Backfeed voltage during 2, 3 and 4 pair operating modes

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Objectives

- To investigate the effect of excluding backfeed requirements for 3-pair mode.

- To check if and in which parts, the IEEE802.3bt D3.4 need to be updated as a result.

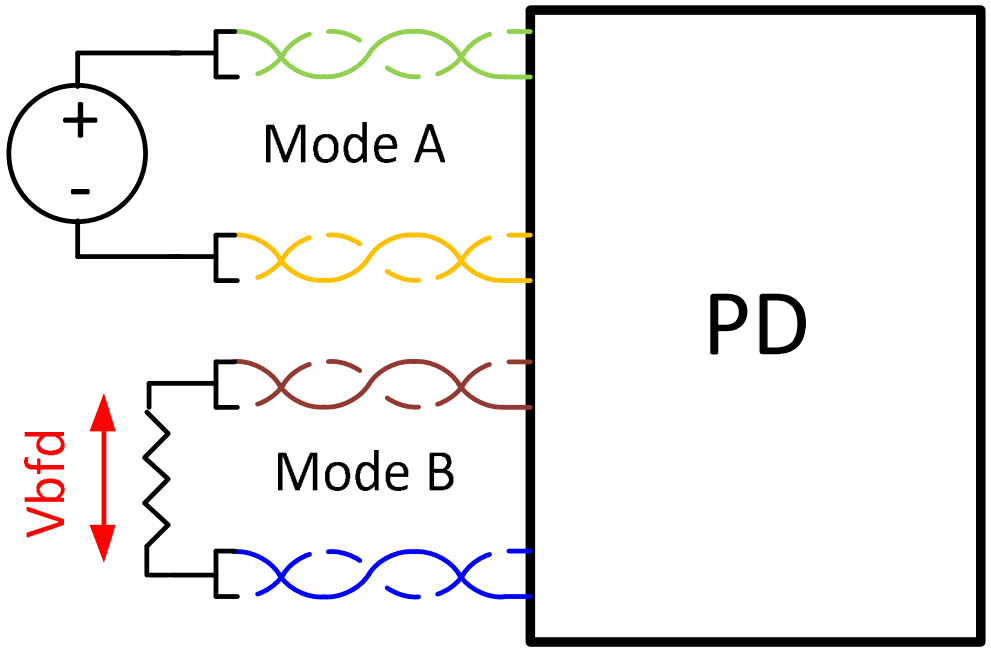
Backfeed requirement……1

145.3.8.8 Backfeed voltage

"When any voltage in the range of 0 V to VPort_PD-2P max is applied across the PI at either polarity specified on the conductors of either Mode A or Mode B[1] according to Table 145–20[1], the voltage measured across the PI for the other Mode with a 100 kΩ load resistor connected across that other Mode shall not exceed Vbfd as defined in Table 145–29."

(1) ".. on the conductors of either Mode A or Mode B.." is 2-pair or 3-pair per Table 145-20

Vbfd Must be less than 2.8V over 100KΩ



Backfeed requirement……2

- The backfeed specification[1] in D3.4 applies for 2-pair and 3-pair mode per Table 145-20 in the 2-pair mode section.

1. Originally came for 802.3af/at for 2-pair PSEs

In addition (Backfeed=PD sourcing power):

There is a requirement: **"PD shall not source power to the PD PI"**

-Added to the spec to cover auxiliary PD power supply connection that its voltage and current capacity are not limited/specified by the spec.

Table 145–20—PD input power configurations

Pairsets	Mode A		Mode B	
Pairs	Pair 1	Pair 2	Pair 3	Pair 4
Conductor	1 and 2	3 and 6	4 and 5	7 and 8
	Valid 2-pair configurations			
	P	N	—	—
	N	P	—	—
	—	—	P	N
	—	—	N	P
	P	N	P	—
	P	N	—	P
	N	P	P	—
	N	P	—	P
	P	—	P	N
	—	P	P	N
	P	—	N	P
	—	P	N	P
	Valid 4-pair configurations			
	N	P	N	P
	N	P	P	N

