IEEE 802.3 DTE Power via MDI
Detection Methods - Reliability Analysis

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Topics

- Probability of false positive detection
- Definition of "Absolute" and "Behavioral" methods for signature detection
- Summary

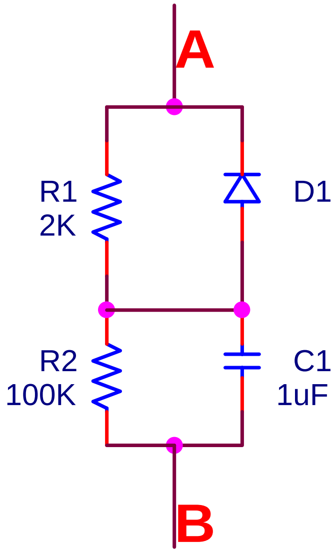
Probability of False Positive Detection

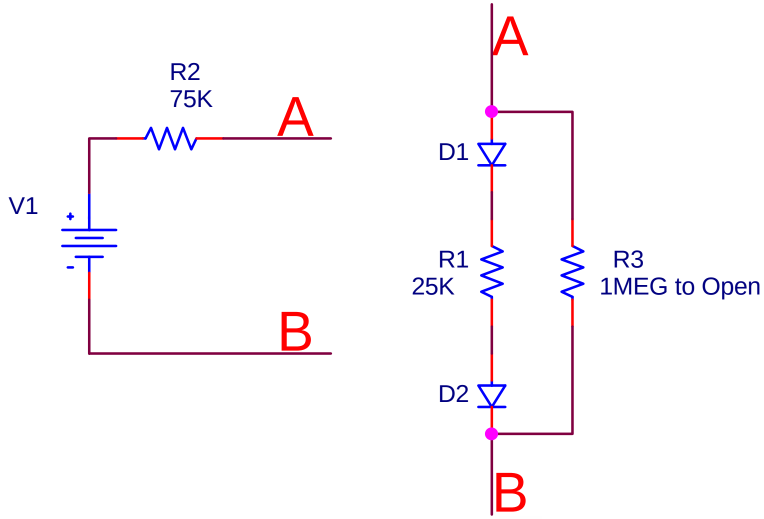
- Objective

  Decreasing the probability of falsely identification of non-PD as a valid PD

Probability of False Positive Detection

Comparison between “AC Coupled Diode” and “Resistor+diode” method



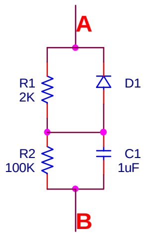


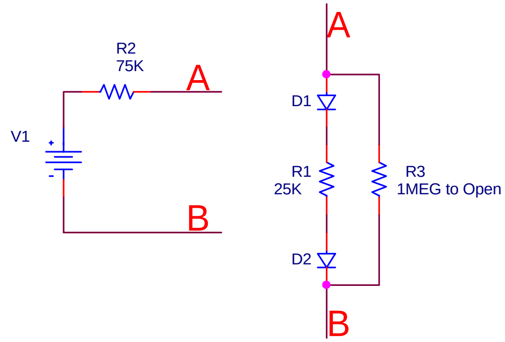
- Target:
  Looking for received/non-received pulses at specified condition.

- Target:
  Looking for specific value at specified conditions.

Probability of False Positive Detection.

- Comparison between “Diode” and “Resistor” methods.



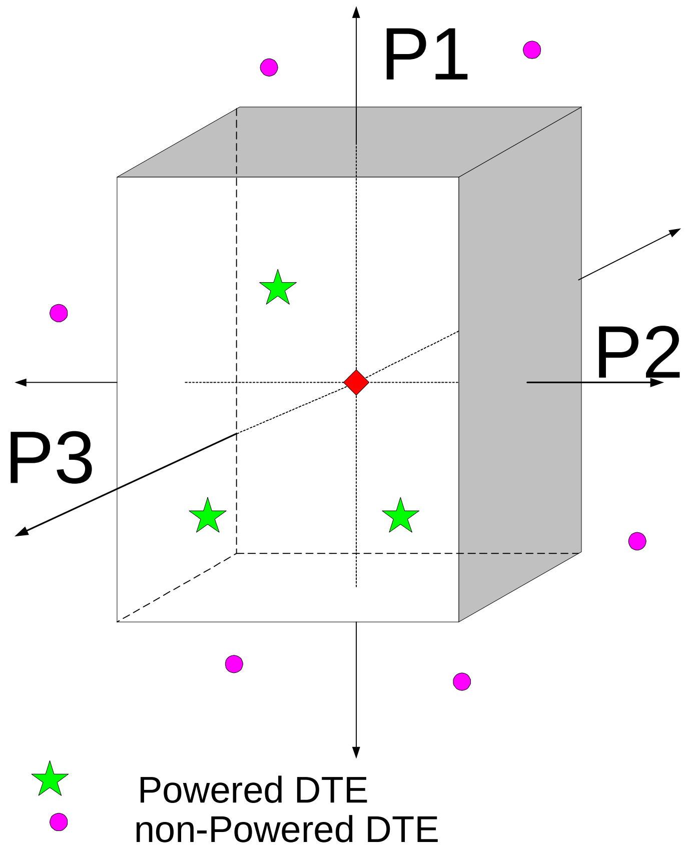


- What is the probability to receive
  a: the “correct” result when each of the components changes around its nominal value
  b: When all components value change simultaneously?

