1000BASE-T1 PHY Synchronization Method & Start-up Process and Link Failure Case Analysis

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Peiqing Wang & Mehmet Tazebay

Broadcom Corporation

Contributors

Ahmad Chini, Broadcom

Mehmet Tazebay, Broadcom

Mike Tu, Broadcom

Peiqing Wang, Broadcom

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Overview

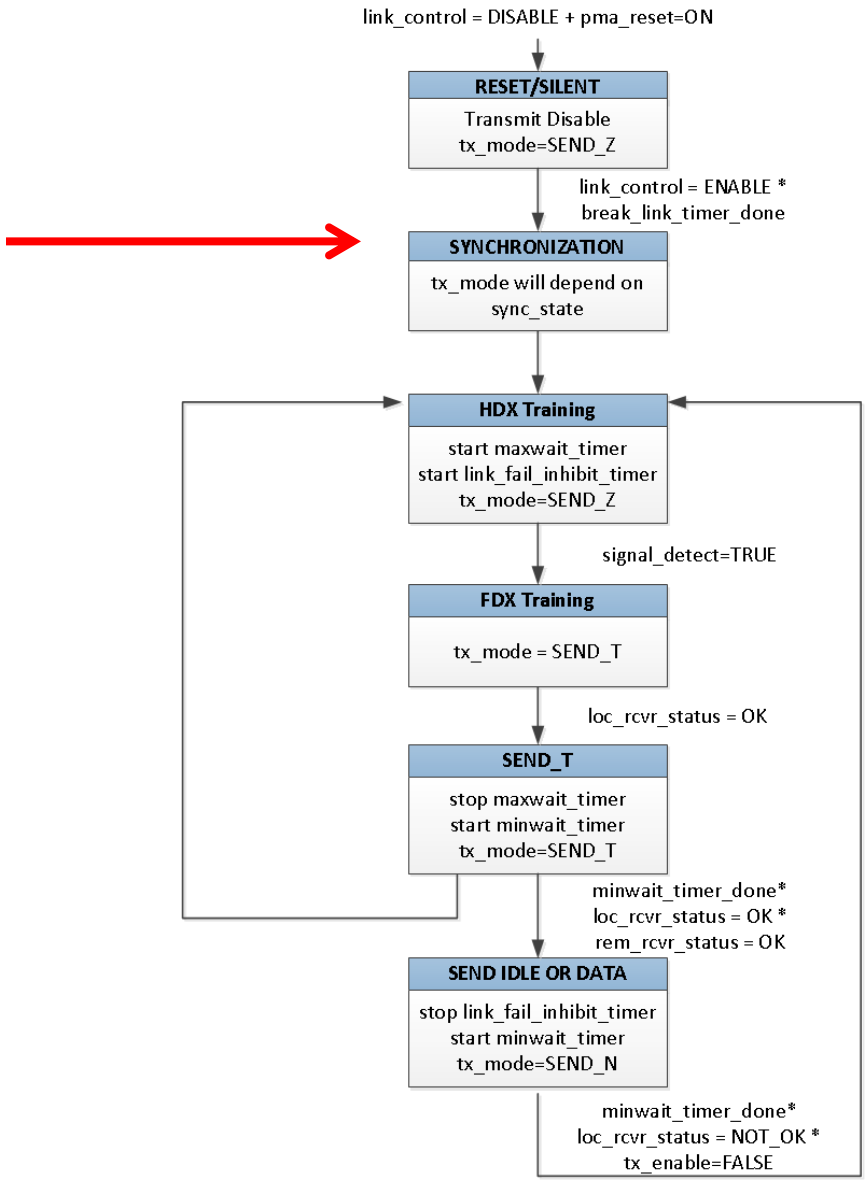
- Clause 28 & Clause 73 Auto-Negotiation schemes provide a synchronization and capability exchange mechanism for 802.3 PHYs.
- Both Clause 28 and Clause 73 are proven to be robust for multi-pair / multi-speed PHYs.
- An optional AN scheme (based on Clause 73) is being considered for 1000BASE-T1 and 1TPCE.
- However, a robust independent synchronization method and a start-up process is necessary as
  - We need to prove that the modifications to Clause-73 state machines will work which requires effort & time.
  - AN will be bypassed for certain use-cases and a forced-mode will be applied.
  - When the link partners are pre-configured (Master/Slave, etc.) then, there is no need for AN overhead
- When Master and Slave is pre-determined then, a fast and robust synchronization method can be attained for 1-pair PHYs in the forced mode.
- In this contribution, a method for PHY synchronization and a robust start-up process will be proposed for the forced mode and various corner cases for link failure will be discussed.