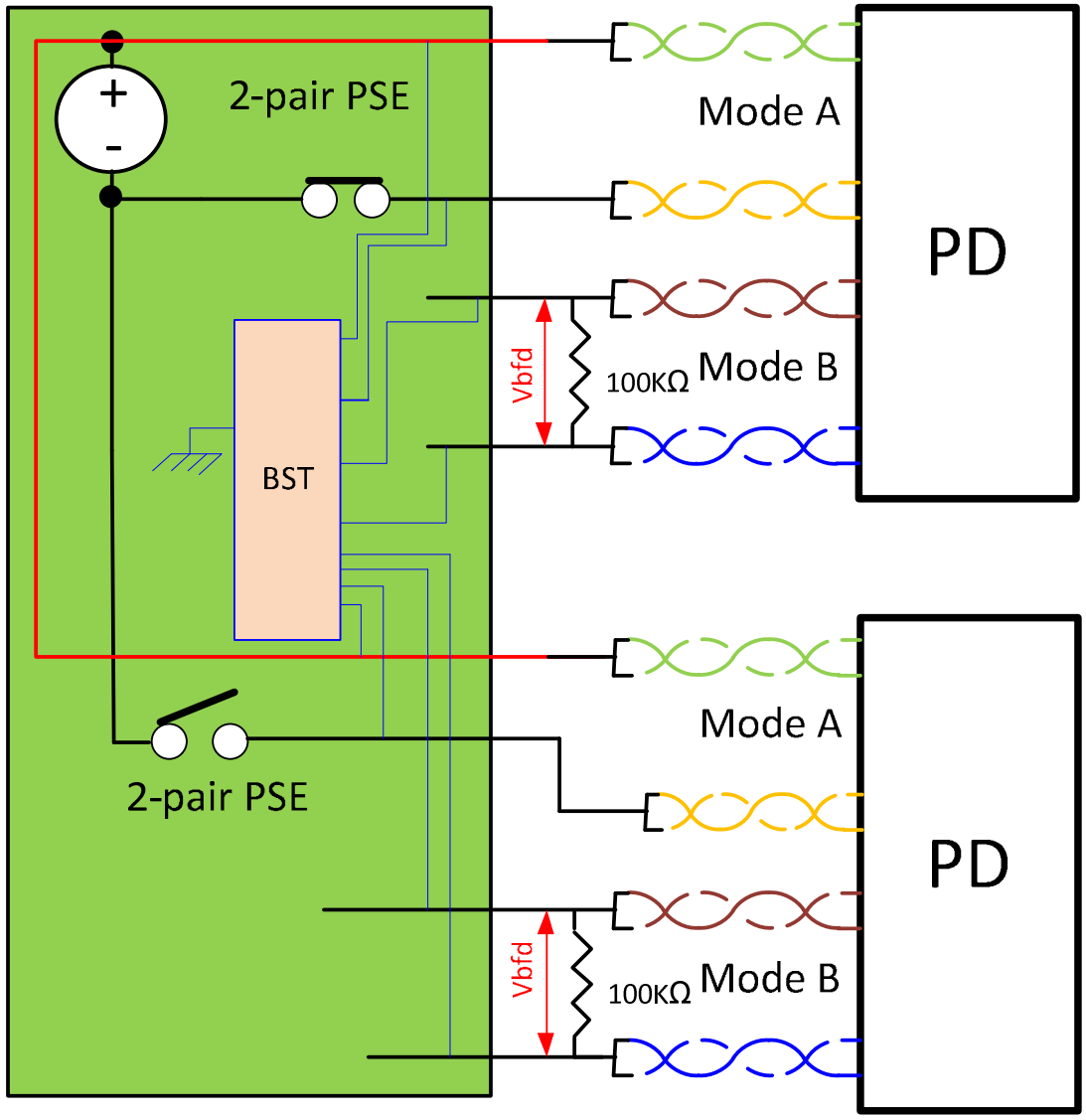
The reasons for backfeed specification

- To prevent pollution of adjacent PSE ports
  - In some PSEs, poorly DC-isolated Bob Smith terminations can couple PD Backfeed to adjacent ports, resulting in corruption of the detection signature
- To prevent damage to non PSE pairs with low impedance terminations
- To set a well-defined behavior of an unpowered PD mode
  - Backfeed below the PSE minimum OFF/detection voltage value.
- To meet "**The PD shall not source power on its PI** "
  - To handle PD auxiliary power supply with no spec that limits its voltage/power
- To prevent damage to Endspan or Midspan configuration when one of them is OFF.
- In unpowered mode of a Dual-signature PD, PD should show valid detection AND backfeed voltage <2.8 to allow PSE successful detection.