- What will be the Envelope size in which “correct” detection is obtained?

- In order to simplify analysis, we will assume that the Envelope size is simply a function of the product of signal sensitivity to elements tolerance.

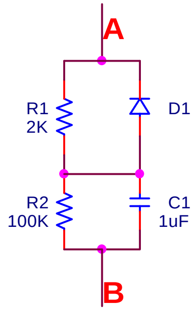
Expected Positive Signature Detection Envelope



- Description of 3 elements signature scheme with nominal values of P1, P2 and P3 with ΔP1, ΔP2 and ΔP3 around the nominal value
- ΔPi= Δ(Expected signal) / Δ(Element-i)
  i =1,2,3.
- Probability of "False Positive" Detection (PFP) is Proportional to Envelope Size (ENS)
- PFP $\propto$ ENS
- ENS$\propto$ $\Delta P1 \cdot \Delta P2 \cdot \Delta P3$

Probability of False Positive Detection

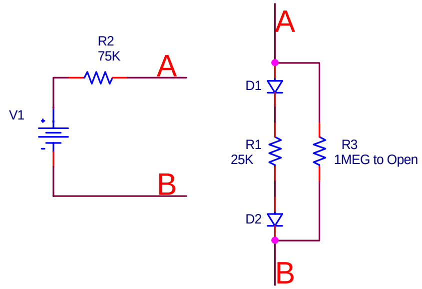
- Comparison between “Diode” and “Resistor” Methods



- ENS(Diode) = Fy· ΔC1·ΔR1·ΔR2

- Fy=Probability to find AC coupled diode scheme in non-Powered DTE

- Fy<1



- ENS(Resistor) = Fx·Fz·ΔP1·ΔP2·ΔP3

  ΔPi=ΔVab/Δ(Element-i), i=1,2,3

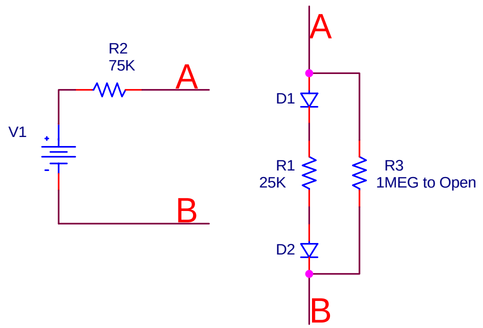
- Fx=Probability to find Resistor+Diode scheme in non-Powered DTE

- Fx<1
- Fz= Positive detection criteria limits
- Practically, V1,R2 tolerance can be ignored by automatic calibration in PSE

Probability of False Positive Detection

- Comparison between "Resistor" and "Diode" methods

  - Practical values (Refer to Annex B for detailed analysis):



- ΔVd= $\pm$ 20%
- ΔR1= $\pm$ 2%
- DR3=1MΩ to open (Leakage current equivalent)
- Fz =Vab Positive detection criteria limits = $\pm$ 2%

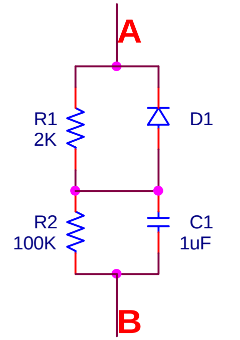
- Generating:
  - ΔVab/ΔVd = $\pm$3.2% max
  - ΔVab /ΔR1 = $\pm$1.2% max
  - ΔVab /ΔR3 = -2% max

- ENS =(3.2$\cdot$2) $\cdot$(1.2$\cdot$2) $\cdot$abs(-2) $\cdot$(2$\cdot$2) $\cdot$ Fx $\approx$ 123$\cdot$Fx

Probability of False Positive Detection

- Comparison between "Resistor" and "Diode" methods

- <u>Measured values (using Nortel prototype)</u>



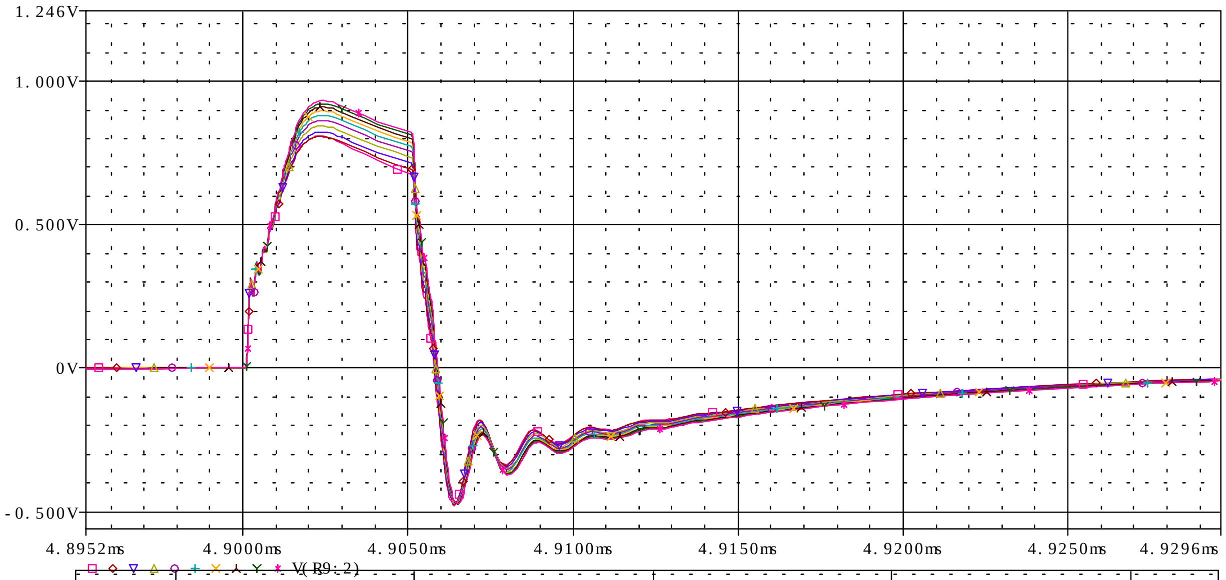
- Software Option A: C1=40nF to Unlimited
  R1=190R to 14K
  R2= from short to open

