IEEE 802.3af DTE Power via MDI

PSE Based **Disconnect-Detection Alternative**

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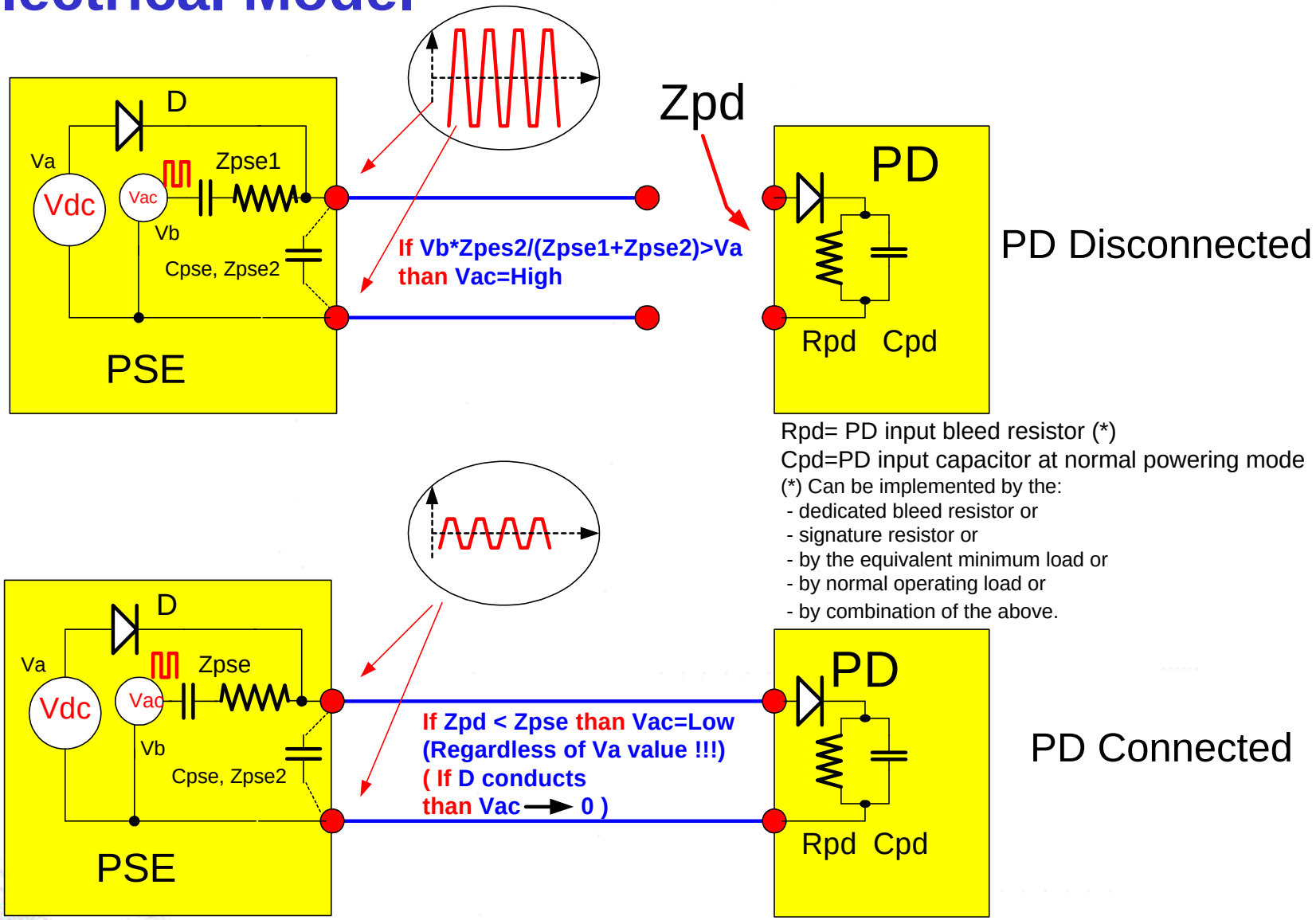
Acknowledgments to: Alon Ferentz, Oren Lavi, Nadav Barnea.

Objectives

- Description of PSE based disconnect detection alternative.
- Looking for concept that is not a function of PD load DC current.
- Presenting how the proposed concept can be
  - Simple
  - Robust
  - Free of EMI
  - Without effect on data integrity
  - Without effect on signature detection function
  - With Low parts count