Synchronization & Start-up Concept

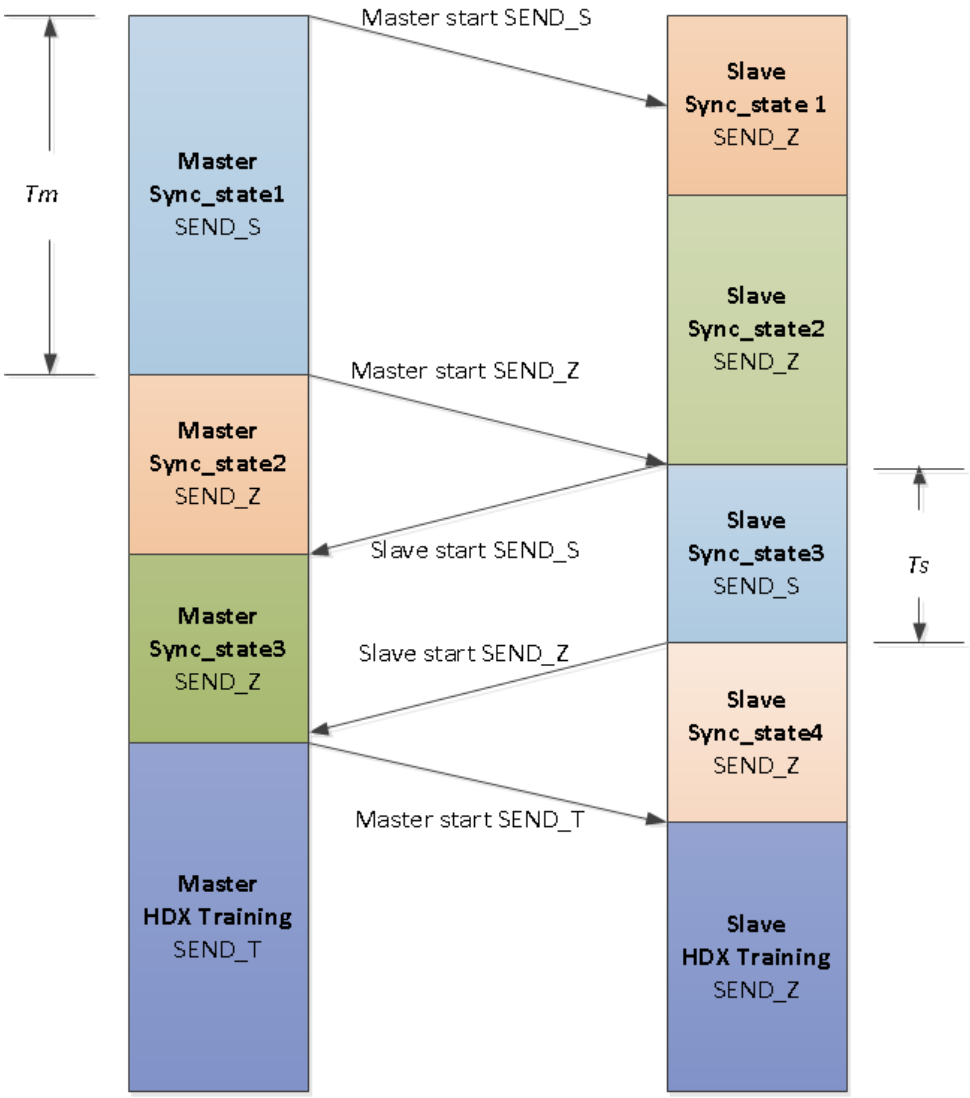
- AN state machine provides synchronization between Master and Slave PHYs
- AN state machine is coupled to both link monitor and PHY control state machines
- AN state machine also provides the following timers to support a robust start-up process
  - ***link_fail_inhibit_timer***
  - ***break_link_timer***
- A fast & robust synchronization mechanism (wo/capability exchange) can provide the same functionality for 1-pair PHYs in the forced mode
- A robust start-up process must handle two link failure exceptions:
  - link failure during start-up
  - link drop after the initial link is established
- In order to provide the robust start up and handle the two failure cases, we need to specify how to start, stop and reset the following two timers in the forced mode
  - ***link_fail_inhibit_timer***
  - ***maxwait_timer*** (used by link monitor)
- Synchronization of these timers between Master and Slave need to be ensured in order to have a robust start-up process