- Software Option A+B: C1=40nF to 4uF (ΔC1=1000%)
  R1=1.35K to 14K, (ΔR1=750%)
  R2= from 2.7K to open.

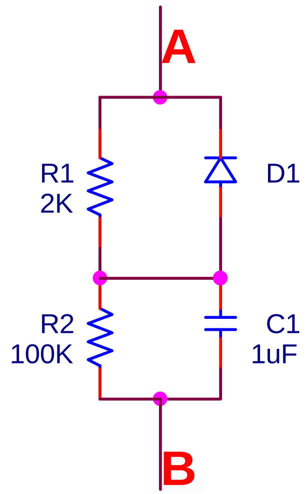
- R2 is actually not needed in Nortel's B.B. (See Annex C for more details)

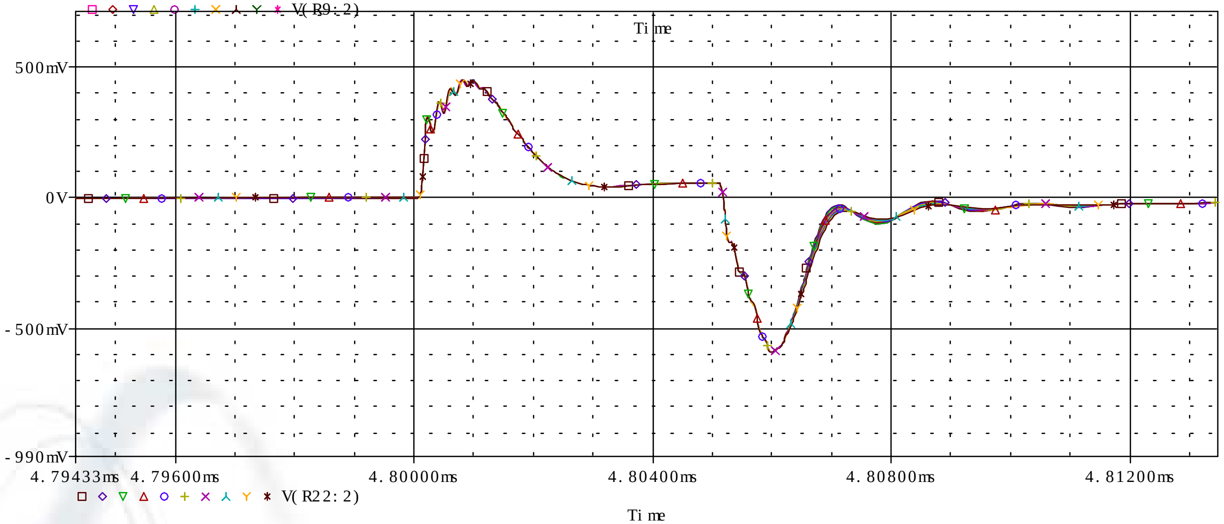
- $ENS = 750000 \cdot Fy \cdot \Delta R2$, Simplifying to $ENS = 750000 \cdot Fy$