The reasons for backfeed specification

- 2-pair multiport PSE
- "BST" is a termination module, contributing to port to port cross-leakage
- If BST is poorly designed, the 2nd PSE will not be able to detect and powerup.
- "From clause 33 and 145:

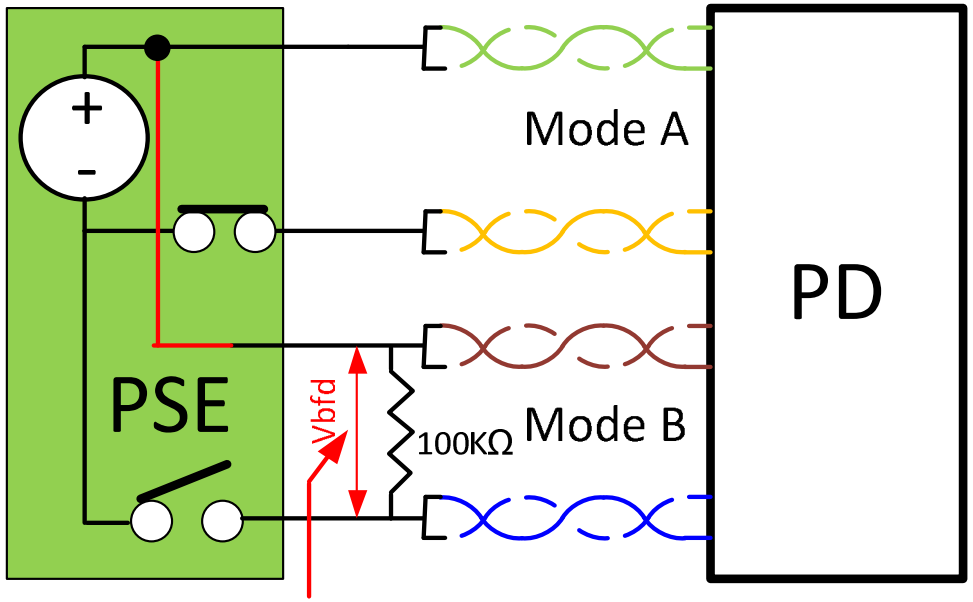
"In a multiport system, the implementer should maintain DC isolation through the termination circuitry to eliminate cross-port leakage currents. "



Problem #1 with the existing text vs. exiting pre-standard PD implementations

- Some Ideal diode bridges in the market don't meet the backfeed requirement when operated in 3-pair mode[1].
  - Designers didn't verify that this specific implementation doesn't match diode bridge behavior, which doesn't have the backfeed issue in 3-pair.
- *Now they are used in pre-802.3bt single-signature PDs.*
  - in most 4-pair PSE implementations, all positive leads are tied together and only the negative leads are switched. This results in 3-pair mode when a 4-pair PSE is powering over 2-pair

Note 1: Found during the last Plug Fest when pre-standard 802.3bt PDs are connected to pre-standard 802.3bt PSEs



Problem #2

- To solve problem #1, we need to exclude 3-pair mode from the backfeed requirements.
- The question is (problem #2): do PDs that generate high backfeed voltage ($V_{Port\_PD\text{-}2P\ max}$) cause interoperability issues and/or damage to:
  - Any 4-pair PSE operating over 3-pair mode?
  - Any 4-pair PSE operating over 4-pair mode?
  - Any existing 4-pair PSE operating over 2-pair/3-pair mode
    - Our spec should not allow potential damage to existing equipment in the field

- **Notes:**
- Type 3 PSEs operating over 2-pairs (replacing Type 1 and 2 PSEs) will obviously have to meet the backfeed specification.
- Dual signature PDs will have to meet it in 2-pair/3-pair/4-pair modes:
  - valid signature on each pair regardless of the voltage on the other pair
  - backfeed specification on the unpowered pair when the other pair is powered

