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10BASE-T1S Autoneg and Link Status Indication

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- 10BASE-T1S defines support for Clause 98 Auto-Negotiation (AN)
  - Defined for Point-To-Point, both Full-Duplex (FD) and Half-Duplex (HD)
  - Not defined for HD multidrop operation
- Clause 98 Auto-Negotiation does not handle the case where one PHY supports AN and the other PHY does not
  - In this scenario the link-up just doesn't happen, AN is stuck
- AN requires a link status indication to work properly
  - 10BASE-T1S in current draft has no such concept of link status (see comment #204 from Steffen Graber)
    - There is no training phase and no continuous IDLE indication on the line
  - Wee need to design something ad-hoc to satisfy this requirement

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- The idea is to add an heartbeat (HB) concept to 10BASE-T1S to generate link status indication.
  - No need for HB in multidrop mode or when AN is not supported or not enabled

- Requirements:
  - Reception of HB indicates the link is up
  - Missing HB / packets for a certain amount of time results in reporting the link to be down
  - HB should not affect existing traffic in normal operation
  - HB should not affect PLCA when operating in P2P HD mode

- Not interfering with TX from MII
  - Re-use of PCS TX COMMAND state to send HB on the line, giving precedence to MII (including PLCA commands)

Figure 147-4 PCS Transmit state diagram (1 of 2)
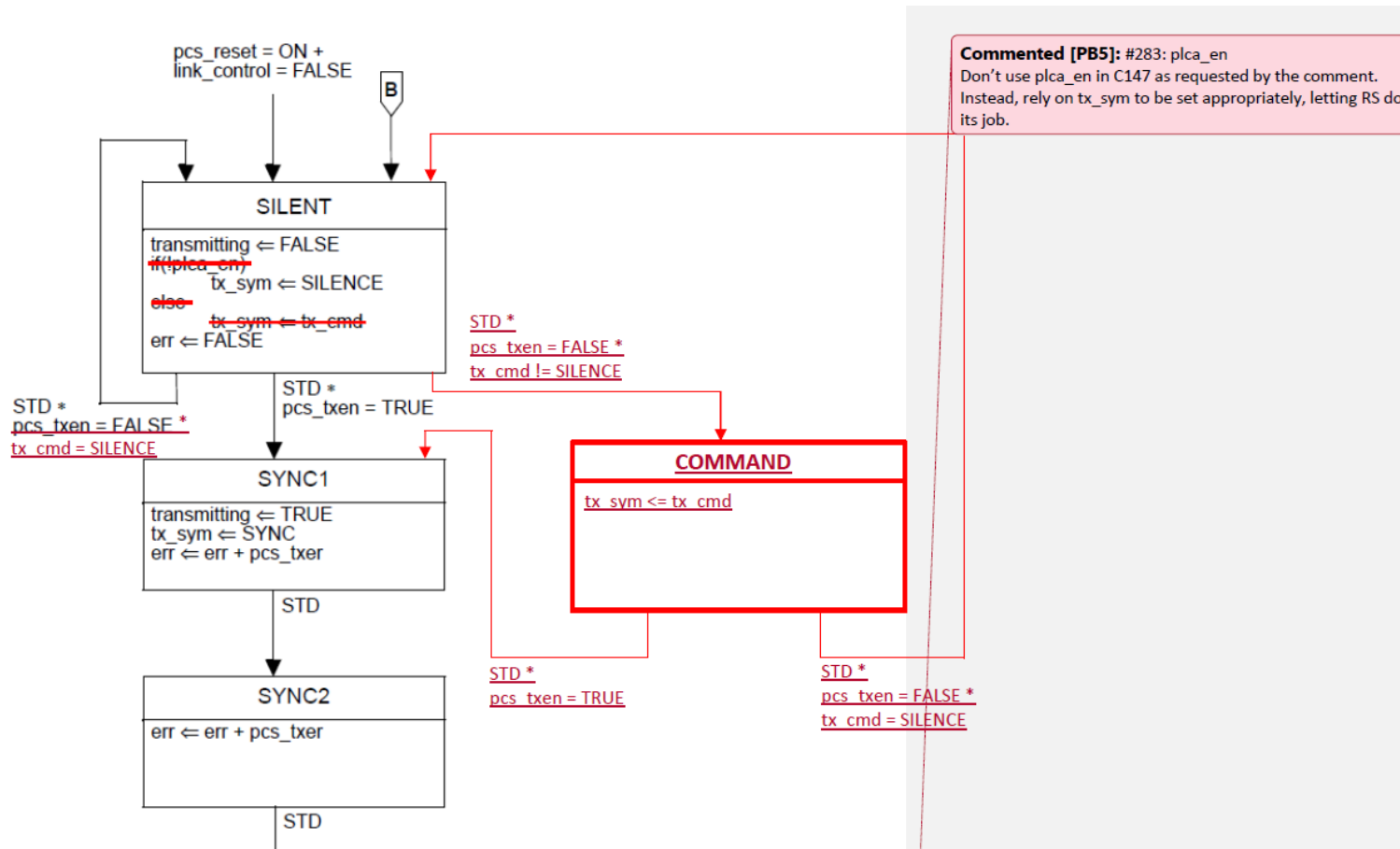
HEART BEAT is a new defined 5B symbol (TBD)