Sensitivity Analysis - Changing C1 from 0.5uF to 5uF step 0.5uF



Forward Polarity

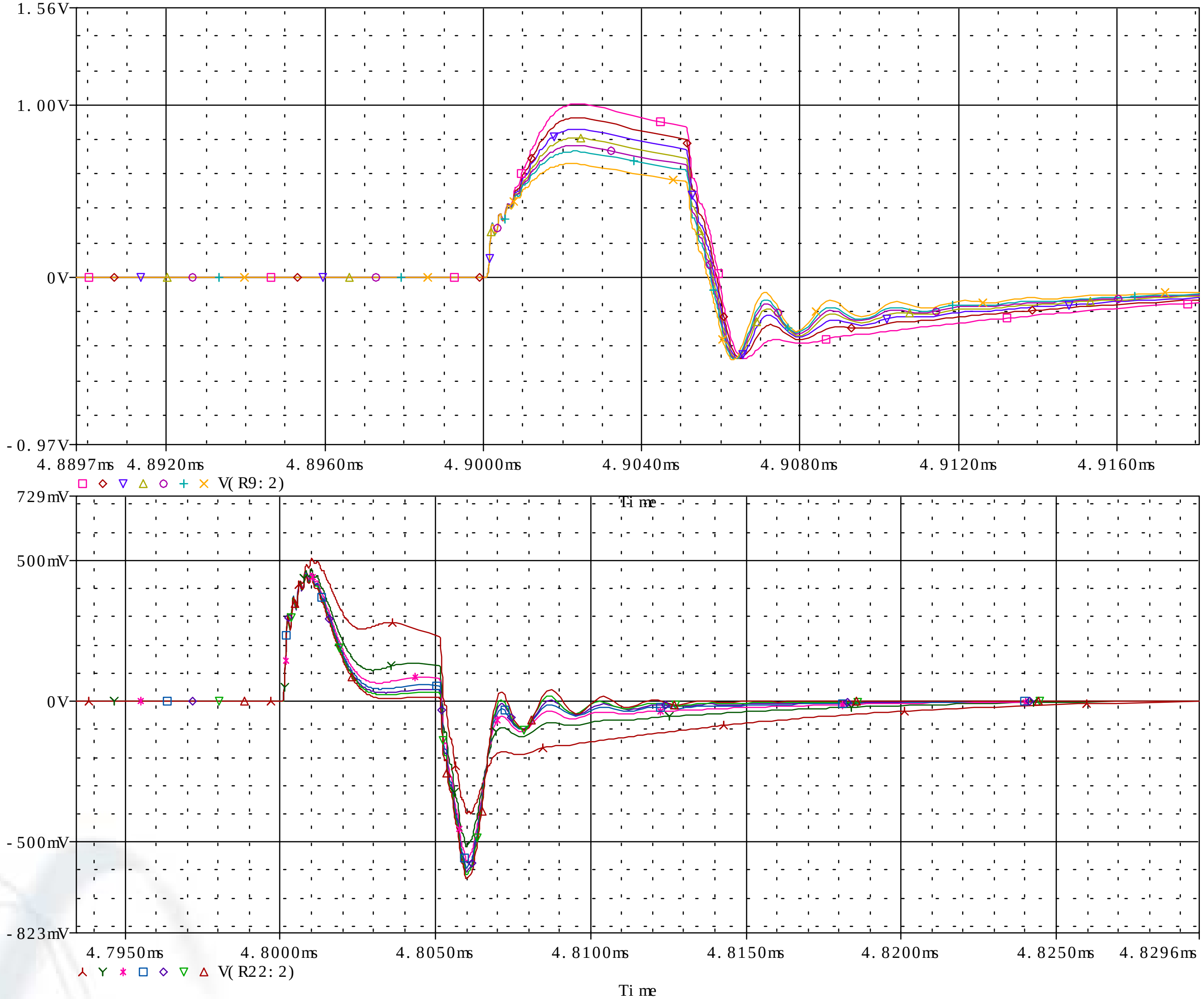




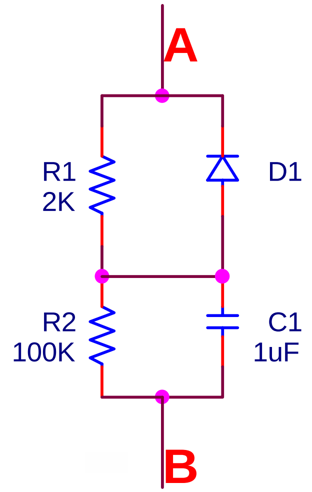
Reverse Polarity

- Refer to Annex A for detailed circuit model.