Reasons to include 3-pair mode in backfeed spec

- It keeps the same intent we had for true 2-pair mode
- It is “worry-free” at this stage of the standard
  - It is cleaner. It is, after all, “2-pair” mode with reinforced positive leads…
  - Well defined requirement to a PD to not source power back to the PSE.
    - There is a requirement: **“The PD shall not source power on its PI ”**
    - Prevent wrong Ideal diode bridge designs which need to have identical behavior to diode based designs, with improved efficiency.
      - Proven for almost 15 years with 2-pair and 4-pair designs
  - Prevent potential damage or improper operation or interoperability issues (will be addressed in next slides case by case if it is a valid concern)
  - Prevent confusion when using rectifier designs intended for SSPDs with DSPDs where they will violate the spec in DSPDs[1].

(1) This argument may be weak since we can make the spec more clear that DSPDs need to meet both valid signature and backfeed requirements on each pair…..

Reasons to ***exclude*** 3-pair mode in backfeed spec

- Allow some low cost Ideal Diode Bridge designs.
  - These low cost designs can fix the problem and stay low cost..
- Existing low cost devices already exhibit high back feeding voltage under 3-pair mode conditions. Compliant Type 3 and 4 PSEs will need to deal with it anyway.
  - anyway? Need discussion.
- 4-pair PSE that operates over 4-pair and is connected to ***single-signature PD*** will not be affected by backfeed.
  - POWER_UP on both pair sets will occur long after CC and detection/classification over each pairset are done, hence a 4-pair PSE is capable of handling the high backfeed voltage.

In order to resolve problem #1 we need to resolve problem #2 first.

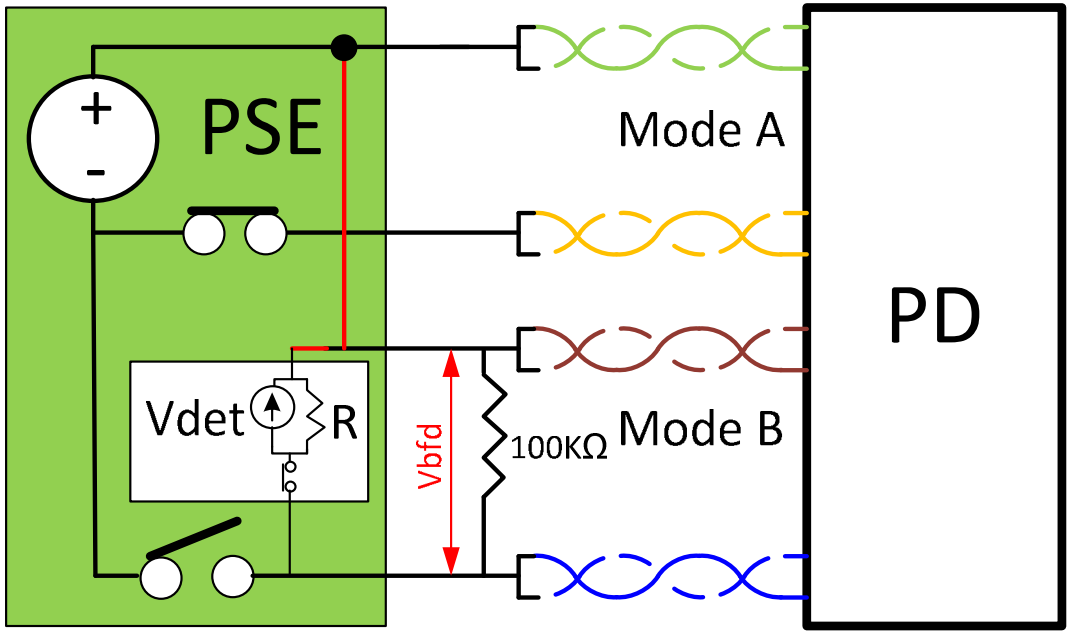
List of issues to address in order to resolve problem #2

- Test conditions: Applying high backfeed voltage (VPort_PD-2P) to the unpowered pair of a 4-pair PSE when connected **to an ideal diode bridge from a schematic that was supplied to me**[1], in the following cases and checking for:
  - damage to existing 4-pair PSE detection circuitry that was used to see up to 30V during detection and backfeed voltage up to 2.8V and now may see backfeed voltages up to 57V.
  - Damage or interoperability issues in a typical Endspan/Midspan configuration
  - When a PSE is connected to a SSPD through crossed cable: Damage to the detection diode across the PI due to reverse polarity[1]?