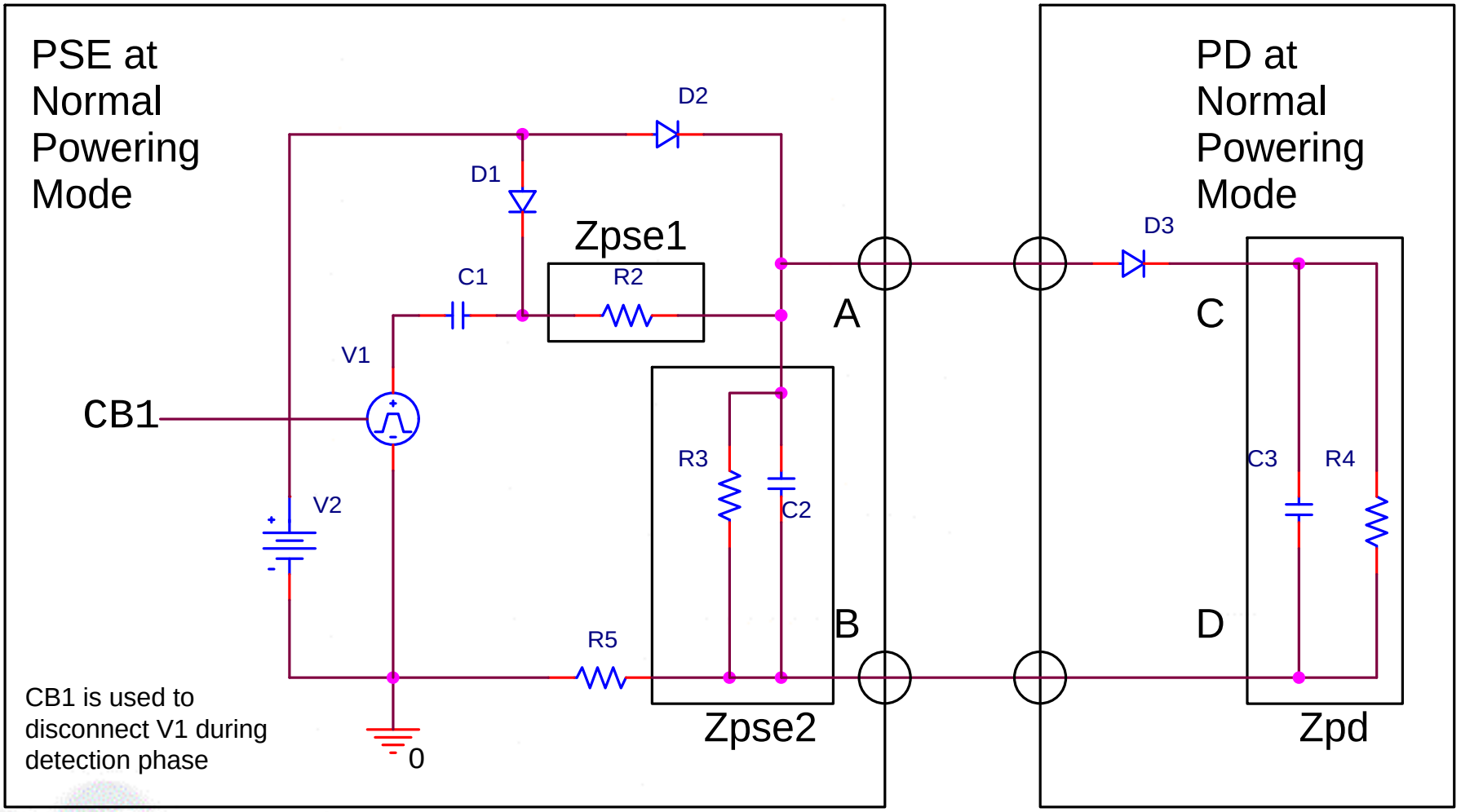
Electrical Model



Key Points

- Detecting PD input impedance by ac signal
- Pd input impedance could be
  - Capacitance (without series diode) or
  - Resistance (with or without series diode) or
  - Combination of series diode and capacitance||resistance