Sensitivity Analysis - Changing R1 from 0.5KΩ to 5KΩ step 0.5KΩ



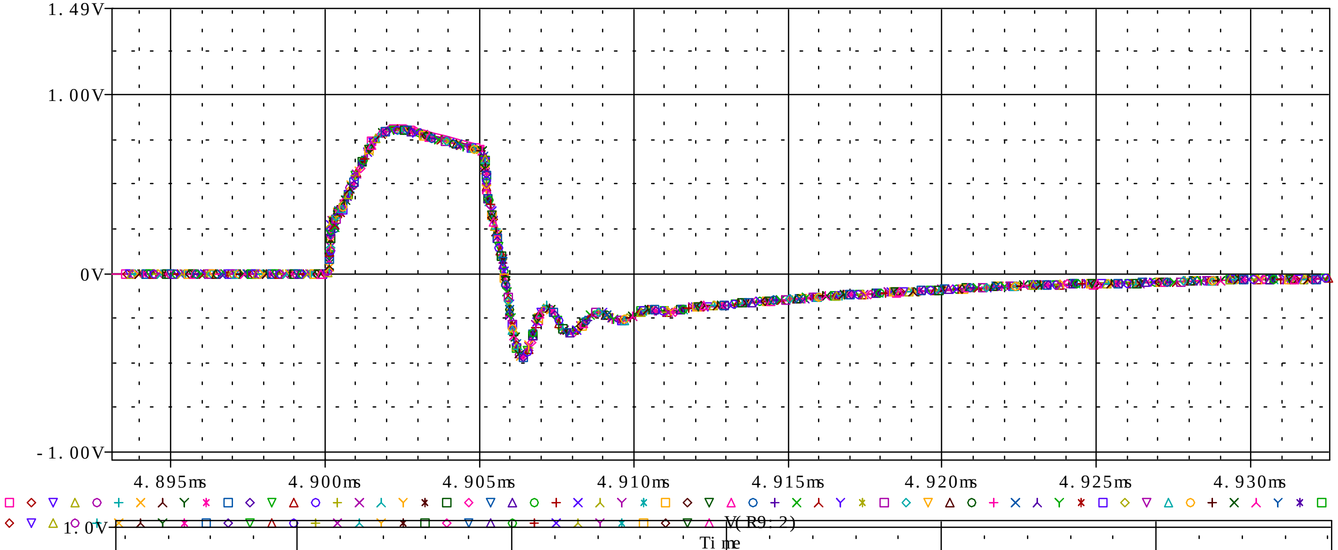
Forward Polarity



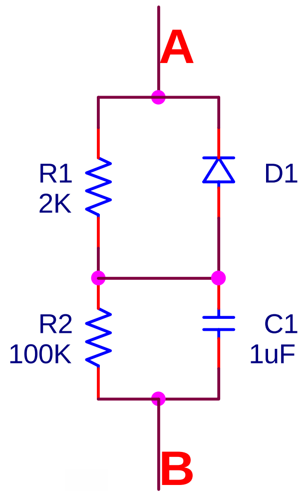
Reverse Polarity

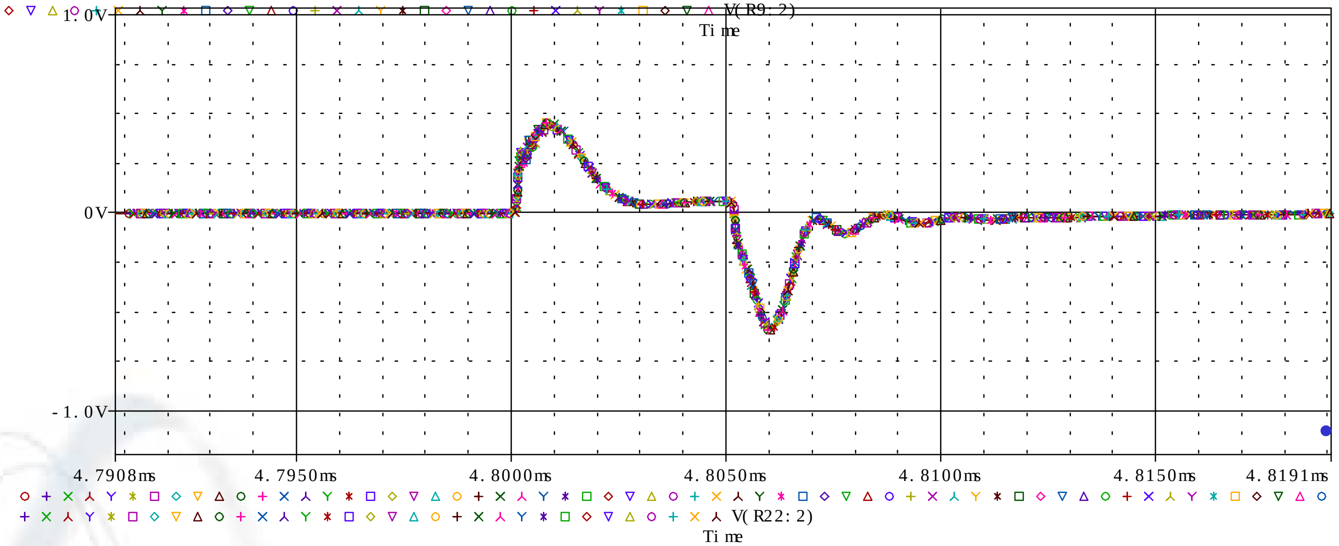
- Refer to Annex A for detailed circuit model.

Sensitivity Analysis - Changing R2 from 10K to 800K step 10K



Forward Polarity





Reverse Polarity

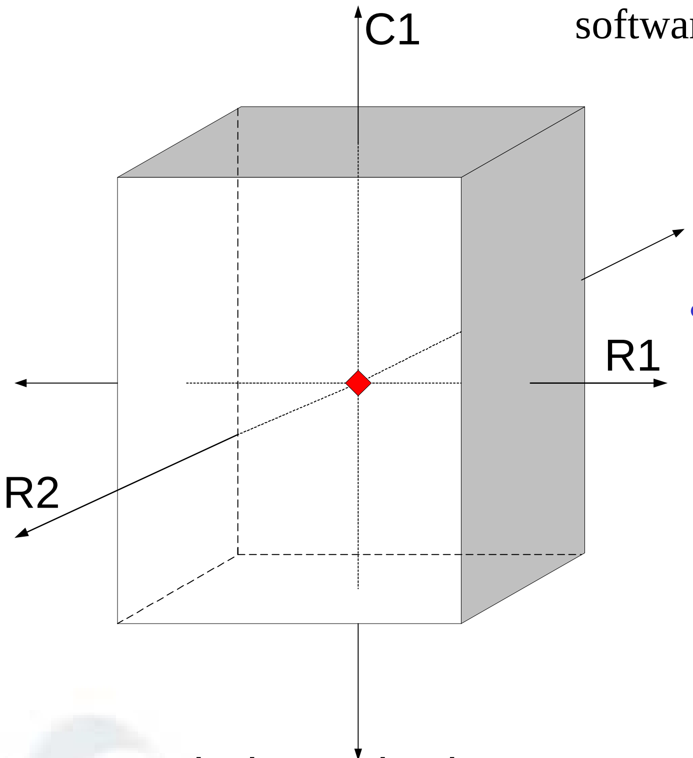
Refer to Annex A for detailed circuit model.

