Fair and “Balanced”…

IEEE 802.3at
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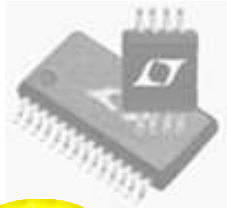
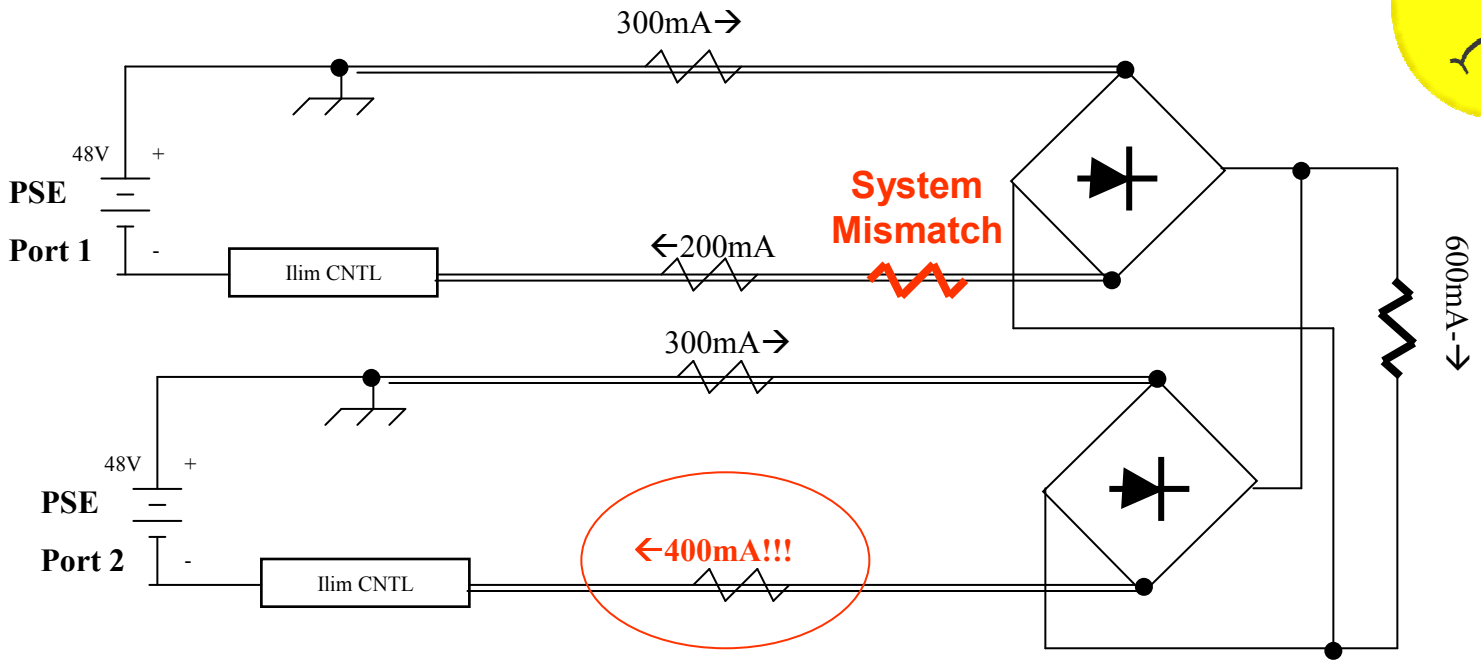
Clay Stanford
Linear Technology

LINEAR TECHNOLOGY

CURRENT MISMATCH IN 4-PAIR SYSTEM



4P system showing current mismatch problem.