PHY Control State Machine

- Synchronization will be established in the PHY Control state machine by adding a new state before the HDX Training
- When the ***break_link_timer*** is expired in the Transmit Disable state, the PHY will go to this new synchronization state



Synchronization Method

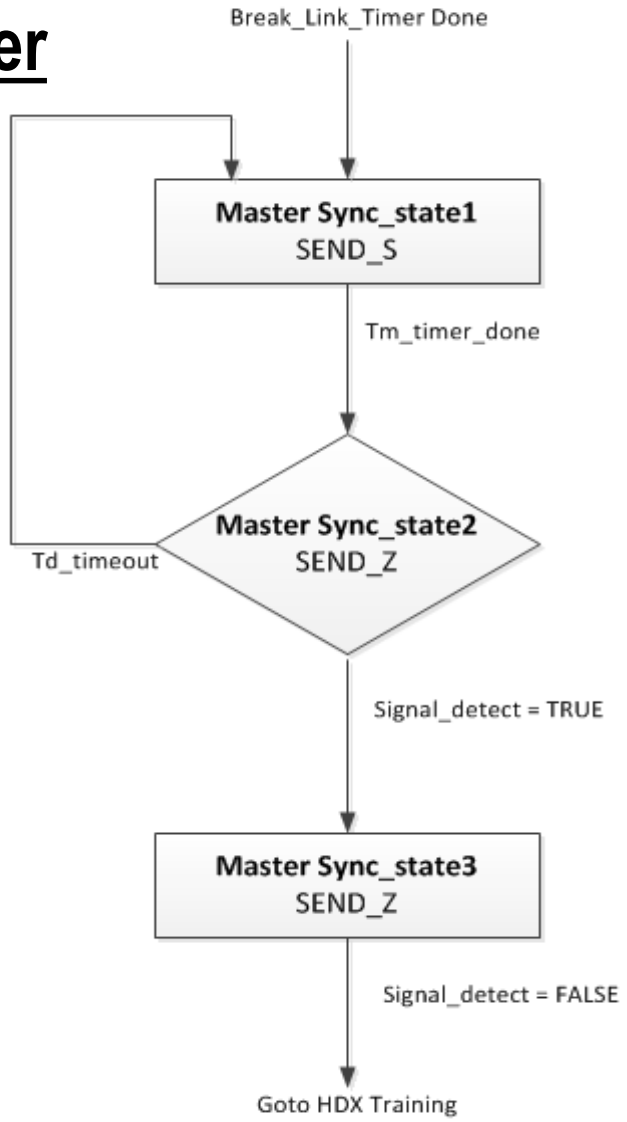


(*Tm*, *Ts* are within a few us)

Synchronization State Machines

- In **sync_state1,** Master sends SEND_S for ***Tm*** duration then, it will go to **sync_state2**
- In **sync_state2,** if Master detects the signal energy before ***Td*** times out , it will go to **sync_state3**. Otherwise, it will go back to **sync_state1** and starts SEND_S again
- In **sync_state3**, after Master detects SEND_Z from Slave then, it will finish its synchronization and go to HDX training.