Comparison of Expected Positive Signature Envelope

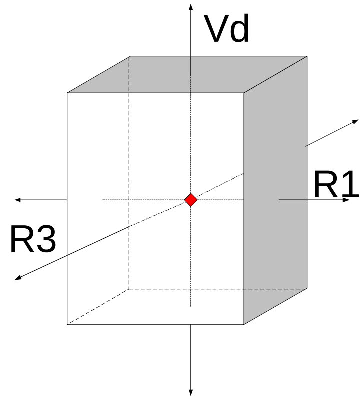
- ENS(Diode)/ENS(Resistor) =(750000/123)·Fy/Fx ≈6100·Fy/Fx

AC coupled diode software algorithm

Diode method and Resistor method Hazard Matrixes



- Ratio ≈6100·(Fy/Fx)



Diode method

- ENS=750000·Fy

Resistor method

- ENS=123·Fx

Comparison of Expected positive signature Envelope

- ENS(Diode)/ENS(Resistor) $=6100 \cdot Fy/Fx$
- What are the values of Fy, Fx?
- We know from Nortel's and Lucent's tests / Hazard Matrix that Fy<1, Fx<1 i.e. the probability to find AC Coupled Diode scheme or "Resistor +Diode" scheme in non-PD or in non-compatible 802.3af powered DTE is low
- Further work is required to determined how low Fy and Fx are. However, we can practically assume that they are with the same order of magnitude
- In order to match the resistor method, the factor $6100 \cdot Fy/Fx$ should be approximately 1

"Behavioral" Signature Detection vs. "Absolute" Signature Detection

- Expecting the "Correct Signal" at a specific set of conditions is "Behavioral" Signature Detection
  - Allows for different implementations
  - All Implementations will generate "correct results"
  - Insensitive to circuit elements value

- Expecting a "Specific" value at a specific set of conditions is "Absolute" signature detection
  - Allows for a single (theoretically) implementation
  - Only one value will generate valid result
  - Highly sensitive to elements value change

"Behavioral" Signature vs "Absolute" Signature Detection

- AC Coupled diode scheme is of a Behavioral type
  - Wide components value range generates valid identification
  - Probability of wrongly powering non-PD may be increased.
- Resistor scheme is of an Absolute type
  - Wide components value range will not generates valid identification
  - Low probability for powering non-PD

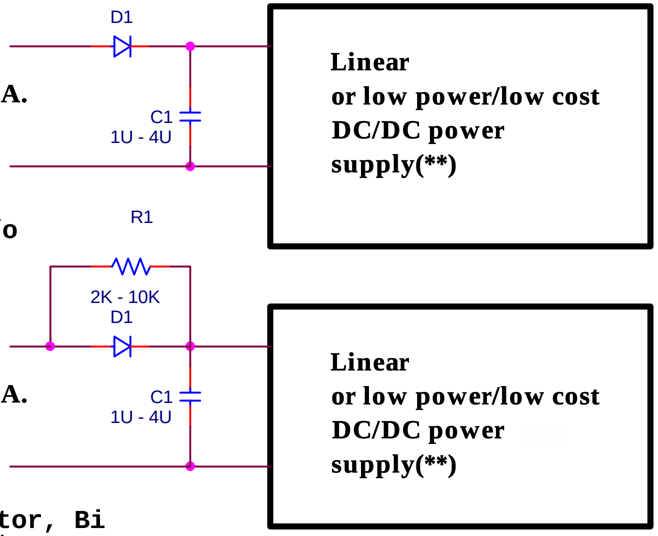
Demonstration of AC coupled diode behavior

- Reverse polarity protection used in some DC/DC converters, exhibits behavior of an AC coupled diode if PD power supply is accidentally reversed.
  - If detection algorithm ignores polarity, it will happen at correct connection as well.

AC Coupled diode behavior
***Can be detected with Nortel's prototype, software option A.**
***Can not be detected with software option B.**

R1 is used for fast discharge of input cap w/o dissipation power at normal operation

AC Coupled diode behavior
***Can be detected with Nortel's prototype, software option A.**
***Can be detected with software option B.**



(**) In low power / low cost switching regulator, Bi Polar transistor is used as the switch element

Test conditions:

- Feeding through data pairs
- PD contains reverse polarity protection circuit
- Connection from PSE to PD is done with straight and with cross-over cable.

Summary

- 802.3af specification should define the detection scheme type required, Absolute or Behavioral. (I.e. sensitive to component values or not)
- An Absolute type scheme may exhibits higher immunity to False Positive Detection.
- False positive detection due to AC coupled diode Behavioral nature, has been demonstrated by using Nortel's prototype.
  - Further work needed to reduce the factor $6100 \cdot Fy/Fx$.
  - It is recommended to reduce the factor "6100" in the AC coupled diode method.

