

# Backfeed in a 4-pair context v250

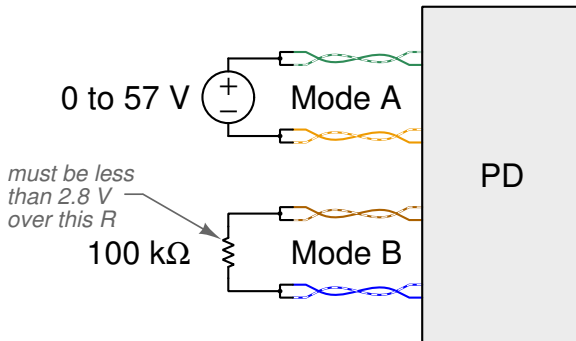
**Lennart Yseboodt**

Philips Lighting – Research

May 19, 2018

## Backfeed requirement

“When any voltage in the range of 0 V to  $V_{\text{Port\_PD-2P max}}$  is applied across the PI at either polarity specified on the conductors of either Mode A or Mode B according to Table 145–20, the voltage measured across the PI for the other Mode with a 100 k $\Omega$  load resistor connected across that other Mode shall not exceed  $V_{\text{bfd}}$  as defined in Table 145–29.”



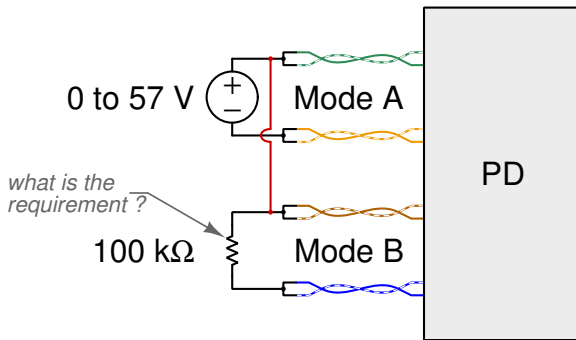
## Purpose of backfeed specification

The purpose of the backfeed specification historically is to prevent a PD, powered in 2-pair mode, from producing a voltage / power level on the unpowered Mode, which is also connected to the PSE and potentially damaging the PSE.

But how does the backfeed specification translate to 3-pair and 4-pair situations ?

## 4-pair backfeed

A 4-pair capable PSE typically ties the positive lines together at the PSE end. Even in “2-pair” mode, there are two pairs connected to the positive  $V_{PSE}$ . **Does the backfeed requirement still apply? Should it?**



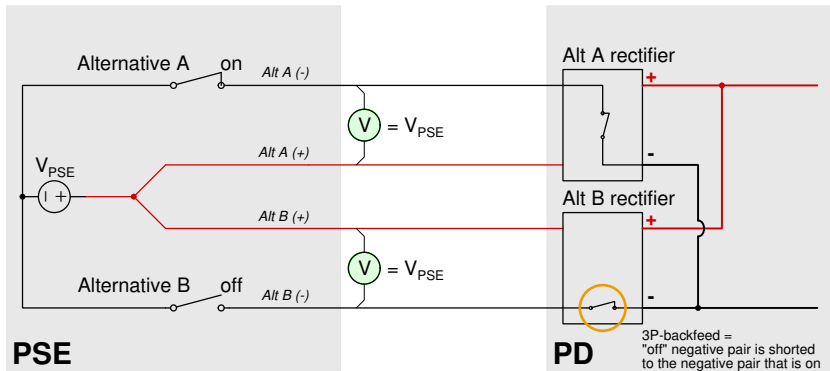
## Ambiguity current text

The current text is ambiguous as to whether the condition of two positive pairs is one where backfeeding is limited to  $V_{bfd}$ . The intent of the text did not anticipate more than 2 pairs being powered (as this is old text), but it does not clearly exclude it, since connecting one pair of a Mode to a supply rail does not constitute “applying a voltage”.

The common interpretation of this current text would be that the backfeed spec only applies when a voltage is applied on one of the Modes exclusively: “...on the conductors of **either** Mode A or Mode B, according to Table 145–20, ...”

