The effect of aging on PD forward voltage and PD PI per-to-pair effective resistance/current unbalance

IEEE802.3bt

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Comment (145.2.8, P152 lines 46-51)

The following question has been asked regarding diode aging and its effect on PD_Vdiff that affect unbalance.

Background:

Our spec defines unbalance requirements for the PSE in terms of VPort_PSE-2P, Icon-2P_unb and for the PD in terms of Icon-2P_unb and inexplicit design requirement to keep PD pair to pair voltage difference generated by forward voltage difference of each two diodes, PD_Vdiff, to 60mV max measured at 1mA. The PD_Vdiff has the highest effect on the system current/resistance unbalance.

The following use case has been investigated:

A PD is connected to a PSE over 4-pairs. The PSE is using Alt A (MDI) and Alt B (X) resulting with 1,2 and 7,8 are positive and 3,6 and 4,5 are negative. It runs this way for MANY years. The PD front end is not an active bridge, it is a diode bridge. The PSE has been replaced and it uses Alt A (MDI) and Alt B (S). Now, 1,2 and 4,5 are positive and 3,6 and 7,8 are negative. Now we have diodes that have been aged (1,2 and 3,6) in parallel with diodes that have never have current through them (the ones in 4,5 and 7,8). This is not simply switching from the old diodes to the new ones, its mixing old with new. The questions are:

1. If the aging influences Vf, then we may have higher mismatch between the diodes in parallel leading to higher unbalance.
2. In an extreme case, we may have a runaway situation as the aged diode drops more power and heats more than the 'new' diode.

Answers:

1. All diodes in the diode bridge must have 60mV maximum Vdiff between any permutations of each two diodes.
2. Silicon doesn't have a memory. The performance characteristics change may change after diode end of life time due to mechanical construction and other issues that are function of current conduction.
3. Diodes that are at their end of life will introduce higher leakage current, higher VF, and other parameters will exceed the spec.
4. If the diode is kept with their allowed operating conditions, VF will not change significantly during the diode defined life time with or without current conduction.
5. Life time of a diode of reliable vendor can be 20 years. The lowest life time value of reliable vendors is 10 years. The typical is somewhere between these ranges.
6. Because of the above, any component in the PD or PSE need to be selected with life time which exceed the product life time like any other designs.
7. If vendor follow the above rules, the effect of aging should not be a problem for VF (or another parameter).

Remedy

1. Select the diodes (or any other components) with the required performance for a life time duration >= required device life time duration.
2. Select the diodes with 60mV maximum dVF voltage difference between each two diodes. VF is measured at 1mA.
3. No changes or additional requirements are needed for IEEE802.3bt spec.

Details:

Questions:

1. How does ageing affect the Vf of silicon Schottkys?
2. By what % would the Vf increase in 10 years?
3. What is the typical “life time” of a diode used in a PD in which its parameters are still meets their spec?
4. What is the typical “life time” of the diodes used in a PD?

These are the main factors which degrade over time for Schottky diodes:

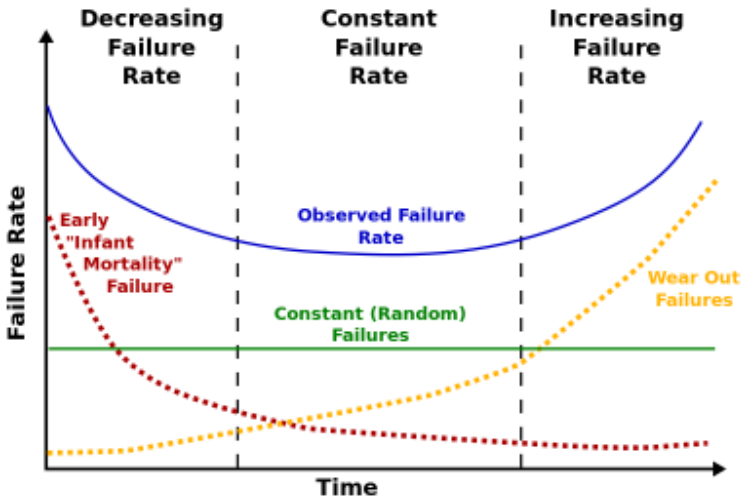
1. Schottky interface
2. Topside metallization (crystallization of Aluminum)
3. Die attach/solder (solder becoming weaker, more voids etc.)