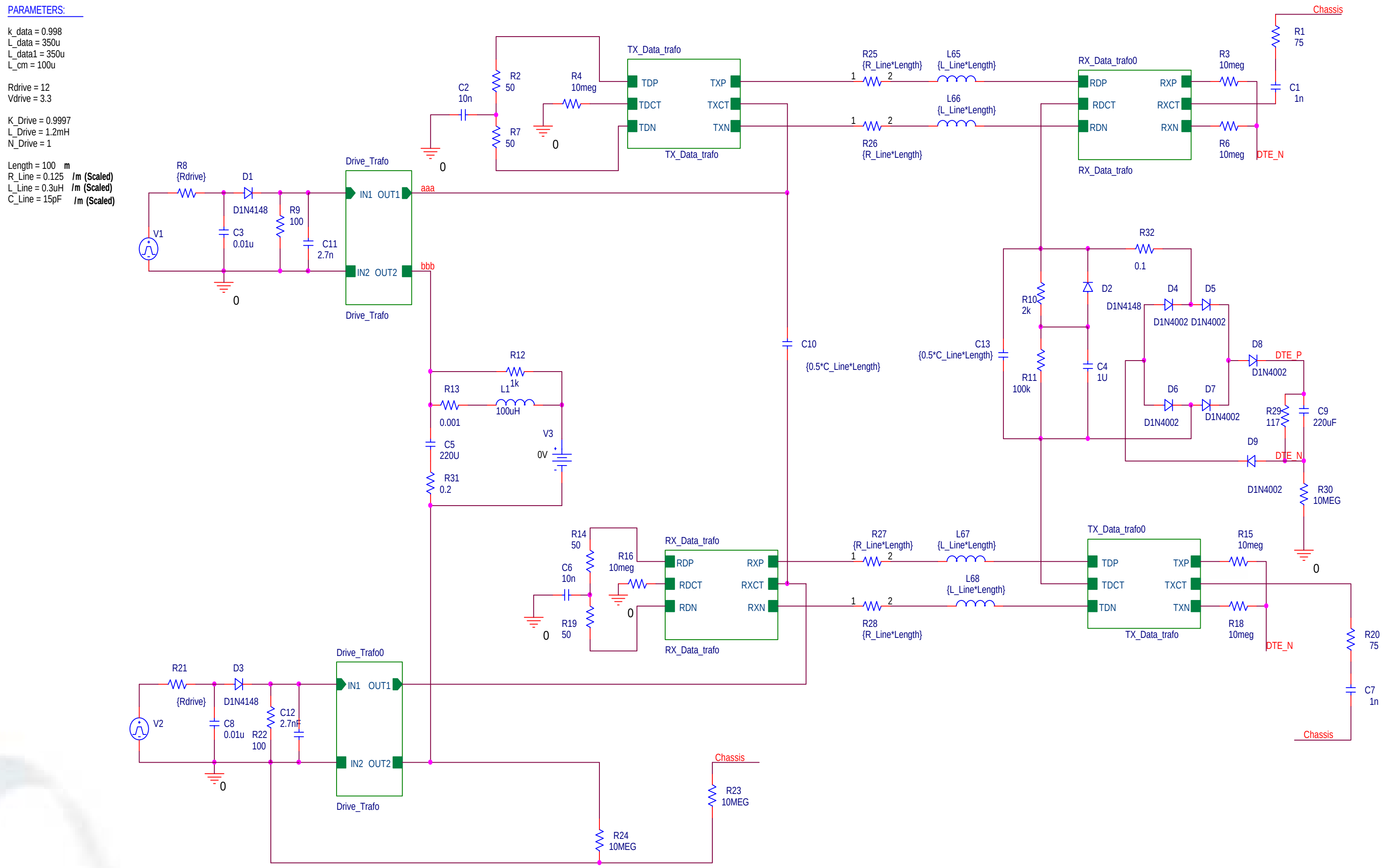
Summary

- Improvements to AC Coupled Diode software/hardware should be considered in order to narrow the components tolerance which will generate positive results.

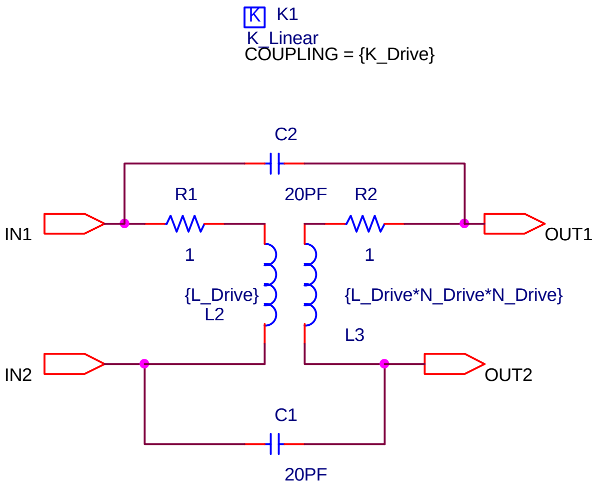
  - Enhancing software option B, by setting min/max range for the higher duty cycle needed to charge C1 and getting no pulse in either diode polarity (Enhancements to Nortel’s option B software).