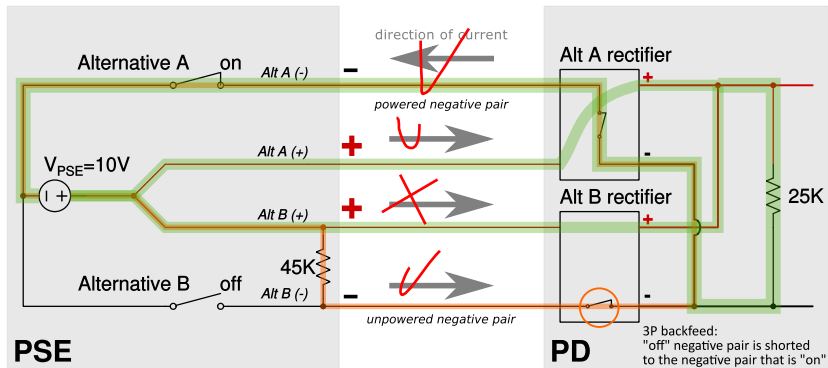
**Given that this text is not iron-clad, it is vastly preferred that we FIX this, rather than leave it be.**

## Cause of backfeed in the PD



Just like the PSE shorts the positive pairs together, the some PDs short the negative pairs together when exposed to 3-pair power ( $2 \times$  positive and  $1 \times$  negative voltage).

# Detection corruption issue



If the PSE ties an "off" negative pair to the positive (via a discharge resistor) and the PD connects the negative pairs together, this causes this resistor to appear in parallel to the PD detection resistor.

⇒ **PDs may not tie negatives together in the detection voltage range.**

shall

## Classification offset issue

During classification the same PSE discharge resistor can increase the observed class current. With a 45 k $\Omega$  resistor, the maximum offset current is  $20.5 \text{ V} / 45 \text{ k}\Omega = 456 \mu\text{A}$ . There is 1 mA of margin between the PD and PSE classification signature current spec, which can absorb this.

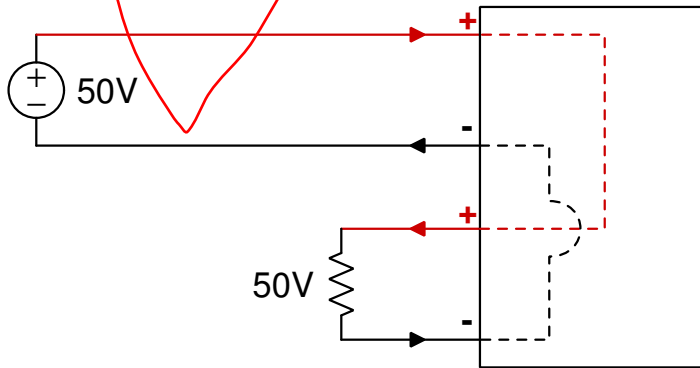
It requires that the permitted PSE reverse current is limited to about 500  $\mu\text{A}$  in the classification range.



## PD shall not source power issue

Backfeed is different from sourcing power, even though in both cases a voltage appears on the PD PI.

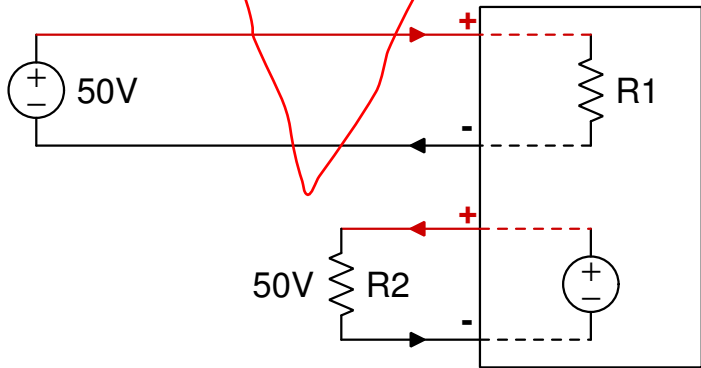
**This is backfeed or reflecting voltage:**



## PD shall not source power issue

Backfeed is different from sourcing power, even though in both cases a voltage appears on the PD PI.

**This is sourcing power on the PI:**



## How to tell the difference ?

When a PD is sourcing power, as drawn in the previous slide, the power consumption of R1 + R2 will exceed the delivered power of the PSE.

In case of backfeed the total power consumed and the PSE delivered power are precisely the same.

Ergo, the existing requirement “The PD shall not source power on its PI” covers what we need it to cover.

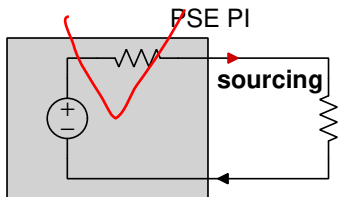
## 3P-after-4P

The backfeed specification also holds when a PD has been exposed to 4-pair voltage, and then one pair is disconnected (switch to 3-pair). Such behavior is allowed by PSEs (eg. for Class 1–4 the PSE can freely switch between 4P, 3P, and 2P).