It is transmitted by PCS TX, using the already available tx_cmd variable.

tx_cmd shall be assigned to hb_cmd in the case there is no signaling from PLCA (i.e. PLCA takes precedence).
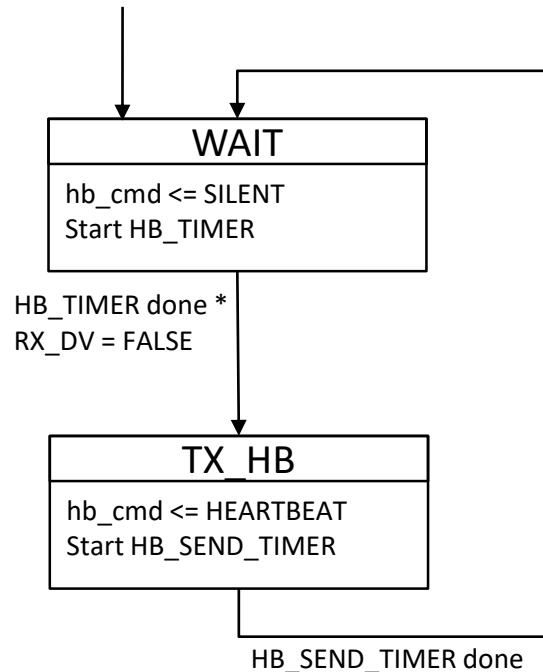
- **Half-Duplex P2P case**
  - Possible collisions between HB and data packets
    - Data will be re-transmitted by MAC (normal CSMA/CD behavior)
    - HB sent with random period to statistically avoid collisions
- **Half-Duplex P2P with PLCA enabled**
  - HB should not trigger physical collisions when PLCA is enabled
  - Turn-off HB when PLCA is enabled, rely on BEACON instead
  - Special case: PLCA leader (local_nodeID = 0) is the one generating BEACON, thus it can't detect other PHY presence.
    - In this case we can just reset link status when AN data is received

Heart Beat Transmission

pcs_reset = ON +
mask_hb = TRUE +
Auto-Negotiation_enable = 0 +
Auto-Negotiation complete = 0

