Consideration on multidrop powering over data-pair and non-data-pair

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Multidrop powering proposals @data-pair

So far, we have the following SPMD power supply related proposals:

- **stewart_01_0720**: Propose a simple vote to determine if PDs of various “types” are present
- **cjones_01_082620v1, cjones_01_092320**: Propose a power up and PD removal scheme for SPMD
- **paul_01_da_120220, Paul_01_da_121620**: Give analysis of power coupling inductance and droop
- **paul_01a_da_012721**: Propose to use ‘Tokens’ to decide power classes
- **paul_01_da_022421**: Give analysis of PSE power output
- **paul_01_da_051921**: Give analysis of startup sequence
- **cjones_01_052621**: Give further discussions of proposed SPMD power up procedure
- **Paul_da_082521**: Give analysis of power coupling networks Cnode
- **paul_01_da_09142022**: Provide basic parameter estimations for power development
Review of the power solution decision tree

Power Solution - (Already down to one branch, details needed)

- Minimal Data-Pair Power + Non-Data-Pair Power
  - Next step – need presentations on detail
  - How much power on data pair – need proposals
    - Feasibility (Economic & Technical) - Analysis on circuits, e.g., inductor sizing
    - How much power per node (data and non-data)… need proposal and how to specify
    - Architecture (and how it impacts power delivery)
      - What might be on the wiring side of the isolation barrier
      - How does a node connect into the mixing segment (tapped, in-and-out, ?)
      - Is non-data-pair power pt-to-pt or multidrop? Does that impact control
  - Power control & management
    - Needs proposal on power management TLVs/hooks
    - Minimal control vs. envisioning many possibilities
    - Process may benefit from having strawman ‘defaults’ on some of these which are more easily achieved… (for discussion)

How to achieve multidrop power supply over both pairs?
For 4-pair PoE:
- PD detection is done via detecting voltage sent by PSE and current returned from PD.
- After validated detection, classification is done via classifying voltage sent by PSE and current responded from the connected PD.
- Also, PD classification can be optionally achieved by LLDP.

For single-pair PoE: PoDL
- PSE checks for a ~4V zener with a ~10mA test current for PD detection.
- After validated detection, PD classification is done using Serial Communication Classification Protocol (SCCP).

For SPMD:
- Can we **detect and classify PDs** by using the **classical voltage-current loop**?
- The difficulty is: all nodes share the medium, thus the returned current triggered by PSE detecting voltage from different PDs may be **mixed up**.
Previous discussion on multidrop powering procedure

PSE does not provide power until at least one PD is detected

PSE turns on with limited power

PDs are powered up in low power mode

Negotiate power by LLDP

No PD detection for high power supply

PDs get extra power after negotiation

If not, stay in low power mode

PSE adjusts supplied power after LLDP negotiation

PSE power budget is retrieved when PD removal is detected (e.g. by LLDP)
Assumptions of SPMD over both pairs

- Power over data power is only to power up the PHY and MCU w/o power management.
- Power management is for non-data pairs (extra power).
- Repeaters are not considered here.
Key points:

- PSE provides limited power for PHY and MCU through the **data-pair** (at least one PD is detected, then apply power);
- PHY and MCU is activated and work;
- Then, a polling-detection mechanism can be run to provide extra power over non-data pair:
  - Master (node with PSE) sends beacon over **data-pair** to start the detection cycle;
  - Paths of non-data pairs between the Master and all other nodes should be disconnected.
  - Then, a node transmits signal (e.g. predefined pattern) over the data-pair to claim its detection slot;
    - Transmit timeslot is determined by each node’s ID and counter (by PLCA mechanism)
  - Meanwhile, the **non-data pair** path between the node and the master is connected (which is controlled by its MCU through a simple switch).
Key points: (Cont.)

- In the detection slot, PSE sends detecting voltage through **non-data pairs** and receives response current from the connected PD.
- With this, PD detection can be done one-by-one through L1 method similar to what we have done before.
- Moreover, the PD classification can be done right after the detection or in another PLCA cycle.
- Alternatively, it can be just left to upper layer protocol (like LLDP).
Some Benefits of this Layer 1 detection

- PSE is able to determine whether the connected node is a legal PD before applying higher power which might cause damage.
- With L1 detection design, we can provide short-circuit isolation instead of shut down the entire link when some PD is short.
With a switch in PD node:

• MCU controls the switch to connect power input to the PD load after passing detection & classification;

• If PD short-circuit occurs, the switch can be automatically disconnected based on $V_{out}$;

• The fault node can be isolated from other nodes being protected from shutting down;
  - The switch can be implemented by a MOSFET or triode;
  - The short-circuit detecting & isolating circuit can be realized by simple analog components such as diode, triode...

• After short-circuit is fixed, MCU can connect the PD again (automatically or artificially) to the non-data pair.
  - MCU and PHY gets power from the separate data-pair.
The updated multidrop powering procedure

PSE does not apply voltage until at least one PD is detected (coarse test via data-pair)

PSE turns on with limited power

PDs get low power through data pairs for PHY and MCU

Run polling detection (fine test via non-data pair)

If not, stay in low power mode

Run polling classification or LLDP(optional) after granted by detection

If not, stay in low power mode

PDs get extra power after granted by classification

PSE adjusts output after classification

Ensure a valid PD for high power

PSE power budget is retrieved when PD removal is detected.

PD load is cut off when short-circuit is detected

One-by-one protection
Summary

- A SPMD power solution over data-pair and non-data-pair is proposed for discussion.
- PHY and MCU on a node can get basic power from data pair.
- Node can get extra power from non-data pair.
- PD detection & classification (optional) can do one-by-one L1 detection with assistance of PLCA.
- Fault PD on non-data pair can be isolated to protect the entire system from shutting down
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