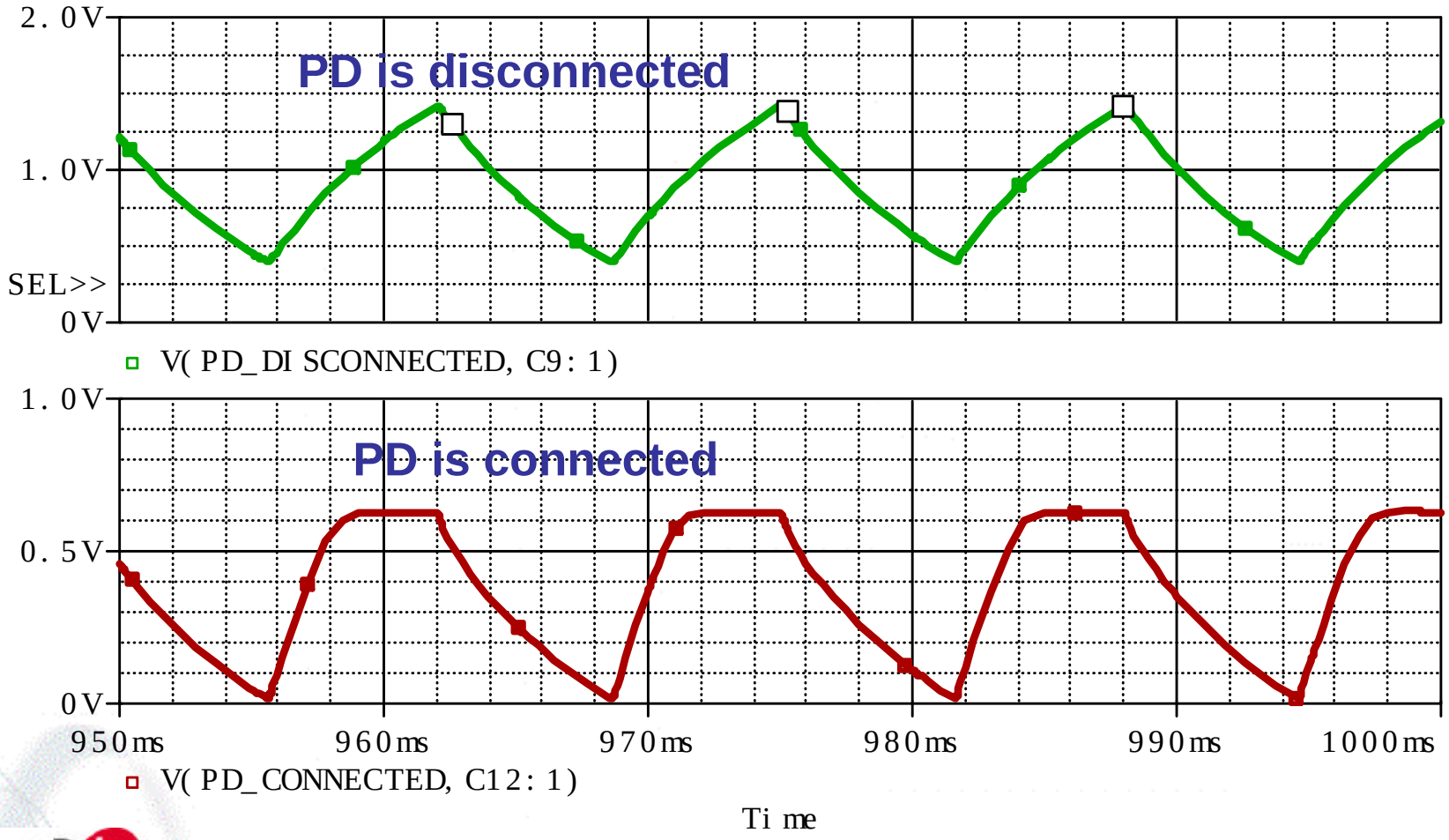
Real Circuit



Simulation Results- Detected AC Signal

PSE main dc source=0V. ➔ No dependence on DC load current

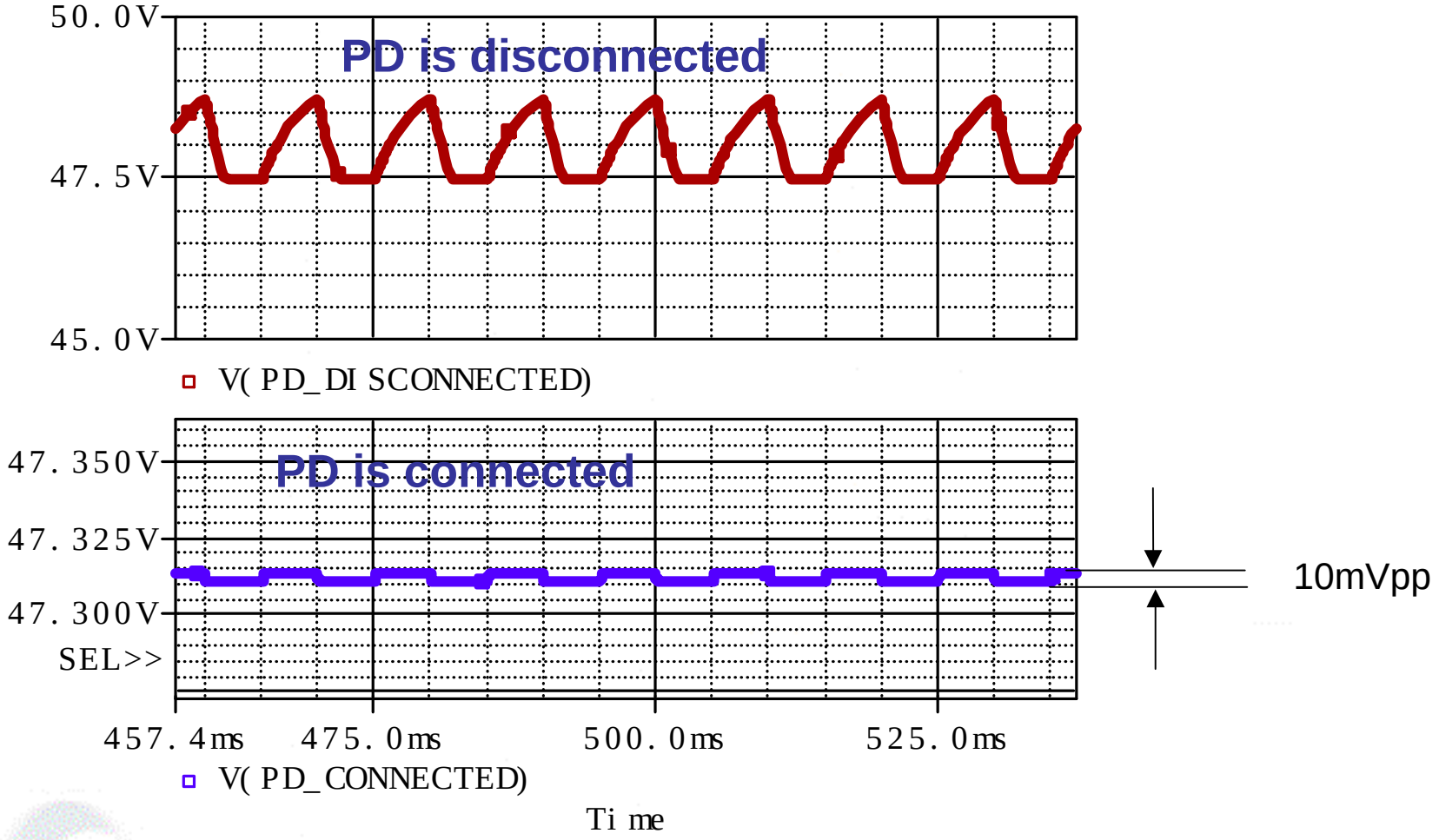
R2=25K, C2=0.33uF, C3=100uF, R4=25K



Simulation Results- Detected AC Signal

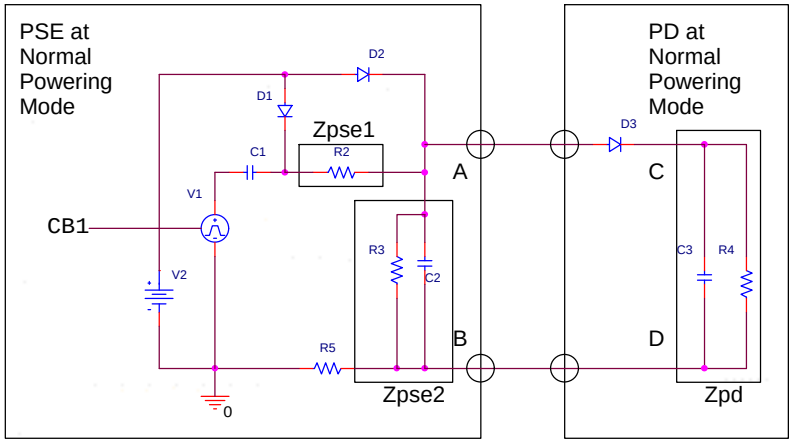
PSE main dc source=48V

R2=6.8K, C2=0.33uF, C3=100uF, R4=25K



Numbers

- AC source signal:
  - Low frequency (50 -150Hz, 50% Duty), 3.3V or 5V logic levels or lower.
  - Cpse max=0.52uF
  - C1, D1 can be used for all ports in a multi-port system. C1=5-22uF
  - D2, R2 required for each port. R2=6.8K or higher



- PD
  - Cpd min = 5uF
  - Need min. bleed resistor to discharge Cpd which is already there.