    When a PSE is connected to SSPD through crossed cable: safety (>60V) between the two modes[1]?
  - increasing PSE susceptibility to cross leakage current issues that will prevent successful detection on adjacent pairs/ports (now leakage may be higher by 57V/2.8V=~20)
  - Other? Group/system vendors need to check for other use cases to ensure we are not creating problems in such late stages of the standard.

Potential damage to detection circuitry during Detection to legacy Endspan/Midspan configurations and existing 4-pair PSEs

- Detection circuitry has to handle up to 57V and not 30V as in typical diode based bridge designs.
- Vendor1 results: PSE ok at 57V and power dissipation for any duration.
  - Details: Rdson*Iport^2 > 57^2/R per port ➔ No issues
  - R is the PSE output resistance across the PI during OFF/DETECTION state
  - Increasing R has no significant value compared lowest possible R. The minimum value of R (Rmin) must be Rmin≥45K to meet spec. See note 1.



Note 1:

having R close to Rmin≥45K during OFF/Detection states is advantage compared to R>Rmin since it allows fast discharge of PD input caps and make PD ready for next new detection faster.

Endspan/Midspan configuration

- Since a Midspan, when connected to Endspan, breaks the DC continuity over at least one positive pair, ***the 3-pair mode is avoided*** which results in true 2-pair mode operation, which meets the backfeed requirement.
- Conclusions: No issues with Endspan/Midspan configurations

PSE is connected to SSPD through crossed cable - 1

- To verify that when a crossed cable is used, the unpowered PSE alternative doesn't experience reversed voltage that could damage the detection diode across the PI (Figure 145-19 and 145-20).

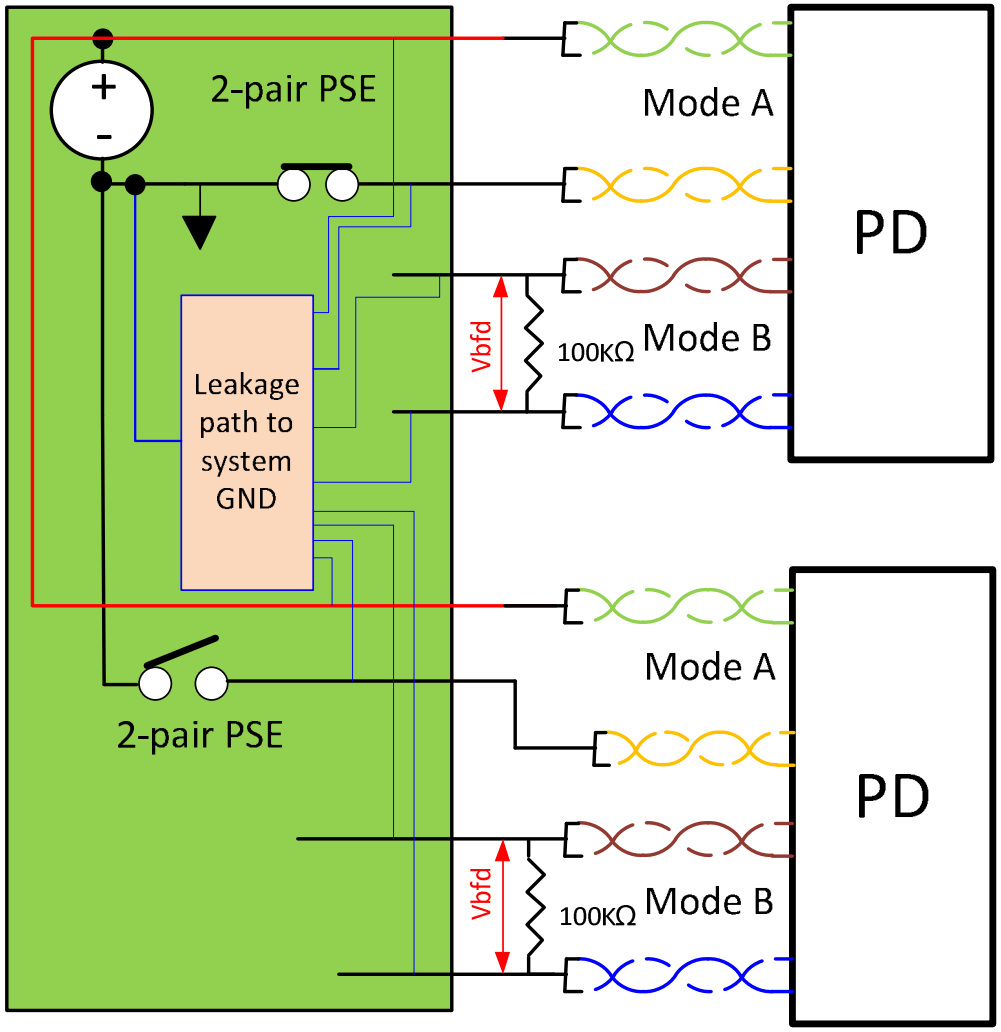
- Analysis results: per the specific ideal diode bridge schematic that I have received, which generates backfeed (VPort_PD-2P) in 3-pair mode:
  - The root cause of the high backfeed voltage on the unpowered pair is that the two control circuits of the two Ideal diode bridges get the positive pair voltage since they are both tied together at the PSE. This causes the relevant negative side MOSFET in the ideal diode bridge to be ON, on the unpowered pair which in turn generates the high backfeed voltage (instead of staying OFF as it would in a diode bridge implementation).
  - The bridge still determine its polarity only as a function of its input voltage independent of the 2nd bridge, resulting in the correct backfeed voltage polarity at the unpowered PSE alternative.
  - Conclusion: No issues with crossed cables