WAIT

hb_cmd <= SILENT
Start HB_TIMER

HB_TIMER done *
RX_DV = FALSE

TX_HB

hb_cmd <= HEARTBEAT
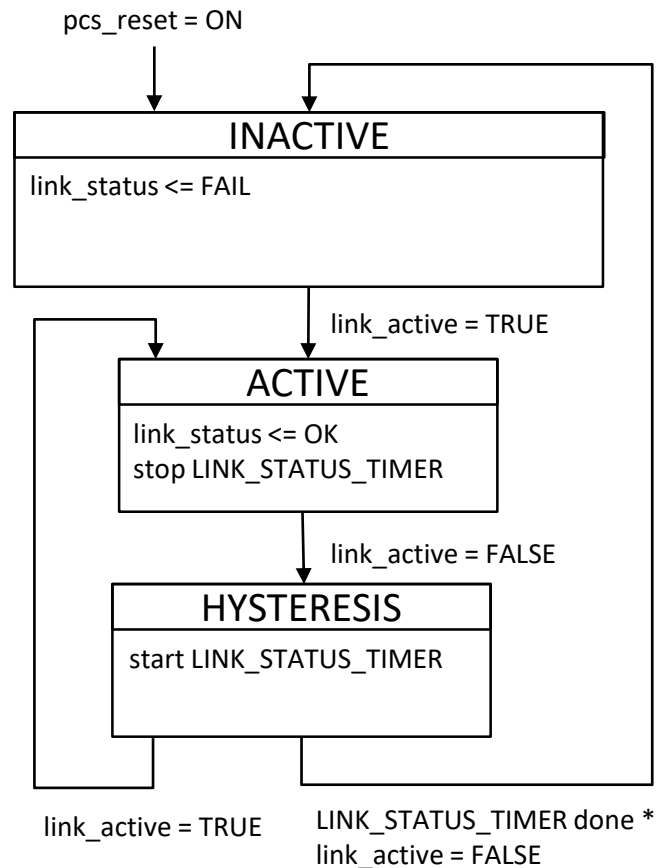Start HB_SEND_TIMER

HB_SEND_TIMER done

HB_TIMER is a timer
with random duration

- FSM to generate the HB periodically
  - Disabled when PCS is in reset or AN is either not supported or disabled
- HB_TIMER represents the period of the HB.
  - This should be a fixed value plus a random part in order to statistically avoid collisions when operating in HD mode, just like AN does.
    Proposal: 50 + random(0, 100) ms
- HB_SEND_TIMER this times the duration of the HB signaling on the line
  Proposal: 20 bit times

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Heart Beat Reception

pcs_reset = ON

```
        INACTIVE
  link_status <= FAIL
```

link_active = TRUE

```
        ACTIVE
  link_status <= OK
  stop LINK_STATUS_TIMER
```

link_active = FALSE

```
        HYSTERESIS
  start LINK_STATUS_TIMER
```

link_active = TRUE   LINK_STATUS_TIMER done *
                            link_active = FALSE
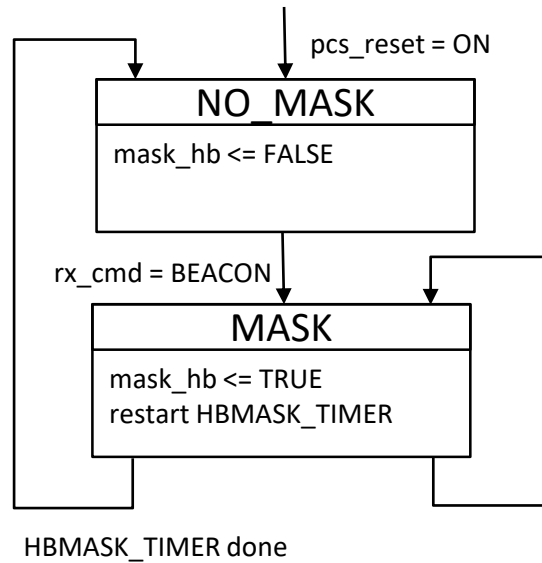
link_active = TRUE if RXDV = TRUE
              TRUE if mask_hb = TRUE
              TRUE if rx_cmd = HEARTBEAT
              FALSE else

- **FSM to generate link status**
  - Link status is reported as FAIL at reset
  - Link status is OK when either valid data or HB is received or when PLCA is running
  - Link status is reported as FAIL after LINK_STATUS_TIMER expires and no data / PLCA commands are received
  - LINK_STATUS_TIMER duration TBD

Heart Beat Mask

pcs_reset = ON

NO_MASK

mask_hb <= FALSE

rx_cmd = BEACON

MASK

mask_hb <= TRUE
restart HBMASK_TIMER

HBMASK_TIMER done

Mask Heart Beat
transmission when
receiving a BEACON

- FSM to prevent HB transmission when PLCA is enabled
  - Mask is reset at PCS reset
  - Enabled when BEACON is detected
  - Reset after HBASK_TIMER if no BEACON is received
  - HBASK_TIMER duration TBD

THANK YOU!