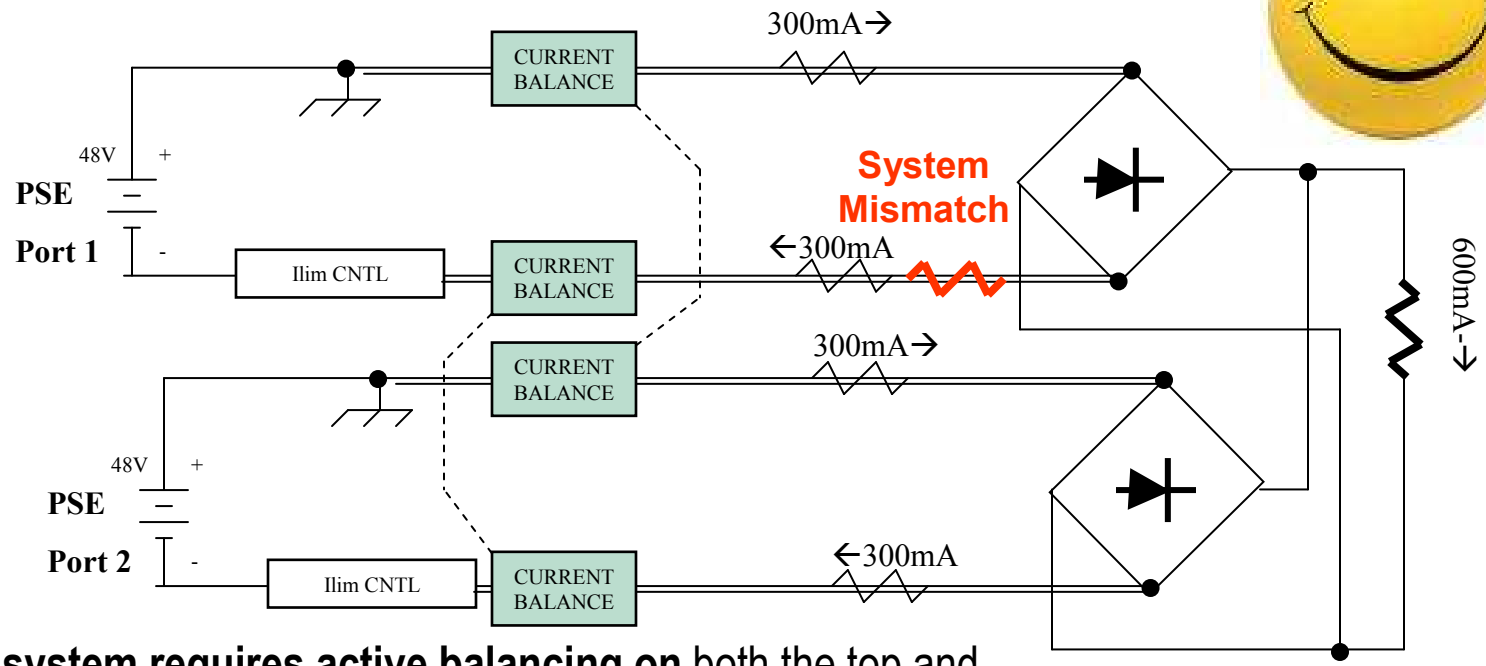


- Loop Resistance is <1Ω in short cable installations
- System mismatch occurs from connector contacts, cable R, diode mismatch and PSE voltage differences
- Mismatch on the order of .25V or .25Ω can throw one port into current limit and shutdown system