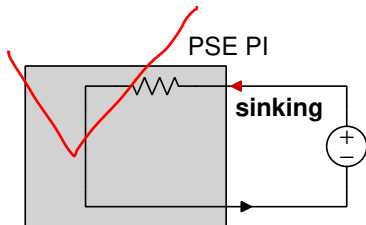
Testing of several active bridges shows that none of these can meet a 3P-backfeed limit of 2.8 V when first exposed to 4-pair, and then disconnecting a negative pair. Each of the tested bridges fails in a unique way, demonstrating the huge amount of permutations and design complexity associated with active bridge design.

Note — PDs must still meet the 2P backfeed spec (2.8 V), regardless if they were exposed to 3P or 4P previously.

## Sourcing and sinking current



*current flows OUT of the device at the higher potential*

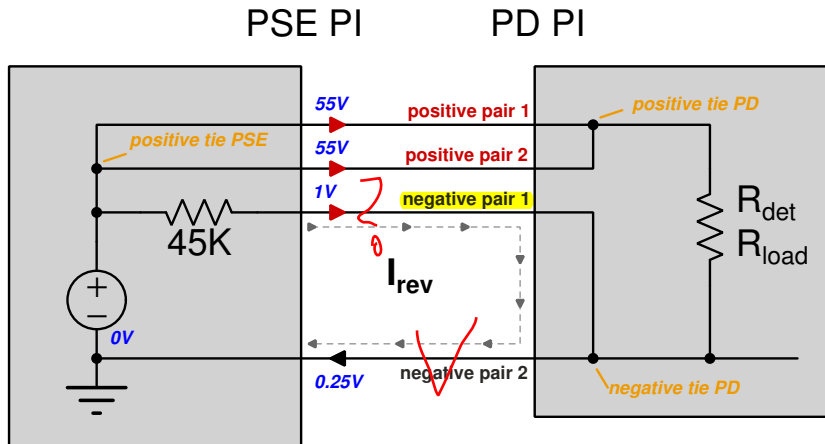


*current flows INTO the device at the higher potential*

**Sourcing current** means that current flows out of a device terminal at a higher potential than where it re-enters the device. The power is being provided from inside the device.

**Sinking current** means that current flows into a device at a higher potential than where it exits the device. The power is provided external to the device.

$I_{rev}$  is sourcing current between two negative pairs



## Reasons to **include** 2×positive in backfeed

- ▶ How sure are we there are no issues with allowing 3P backfeed?  
**Update: one technical issue and one specification issue has been identified**
- ▶ Prevent rectifier designs that are OK for single-signature but are incompatible with dual-signature (confusion, design fails)  
**Update:** no known active bridge scheme is suitable for dual-signature PDs. ~~Use of pure diodes bridges may be the only solution.~~

## Reasons to **exclude** 2× positive in backfeed

- ▶ ~~Severely complicates active bridge design~~
- ▶ Existing devices already exhibit backfeeding under these conditions, PSEs will need to deal with it anyway
- ▶ Backfeed is only possible under 3-pair conditions, which means a PD connected to a 4-pair PSE which is capable of handling the backfeed
- ▶ No existing active rectifier can comply, we're back to diodes only for the ~~next few years~~
- ▶ **Update:** See Lemahieu\_BfdAdHoc\_3Pdetection\_v2.pdf — which shows that (schottky) diode bridges exhibit much higher backfeed voltage under 3-pair conditions compared to 2-pair conditions.



# Baseline options

## Option 10V

- ▶ PD limited to 2.8 V reflected voltage in 3-pair mode up until 10.1 V (detection range)
- ▶ PSE reverse current is 500  $\mu$ A when  $V_{PSE} < 20.5$  V and 1.3 mA when  $V_{PSE} > 20.5$  V
- ▶ ~~PSE reverse current requirement applies at all times~~

>10.1V

## Option 20V

- ▶ PD limited to 2.8 V reflected voltage in 3-pair mode up until 21 V (detection + class range)
- ▶ PSE reverse current is 1.3 mA
- ▶ ~~PSE reverse current requirement applies when operating in 2 pair / 3 pair mode~~

>20.5V

## Recommendation

X No fundamental problem has been shown with 3-pair backfeed.

The companion baseline covers:

- ▶ Explains the effect in the PSE section ('Reflected voltage')
- ▶ Limits the PSE from stealing PD current
- ✓ ▶ Disallows 3P backfeed in the detection range
- ▶ Corrects backfeed specification to apply to 2P only and for 3P only in the detection range (option 10V)