PSE is connected to SSPD through crossed cable - 2

- To verify that when a crossed cable is used, the unpowered PSE alternative doesn't experience reversed voltage which would cause >60V between the modes in Midspan/Endspan configurations

- Analysis results
- 3 arguments that each alone is sufficient to claim NO ISSUES:
- There is no risk of >60V between modes when the PD is single-signature, since any pairs of the same polarity are clamped to each other by the PD diodes.
- In addition, there is no reverse polarity issue in the mentioned ideal diode bridge behavior.
- Since a Midspan, when connected to Endspan, breaks the DC continuity over at least one positive pair, ***the 3-pair mode is avoided*** which results in true 2-pair mode operation which meets the backfeed requirement.

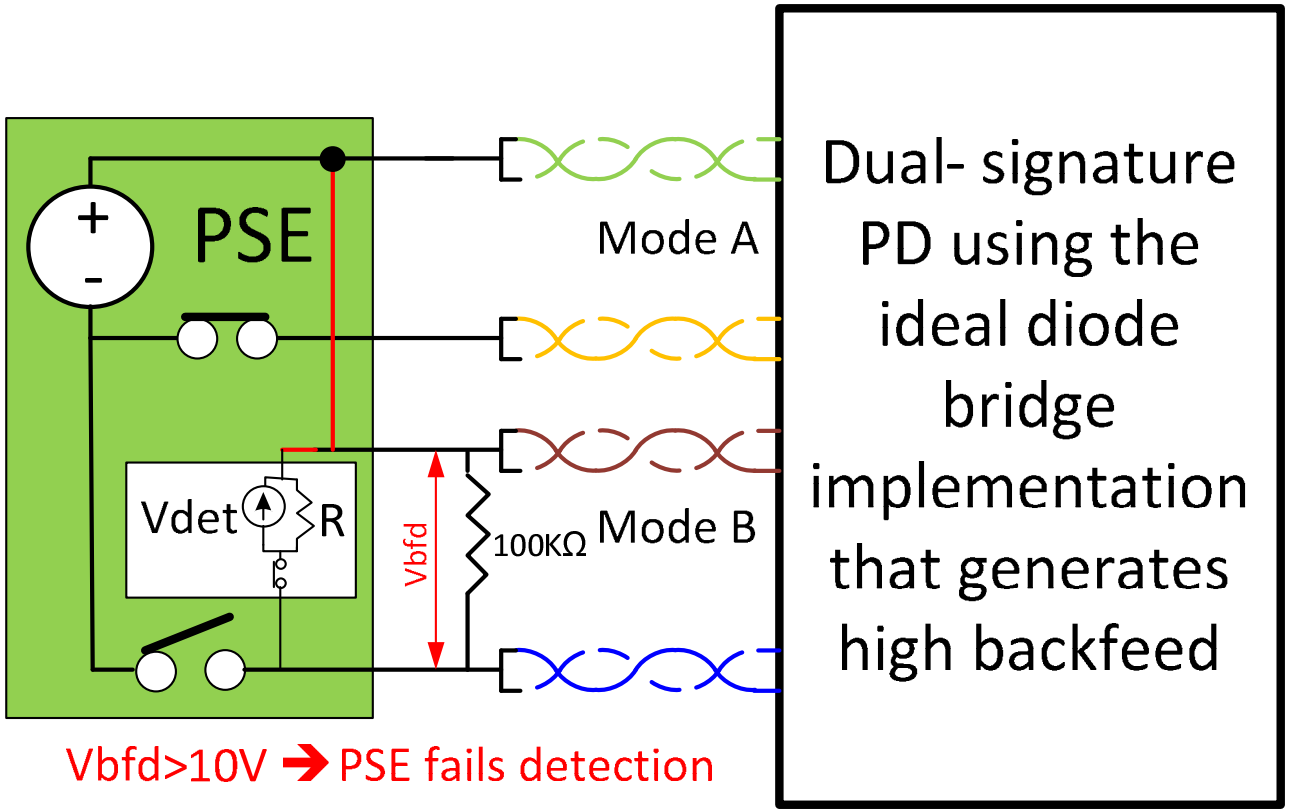
increasing PSE susceptibility to cross leakage current issues between pairs/ports.



- Allowing high backfeed voltage up to 57V may increase existing 4-pair design and legacy 2-pair design susceptibility to cross-leakage current by a factor of up to ~20 (57V/2.8V) and may prevent successful detection on adjacent pairs/ports.
- *I checked Vendor1 system and leakage current is still sufficiently low at 57V so detection is not polluted.*
- **Need data from other PSE systems to ensure backwards compatibility.**

Addressing dual-signature PDs

- The current text looks like it covers both single-signature and dual-signature PD, however dual-signature PDs must meet backfeed for any valid configuration in Table 145-20 (2-pair, 3-pair and 4-pair) and we need to ensure this in the final text of backfeed, if it is going to be changed.



Summary