  - PD min DC current = Don't care due to the fact that the concept works with Vpse=0V as well.

More on the concept..

- When PD is disconnected
  - No Current ➔ No EMI
- When PD is connected
  - Low ac Voltage through high impedance and Low frequency ➔ Very low EMI (close to zero)
- Low frequency AC voltage up to 0.5Vpp allowed according to IEEE802.3af when PD is connected and draws min power.
- When PD is not connected (@ zero load) AC voltage amplitude is not limited. (Practically it is limited by the 57V-44V difference until the power is removed)
- Concept is based on Load-dependent Low Pass Filter

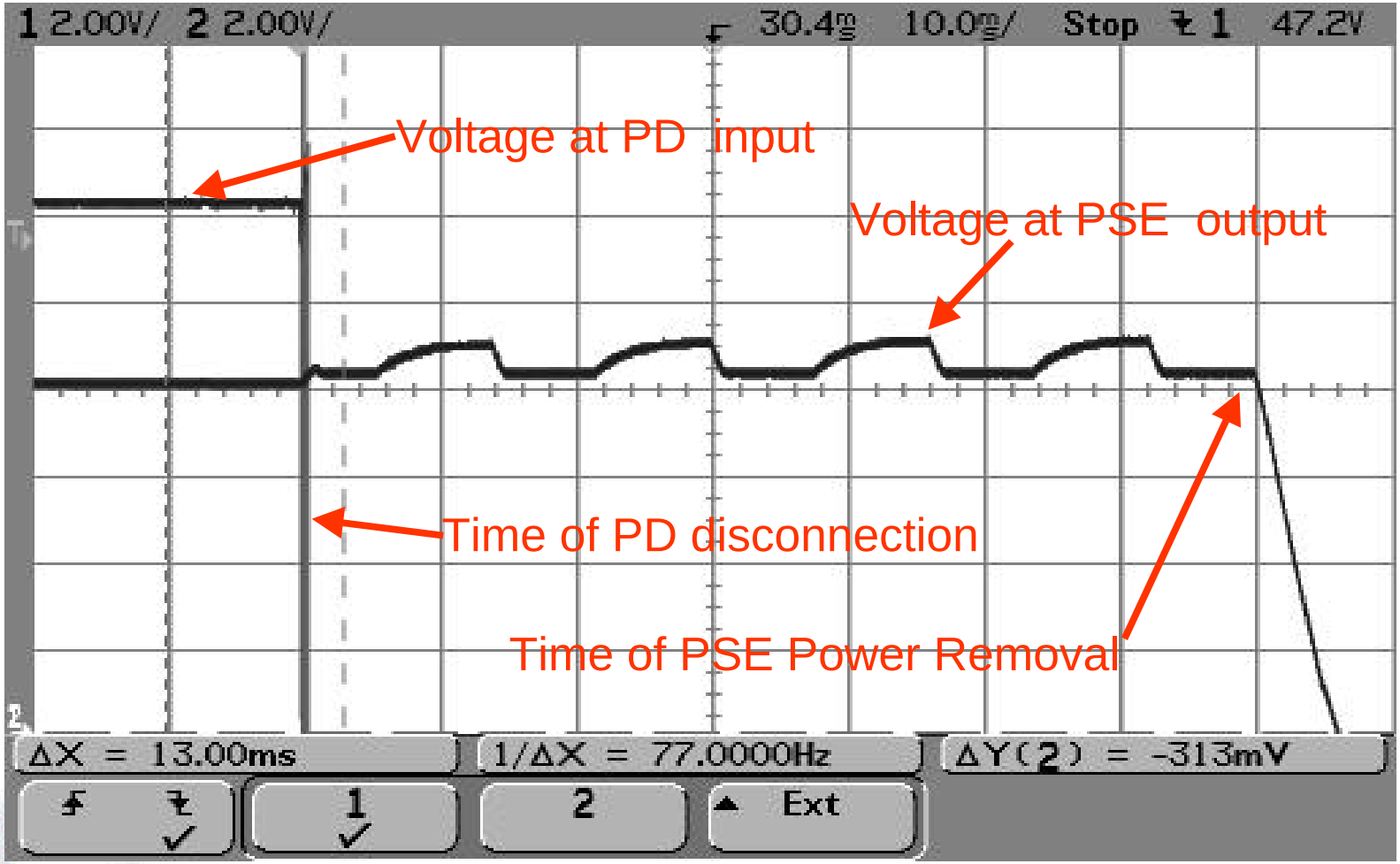
Detection and Disconnect Detection Comparison

