100 ms**
  - Should allow for a repeat of failed start-up
  - Minimize autonegotiation portion of this time
- **Noise environment**
  - Auto-negotiation should be designed for robust operation in the automotive noise environment
  - Work without bypassing receive filters

DME PAGE SIGNALING

- **Should allow for transients during transition from silence to transmit**
  - Rather than transitioning directly from silence to page start delimiter, start with a short preamble of several clock transitions followed by start delimiter.
- **Define silence – e.g. amplitude less than +/-50 mV**
- **DME data rate**
  - 40 ns – 160 ns pulse widths yield a DME bandwidth of 3 to 13 MHz which is below the receive high pass filter cut-off.
  - Instead use 10 ns symbol rate
    - Manchester bit = 20 ns
    - Manchester violation width = 30 ns
  - Transitions separated by 3 symbols instead of 4 are still a Manchester violation and reduce bandwidth of the signal.

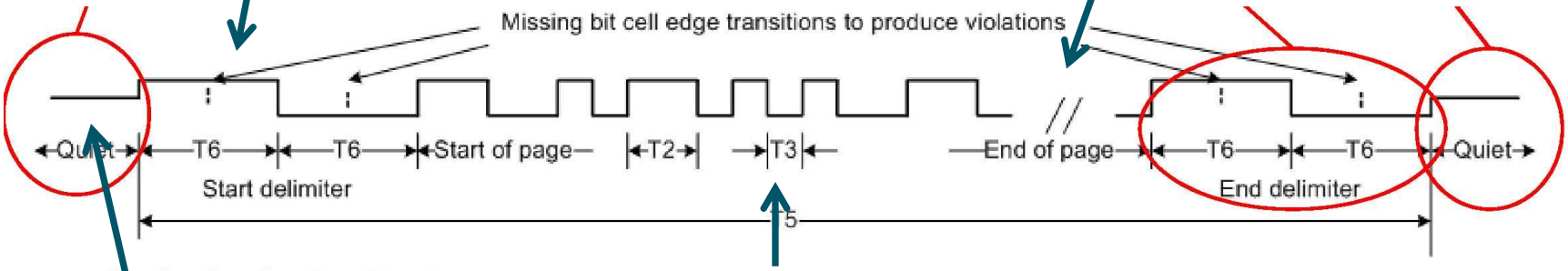
Fast and Robust in presence of burst noise

- **Add a short CRC to the page between the end of page and the random bit**
  - Propose an 8-bit CRC
- **Adapt ability_match and acknowlege_match to require reception of a single page with correct CRC instead of 3 matching pages**
  - If adopted, consider reducing remaining_ack_cnt values for done
- **Consider sending two or three copies of a page per transmission rather than one.**
  - The idea is to minimize the time spent in hand-over when sometimes a page needs to be transmitted more than once.
  - If only one page is needed for match and error rate is low, this won't be needed.

SUMMARY OF DME PAGE SUGGESTIONS

Use 3 * T3 for
Manchester violations

Add 8-bit CRC for validation
Instead of matching repeated pages



T3 = 10 ns nominal

Define Silence and add short preamble

Send 2 or 3 copies of page per transmission?

Arbitration State Machine

- **Suggest leaving open the decision on whether to remove Parallel Detect states**
  - 1 Twisted Pair 100 Mb/s Study Group is operating
  - If a 100 Mb/s project is authorized, it may be desirable to allow parallel detect for 100 Mb/s
- **We agree that all 1000BASE-T1 devices should support Autonegotiation and there is no need to Parallel Detect 1000BASE-T1**

Transmit State Machine

- **To transmit multiple pages per turn**
  - Add a variable to count pages transmitted per current turn
  - Initialize the variable in WAIT 1 and WAIT 2
  - Increment the variable in TRANSMIT DELIMITER TAIL
  - Enter TRANSMIT DELIMITER HEAD instead of WAIT 1 if there are more pages to send this turn
  - Enter TRANSMIT COUNT ACK instead of WAIT 2 if there are more pages to send this turn.

Receive State Machine

- **The current state machine doesn't use the first page received other than doing some correctness tests on it**
  - It tests that there are two Manchester violation delimiters separated by about the right length of time with only pulses in the right length range between them.
  - There is no reason to discard the data from the first page especially if it is validated by a CRC
  - Using the first page shortens negotiation time
  - Consider eliminating DELIMITER DETECT state or replacing it with a set of states like DME CLOCK, DME DATA 0 and DME DATA 1 that collect the data while verifying pulse lengths, page length and CRC
- **To allow multiple pages to be received per turn:**
  - Transitions that currently enter DELIMITER WAIT should enter DME CAPTURE
  - Transition from DME CLOCK to DELIMITER WAIT on detecting silence

Half-Duplex State Machine

- The state machine transitions from RECEIVE WAIT to RECEIVE ACTIVE and from RECEIVE ACTIVE to SILENT based on receive_DME_active = true and receive_DME_active = false, respectively.
- The change of receive_DME_active is based on just detecting a Manchester Violation.
- This seems fragile on a potentially noisy channel
- An error could mean that signal separation may need to be repeated.
- Consider a more robust detection such as testing for Silence before transition to Silent.

DME Page Formating

- **Should Pause be prohibited or discouraged for this environment?**
  - PAUSE isn't used much now
  - PFC uses LLDP to negotiate
- **If Pause is retained, it only needs two bits. No need to reserve a third bit as part of a special C field now.**
- **Add a configured non-random MSB to the Nonce set to 1 for a device that prefers to be Master and set to 0 for a device that prefers to be slave.**
  - Allows Master/Slave to be configured by a compare without other fields
  - Consider deleting F bits.
- **Make all unused bits reserved for future flexibility**

Optional Enhancement of Nonce

- **Inverting the top bit throws away a bit of randomization. Better to randomly select all bits.**

Electrical Interface

- **For noise immunity may also need a squelch.**
- **Don’t bypass the chip receive filtering**
  - Choose a Baud rate that keeps the signal in band
  - Better noise immunity

Conclusion

- **An autonegotiation mechanism will be useful for 1000BASE-T1**
- **Clause 73 provides a good starting point**
- **Some further work should be done to ensure a robust, fast negotiation protocol for use on the 1000BASE-T1 channel.**
  - The changes to the state machine to adapt to single pair are not insignificant and negotiation bugs can cause persistent link failure.
  - The new state machines should be validated with simulations
- **The biggest constraint/unknown is "Being able to autonegotiate within one millisecond" under noise conditions.**
  - Analysis should be done to determine whether it will be more efficient to send a page once per turn or multiple times per turn given the potential page error rate during autonegotiation