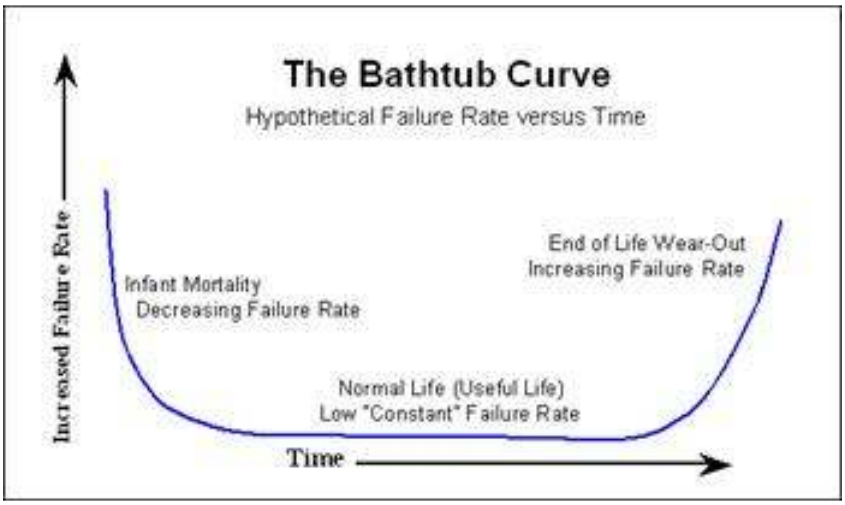
Item 1 is not very relevant for the question above. It is related to increase in leakage current.

Items 2 and 3 would effectively lead to an increase in the series resistance of the device, thereby increasing Vf. Current conduction is indeed the main factor for items 2 & 3. Therefore, the diode that was not conducting would not have aged due to 2 & 3.

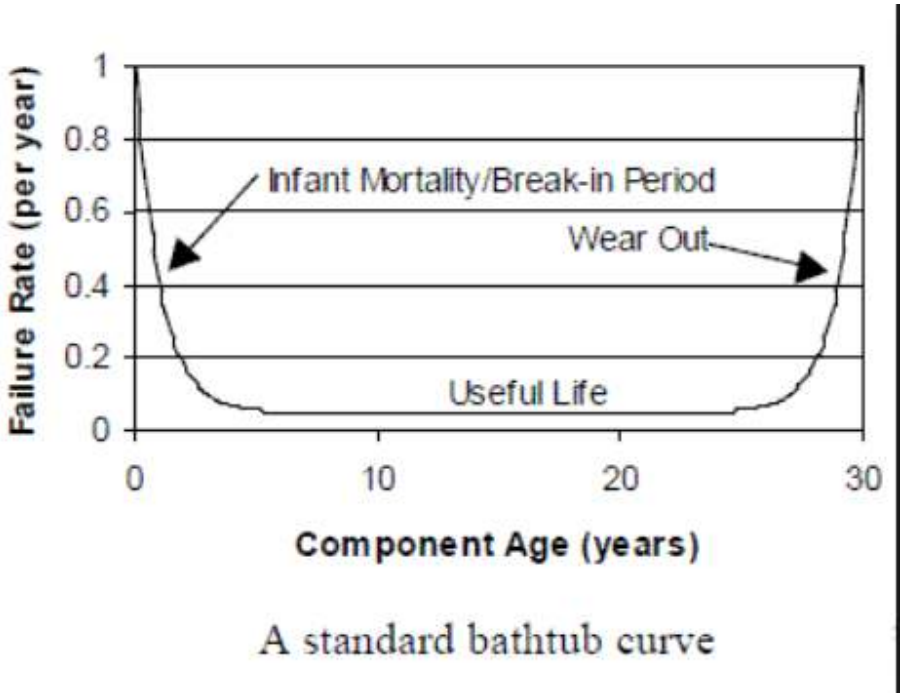
That would lead to the next question: By what % would the Vf increase in 10 years. The answer for this lies in the “bathtub curve” for the device (in this case the diode) lifetime that the manufacturer might have generated for the diode (see example attached). If 10 years is still in the “Normal/Useful Life” regime of the device, then it means that the Vf variation % would be minimal (insignificant), and it would be safe to switch one diode with the other. However, if 10 years is close to or beyond the inflection point towards the “End of Life Wear-Out” regime, then it is riskier as the used die is probably degrading considerably and the Vf might be higher vs. the unused device.

This lead to the next question: What is the typical “life time” of these diodes? (e.g. 1ADC, VR=60-100V, VF=0.45V at I=1A)
It depends on the manufacturer, qual standard followed and their QA. Cheap diodes that come from unreliable sources, would likely not have long lifetimes. On the other hand, some vendors provide diodes for the hi-rel market that would have expected lifetimes of 20 years or more. There are many companies that offer devices with reliability that falls in between these two extremes. More often than not, the manufacturer would provide the qual report, reliability and lifetime assessment for a diode or transistor family upon request.





Example for a component life time:



A standard bathtub curve