Parameters	Probing Signal			
	PD is connected		PD is disconnected	
	Detection	Disconnect Detection	Detection	Disconnect Detection
Amplitude	30V/4=7.5Vpp max	0.5Vpp max	30Vpp	1Vpp - 5Vpp
Frequecy	1Hz - 400Hz	50Hz - 150Hz	1Hz - 400Hz	50Hz - 150Hz
Rise time	10us min	10us min	10us min	10us min
Fall time	10us min	10us min	10us min	10us min

- Disconnect detection ac signal parameters are similar in nature to the Detection probing signal.
  - Numbers can be scale down to any desired value, limited by component accuracy.
- By similarity, the proposed disconnect detection is not contributing to EMI noise nor impair data integrity.
- Confirmed by Lab tests.

LAB Tests and Simulations

Functional Lab Tests

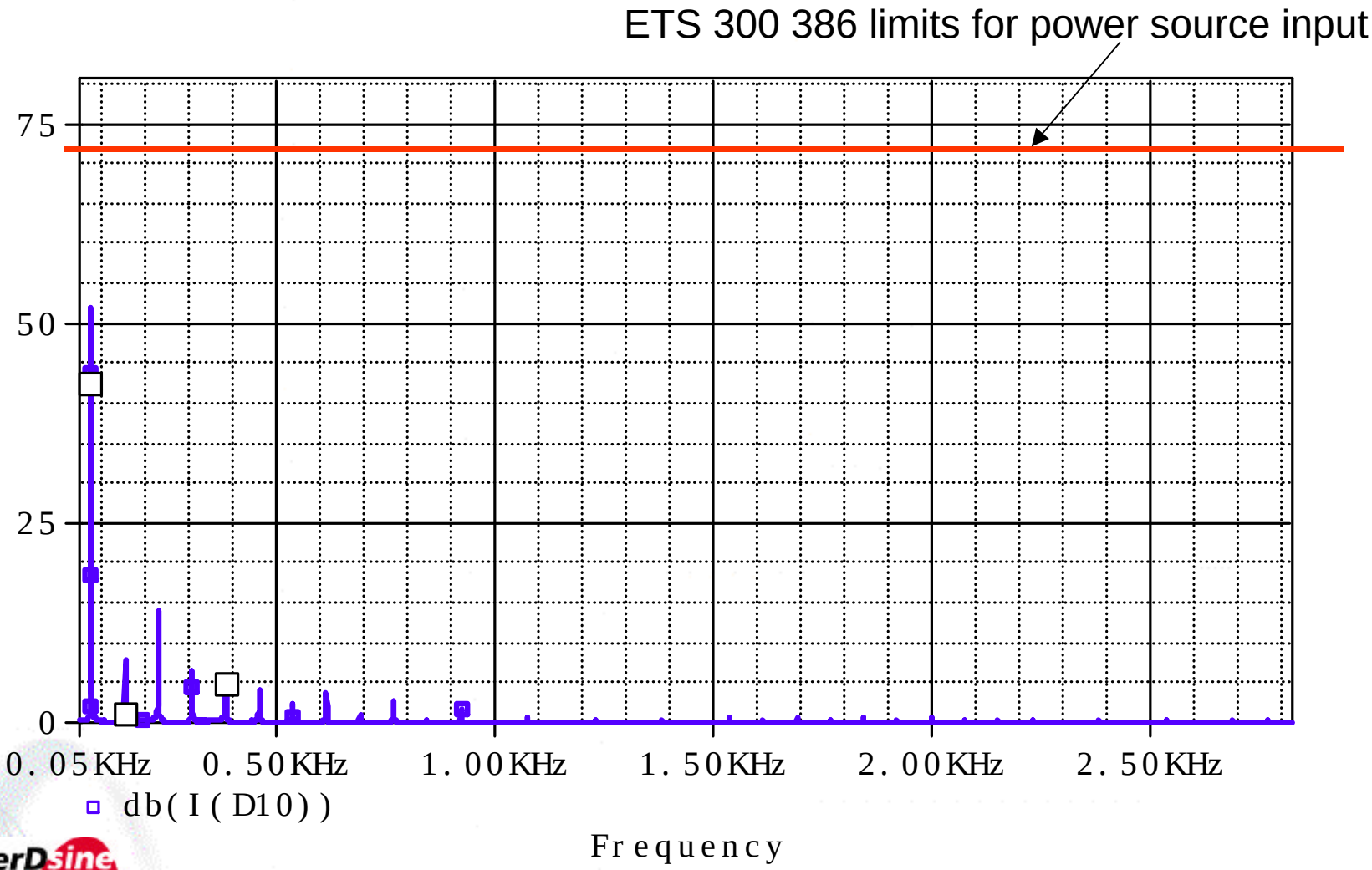


Lab Tests – 10/100 Data Tests

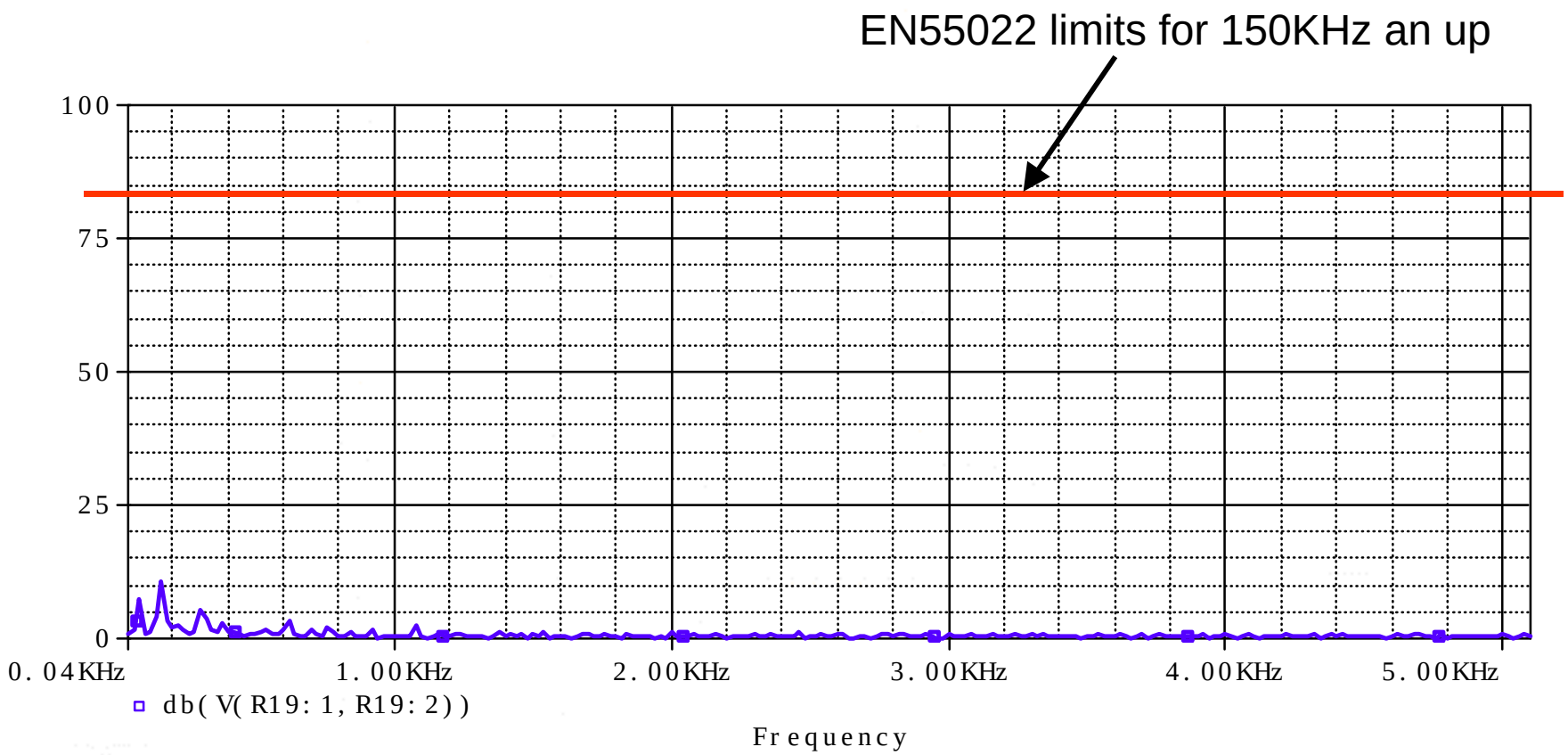
- On each port in a 24 port system
- No changes in results during PD disconnection
- No changes in results for Midspan PSE and End point PSE
- Tested for 10m to 140m, step 20m CAT 5 cables

SmartCounters	Events	Rates	Events	Rates
	2-02 LN-3100A	2-02 LN-3100A	2-03 LN-3100A	2-03 LN-3100A
Tx Frames	642,246,716	148,810	642,246,692	148,810
Rx Frames	642,246,717	148,810	642,246,693	148,810
Rx Bytes	41,103,789,827	9,523,884	41,103,788,337	9,523,885
Collisions	**0**	**0**	**0**	**0**
CRC Errors	**0**	**0**	**0**	**0**
Alignment Errors	**0**	**0**	**0**	**0**
OverSize	**0**	**0**	**0**	**0**
Frag/UnderSize	**0**	**0**	**0**	**0**

EMI Simulations:
Conducted Emission – Differential Mode at Port Output



EMI Simulations:
Conducted Emission – Common Mode Noise



EMI - Radiated Emission

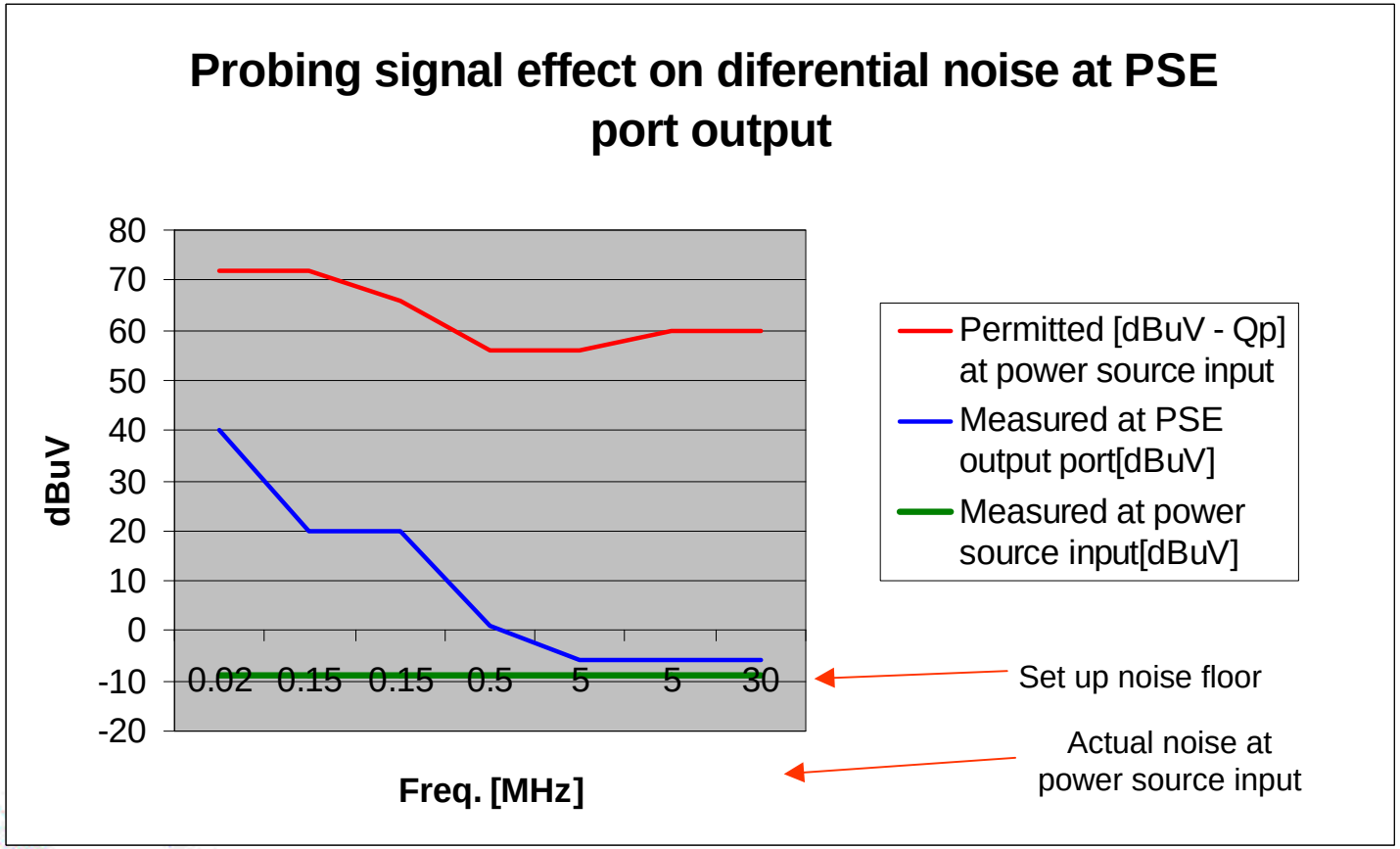
- The requirements starts from 30MHz and ends at 1000MHz
- 30MHz is the ~300,000 harmonic of the fundamental frequency which generates close to zero radiated field.
- Confirmed by Lab tests.