#	Concern	Results	Recommendations
1	Damage to existing 4-pair designs during detection. Spec limits to 30V. Now they will be exposed to 57V max.	1 vendor tested. No issues.	Other vendors to check
2	PDs that equipped with auxiliary power supply with no spec that limits its voltage which now may source voltage/power..	NO DATA	Other vendors to check
3	Damage to non PSE pairs with low impedance terminations	NO DATA	Other vendors to check
4	Susceptibility to increased leakage current that can pollute detection on adjacent pairs/port	1 vendor tested. Leakage current was increased as expected but still sufficiently low.	Other vendors to check
5	Dual-signature in high backfeed voltage conditions	Will not work.	Dual-signature PD must meet backfeed requirements in 2-pair, 3-pair and 4-pair modes
6	Damage due to the use of crossed cables	No issues.	
7	Voltage > 60V due to the use of crossed cables	No issues.	
8	Damage or interoperability issues to typical Endspan/Midspan configuration	No issues.	

Next steps/Recommendations

- We need more data from other system vendors to be sure that excluding 3-pair will not cause damage or interoperability issues.

- We need to address "**The PD shall not source power on its PI**" which is equivalent to backfeed topic.
  - PDs are often equipped with auxiliary power supply. Its voltage is not specified. It can be 70V.
  - What if it backfeed (or source power to PSE) ?

Annex A - References

- The backfeed requirement was added at the last cycle of the 802.3af meeting after a field report results. In addition, a note was added (to complete the info as shown in comment #101 page 23 at: http://www.ieee802.org/3/af/comments/d4.1/P802_3af_D4_1_all_by_page.pdf