LINEAR TECHNOLOGY

ACTIVE CURRENT BALANCING SOLVES PROBLEM

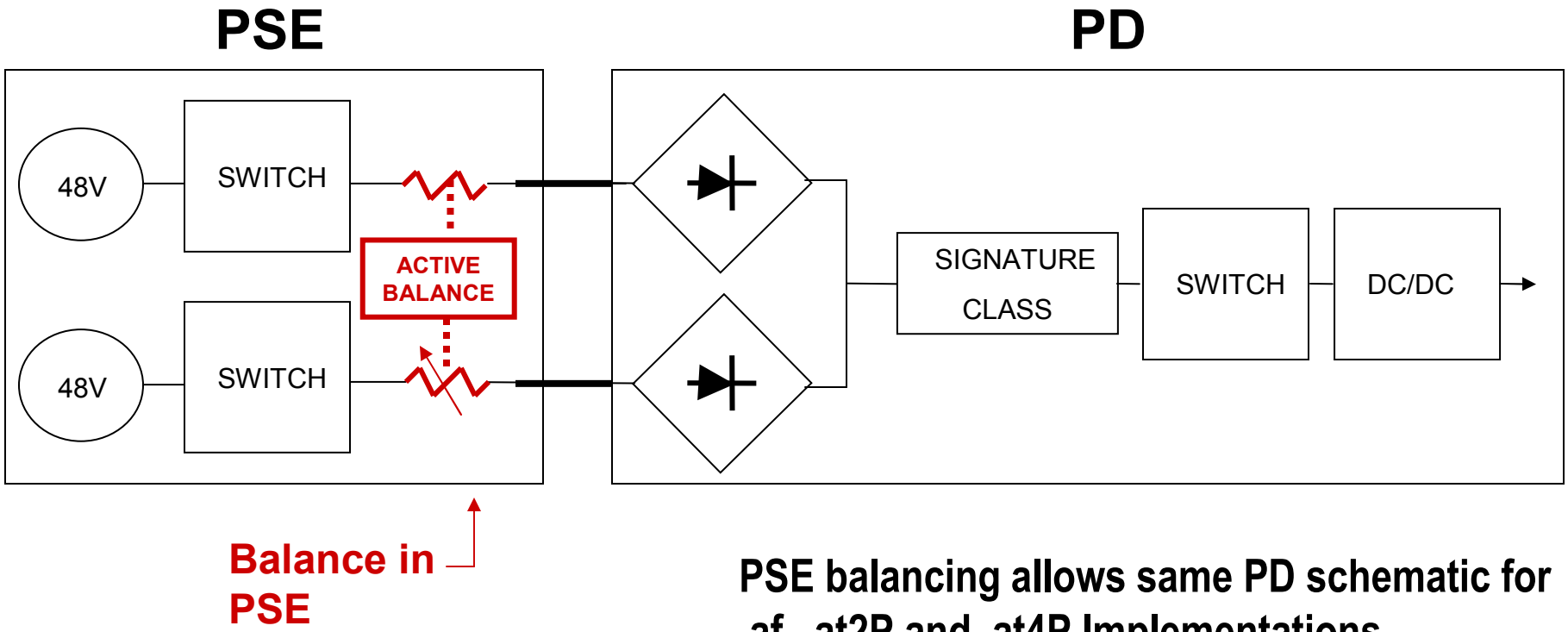
4P system with active current balancing.



- **4P system requires active balancing on** both the top and bottom **power supply rails.**

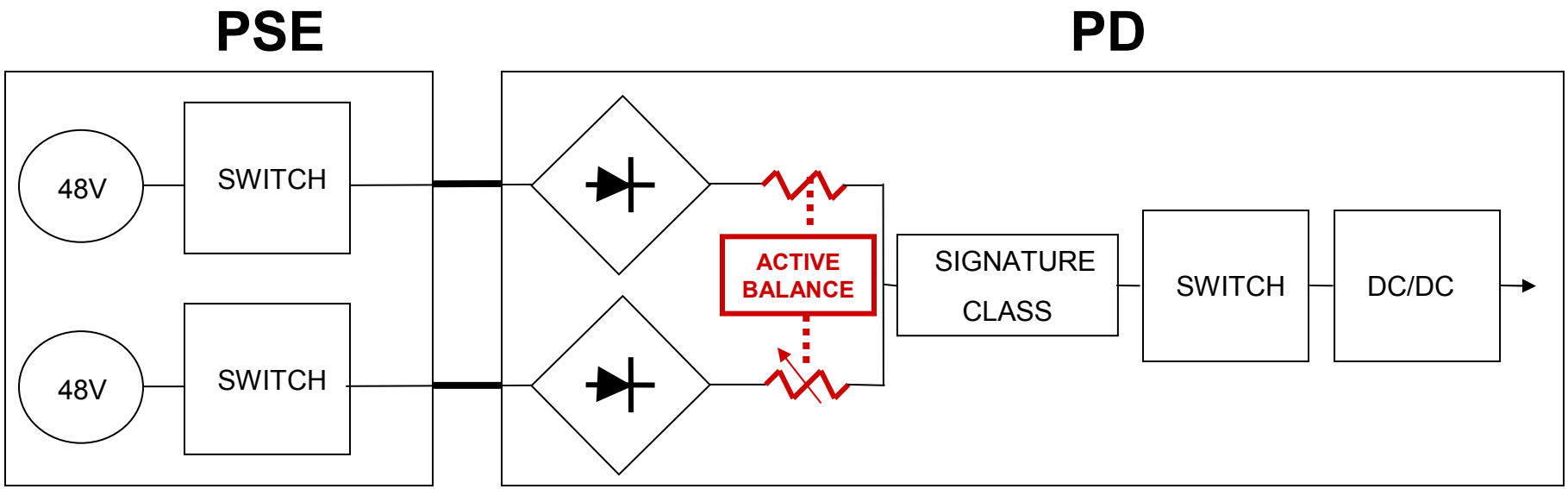
Note: This example shows balancing performed in the PSE. Balancing can also be performed in the PD.