Lab Results: Radiated emission

- (Single and Multi-port system with 3.3Vpp ac source, tr=tf>10uS)
- Reading: less than –26dBuV/m @ 30MHz to 230MHz (setup noise floor)
- Standard requirement: <30dBuV/m from 30MHz to 230MHz @ class B
- Margin: More than 56dB

EMI Tests: Conducted Emission (differential)

- On each port in a 24 port system (Not required by EMI standards at power source output)
- No changes in results for Midspan PSE and End point PSE
- Tested for 10m to 140m, step 20m CAT 5 cables



Differential Conducted Emission Results

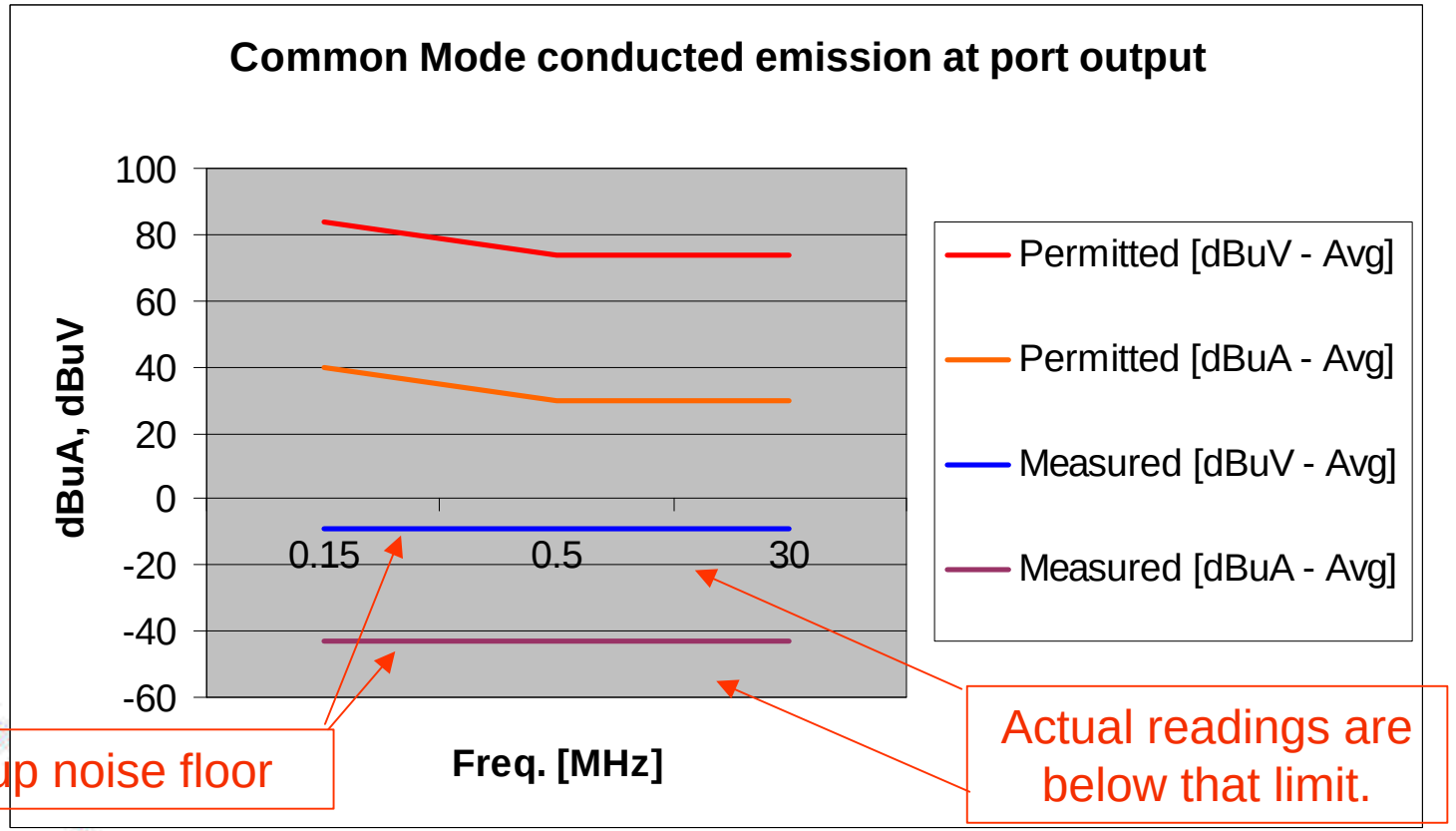
- Source voltage = 3.3Vpp, Duty=50%, tr=tf=10uS, f=77Hz.
- Worst case measurements 5uF<C<570uF, 0.125K<R<26.25K.
- EN555022 and CISPR Class B limits

STD.	Freq.[MHz]	Permitted at power source		Measured at power source	
		input [dBuV - Qp]	output[dBuV - Qp]	output[dBuV]	input[dBuV]
NA	0.0001	NA	NA	73	-9
NA	0.0005	NA	NA	55	-9
NA	0.0008	NA	NA	51	-9
NA	0.001	NA	NA	48	-9
NA	0.01	NA	NA	40	-9
ETS 300 386-1	0.02	72	NA	40	-9
ETS 300 386-2	0.15	72	NA	20	-9
EN55022, CISPR 22	0.15	66	NA	20	-9
EN55022, CISPR 22	0.5	56	NA	1	-9
EN55022, CISPR 22	5	56	NA	-6	-9
EN55022, CISPR 22	5	60	NA	-6	-9
EN55022, CISPR 22	30	60	NA	-6	-9