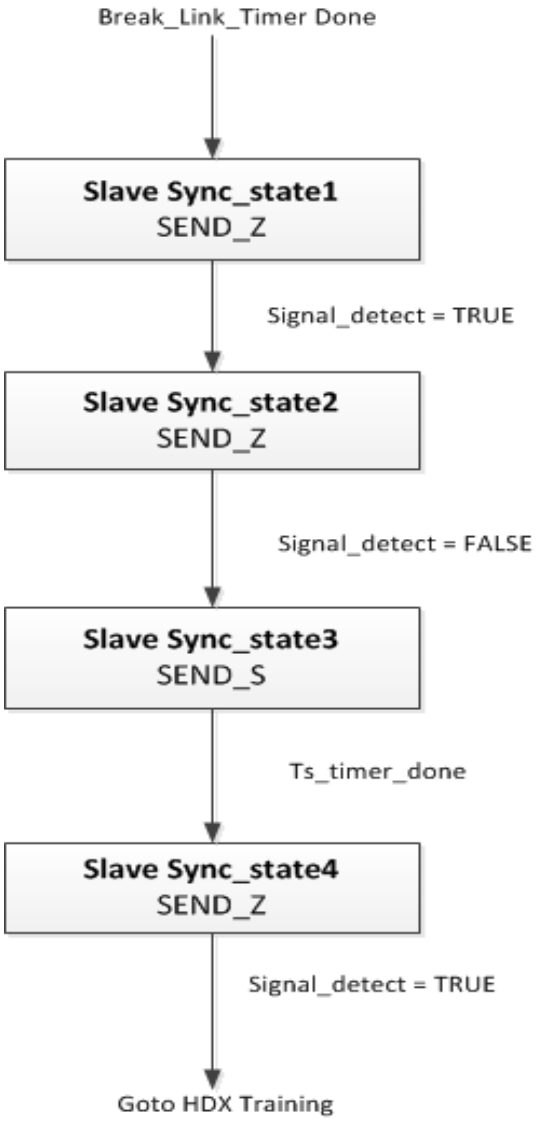
Master



Synchronization State Machines (cntd.)

- In **sync_state1 ,** after Slave detects the signal energy from the Master then, it will go to **sync_state2**
- In **sync_state2 ,** after the Slave detects SEND_Z from the Master, it will go to **sync_state3**
- In **sync_state3**, Slave will SEND_S for *Ts* duration and then, it will go to **sync_state4**
- In **sync_state4**, after the Slave detects the signal energy from the Master, it will finish its synchronization and go to HDX training

Slave



Link Failure Case Analysis

Link Failure Case Analysis

- **Case Study #1: Slave can not link up before its link_fail_inhibit_timer expires**
  - Slave PHY Control will be forced to go back to Transmit Disable state
  - Slave stays there until its ***break_link_timer*** expires.
  - Before Slave's ***break_link_timer*** expires, Master ***link_fail_inhibit_timer*** should also expire
  - While Master still stay in its Transmit Disable state and wait for its ***break_link_timer*** expire, Slave is already in the **sync_state1** of the PHY Control Synchronization main state and wait for signal energy detect
  - After Master ***break_link_timer*** expires, it will go to **sync_state1** and start SEND_S.
  - Once the synchronization process is completed between Master and Slave, the HDX training will start over.

Link Failure Case Analysis

- **Case Study #2: Master can not link up before its link_fail_inhibit_timer expires**
  - Master PHY Control will be forced to go back to Transmit Disable state first
  - Master stay there until its ***break_link_timer*** expires.
  - Before Master's ***break_link_timer*** expires, Slave ***link_fail_inhibit_timer*** should also expire
  - While Slave still stay in its Transmit Disable state and wait for its ***break_link_timer*** expire, Master is already in the **sync_state1** of the PHY Control Synchronization main state and will start SEND_S
  - It is possible that Slave is still in Transmit Disable state before Master finish SEND_S and go to **sync_state2**
  - In this case, Master will time out in **sync_state2** and go back to **sync_state1** again
  - Once Slave go to its **sync_state1**, it will detect the signal energy when Master is in **sync_state1** and SEND_S, then the synchronization process will continue
  - After synchronization is completed, both Master and Slave will start the HDX training again

Definitions & Preliminary Timer Values

TX Mode	Definition
SEND_Z	Send all zeros
SEND_S	Send special periodic PAM2 sequences with good correlation properties
SEND_T	Send PAM2 training sequence

Timer	PHY Mode	Proposed Range
link_fail_inhibit_timer	Master & Slave	200ms +/- 2ms
break_link_timer	Master & Slave	5ms +/- 50us
maxwait_timer	Master	1406ms +/- 18ms
	Slave	656ms +/- 9ms
Tm	Master SEND_S time	2us
Ts	Slave SEND_S time	2us
Td	Master Detection time	2us

Conclusions

- The ***link_fail_inhibit_timer*** and ***break_link_timer*** are required for a robust start-up process during link up
- When AN is bypassed, a synchronization method is needed between Master and Slave in order to support both ***link_fail_inhibit_timer*** and ***maxwait_timer***
- Based on signal detection, a fast and robust synchronization method is proposed
- New PHY Control state diagrams are proposed to support the new synchronization method and the link timers

Thank you for your attention!

Questions?