4-Pair Current Balancing Can Be Implemented in PSE



PSE balancing allows same PD schematic for .af, .at2P and .at4P Implementations

4-Pair Current Balancing Can Be Implemented in PD Front End

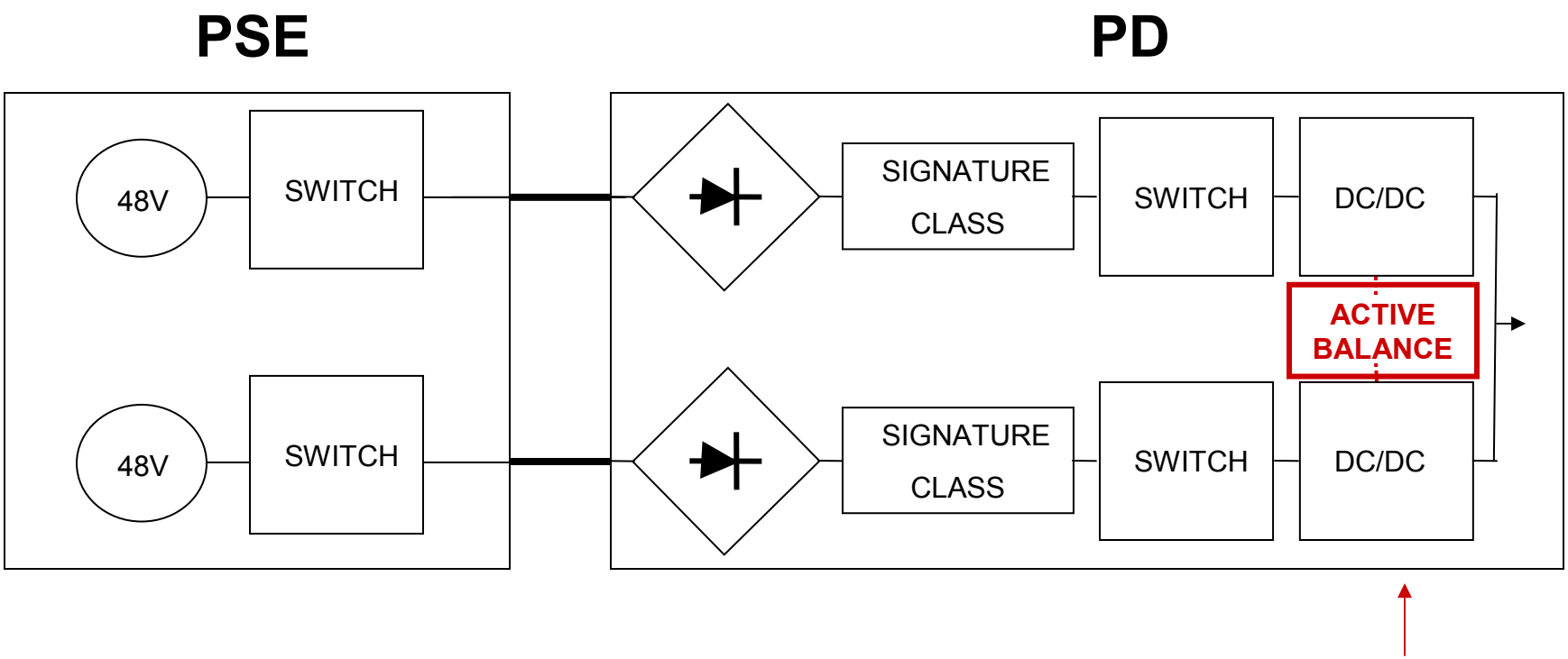


Balance in PD Front End

Allows single signature/class front end

4P PD (≤~30W) is compatible with 2P & 4P PSEs

4-Pair Current Balancing Can Be Implemented in PD Back End



PD Back End balancing is low loss but requires 2 DC/DC Converters!