Setup noise floor.= -9dBuV = 0.355uV

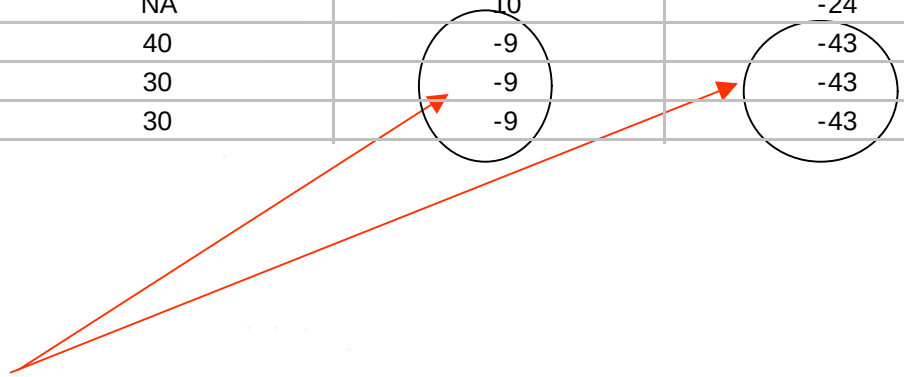
EMI Tests: Conducted Emission (Common Mode)

- On each port in a 24 port system (Required by EMI standards for Telecom ports)
- No changes in results for Midspan PSE and End point PSE
- Tested for 10m to 140m, step 20m CAT 5 cables



Common Mode Conducted Emission Results

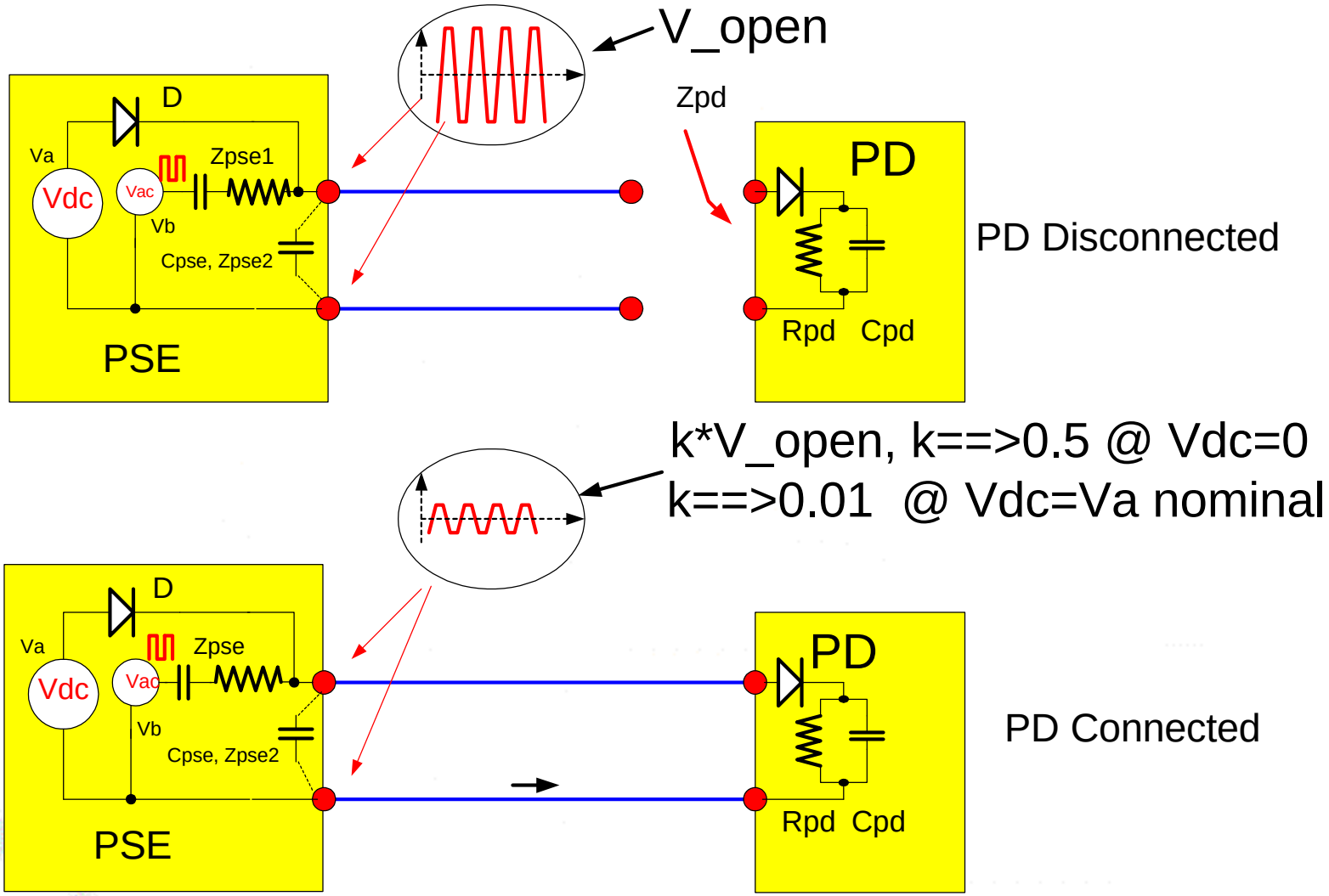
STD.	Freq.[MHz]	Permitted [dBuV - Avg]	Permitted [dBuA - Avg]	Measured [dBuV - Avg]	Measured [dBuA - Avg]
NA	0.0001	NA	NA	43	9
NA	0.0005	NA	NA	25	-9
NA	0.0008	NA	NA	21	-13
NA	0.001	NA	NA	18	-16
NA	0.01	NA	NA	10	-24
NA	0.02	NA	NA	10	-24
EN55022, CISPR 22	0.15	84	40	-9	-43
EN55022, CISPR 22	0.5	74	30	-9	-43
EN55022, CISPR 22	30	74	30	-9	-43