  - AC coupled diode detection algorithm can be enhanced towards Absolute type by implementing the Transformer-less solution of the AC coupled diode method, as described in PowerDsine presentation Sep./2000

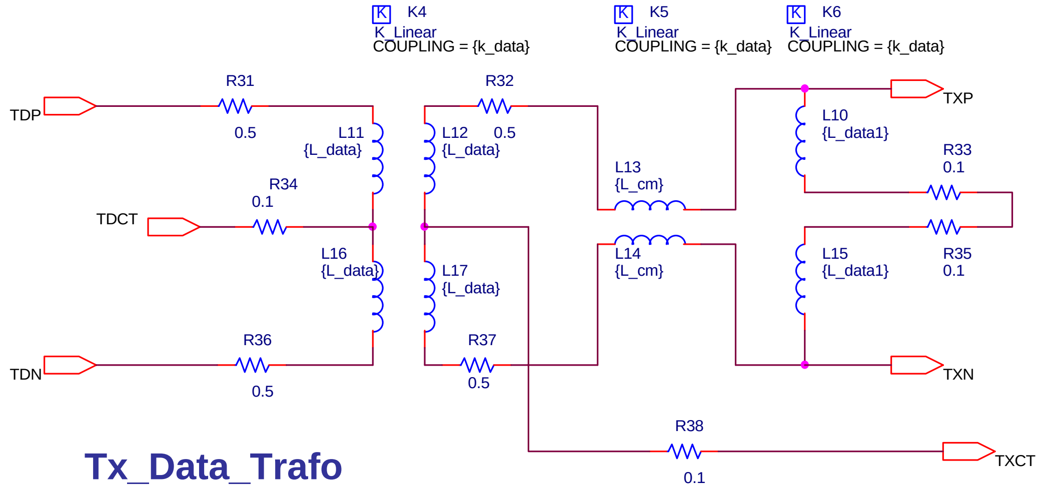
Annex A - Electrical Model for Circuit Elements During Detection Mode.



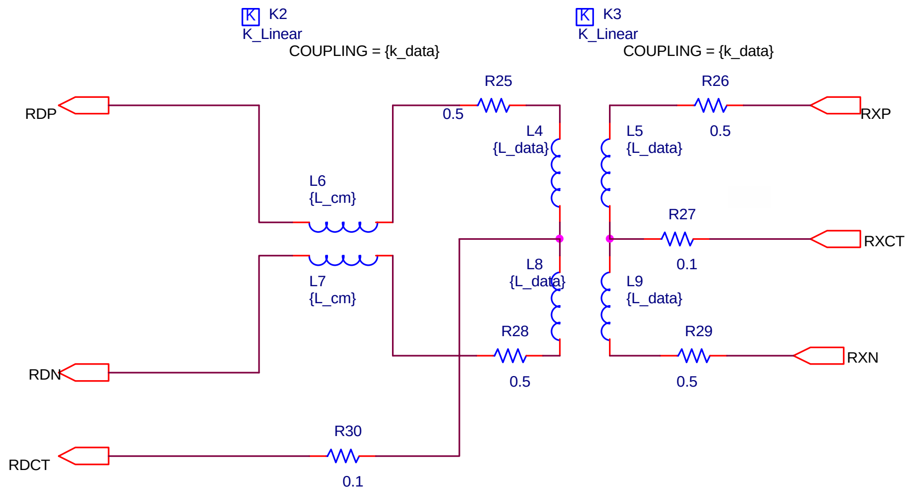
Annex A - Cont.



Drive_Trafo



Tx_Data_Trafo



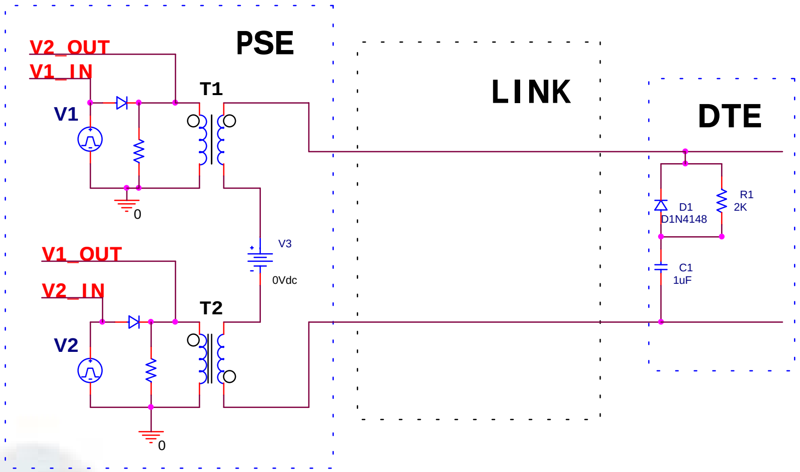
Rx_Data_Trafo

Annex B - Detailed Sensitivity Analysis for Resistor Method

- **Vab = (Vtest/R2 + 2Vd/R1) / (1/R1+1/R2+1/R3)** (Eq-1)
- For the following values:
  - R1=25K ±2%, R3=1MΩ to Open, Vd=0.75V ±20% (±5 tolerance & ±15% change due to ±50°C around 25°C ambient temperature)
  - Vtest=24V±2%, R2=75K ±2% are considered to be locked on their nominal value by internal PSE calibration.
- Under the above conditions Eq-1 can be written as follows:
- **Vab = (0.00032 + 2Vd/R1) / (0.0000133 +1/R1+1/R3)** (Eq-2)
- ΔVab/Vd = ±3.2 % max.
- ΔVab /ΔVR1 = ±1.2 % max.
- ΔVab /ΔR3 = -2% max.
- Combined Worst case analysis = Vab +4.3%, -6.1%

Annex C - Why R2 is not needed in AC coupled diode scheme

- R2 is not needed in AC coupled diode scheme due to the fact that the capacitor C1 (1uF) is discharged through R1 (2K).



Simplified detection elements model during detection mode, with out R2.