Balance PD Back End

Current Balance vs. Current Limit

- **In 4P system, possible to either** balance currents **so equal current flows in each pair**

OR

- Limit current **in first pair to I_{CUT}, then send additional current over second pair.**

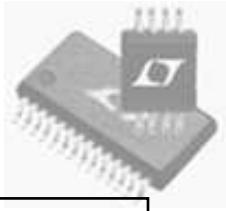
Either may be feasible and standard should allow both. We will refer to current balancing but it should be understood it could instead be current limiting.

Remember this has nothing to do with balancing current in the magnetics.

How Safe Do We Want To Be?

- PSE could implement Broken Wire Detect (BWD)
- PSE should monitor for severe imbalance regardless of current balancing location
  - If balancing is in PD, PSE can't see severe imbalance. Should mandate PSE monitor balance.
- Do we use worst-case cable/connector numbers? May mandate active balancing of magnetics, in which case pair-pair balancing can be implemented with the same hardware.

4P Balance in PSE or PD?



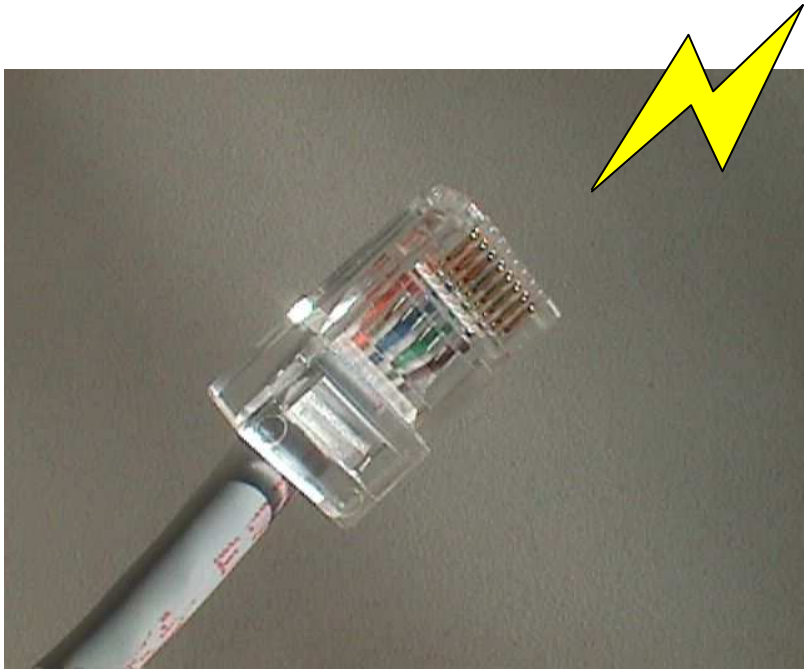
- **In PSE**
  - + Cheapest PD
    - Same schematic as .af
    - Same "cheap" PD cost model as .af
  - + PSE can sense BWD, severe imbalance, etc. and take action
  - – Adds cost to PSE
    - Worst if Si cost >> power supply cost
    - If Si cost << power supply cost, added cost doesn't matter much
    - Requires monitoring top and bottom rails of every port
  - – Adds heat in PSE
  - + **Better if most ports require 4P**

- **In PD**
  - + Cheaper PSE ports
  - + Only 4P PDs bear extra balancing cost
    - Must balance pair current or limit pair power
    - These PDs violate .af "cheap PD" cost model
  - + PDs have the option of high-efficiency balancing in switcher-otherwise adds heat in PD
  - + **Better if most ports can get by with 2P**

BWD=broken wire detect

In Summary

- If 2P is viable, balance 4P in PD
- If 4P is mandatory, balance in PSE
- In the end, it's all about the wire current capacity!!!



- Need agreement on cable current capacity before we decide where to put 4P balance circuit