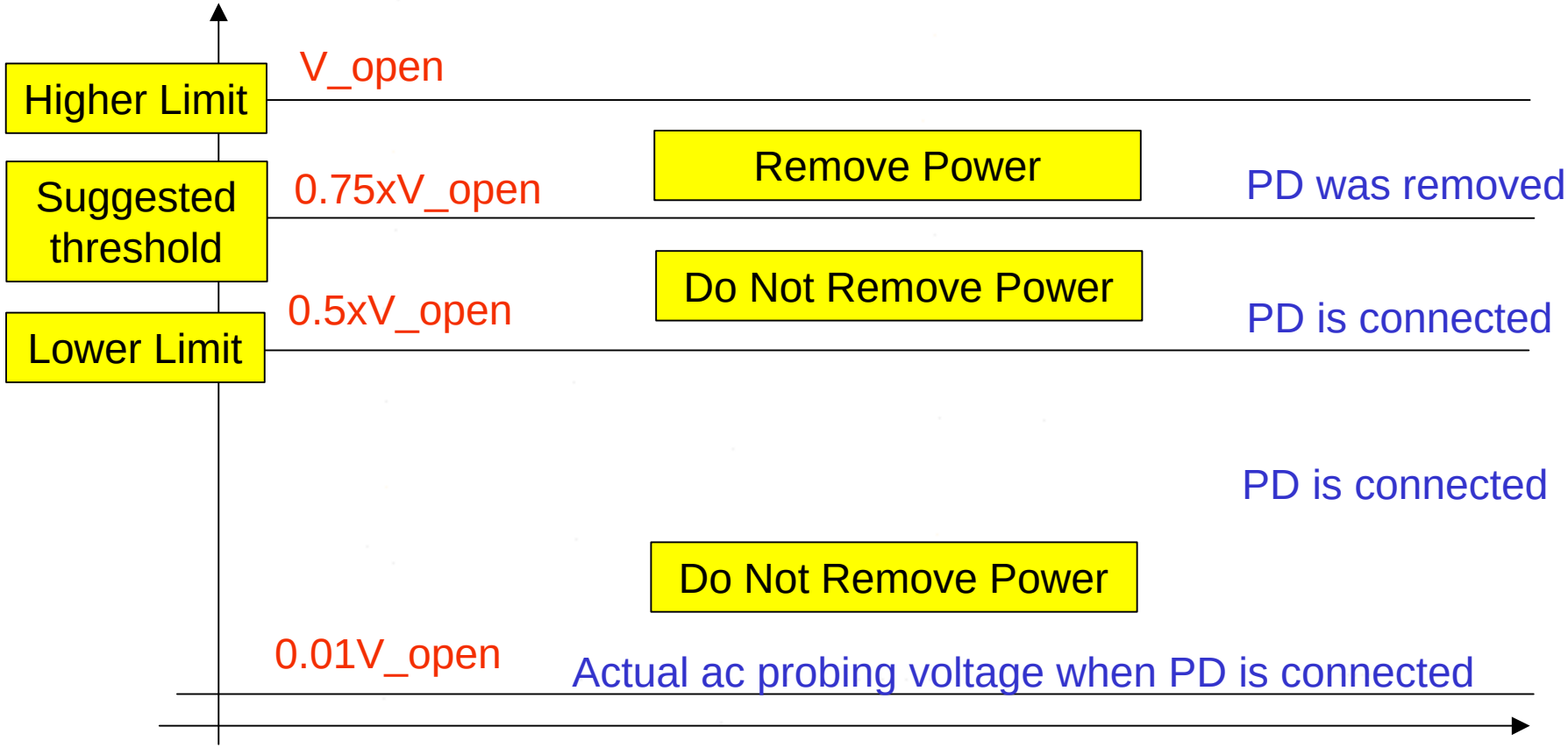
Setup noise floor = -9dBuV = 0.355uV

- 43dBuA = 7nA

AC Probing Voltage – Compatibility to IEEE802.3af



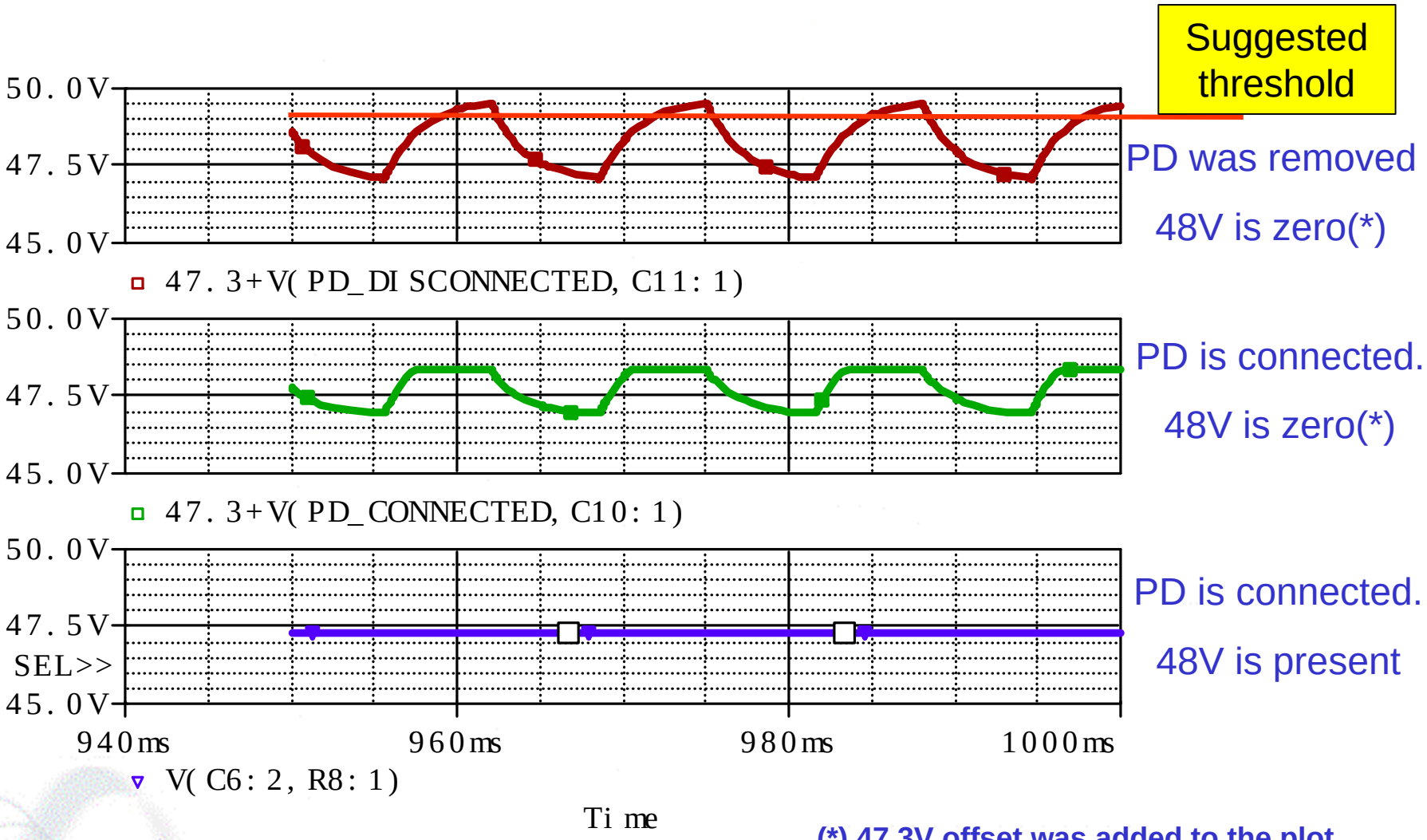
AC Probing Voltage – Compatibility to IEEE802.3af



V_open = port ac probing voltage when the PD is not connected

0.01xV_open <= 0.5Vac_pp to meet IEEE802.3af (0.5Vpp up to 500Hz).

AC Probing Voltage – Compatibility to IEEE802.3af



(*) 47.3V offset was added to the plot to keep the same scale.

AC Probing Voltage – Sensitivity Tests

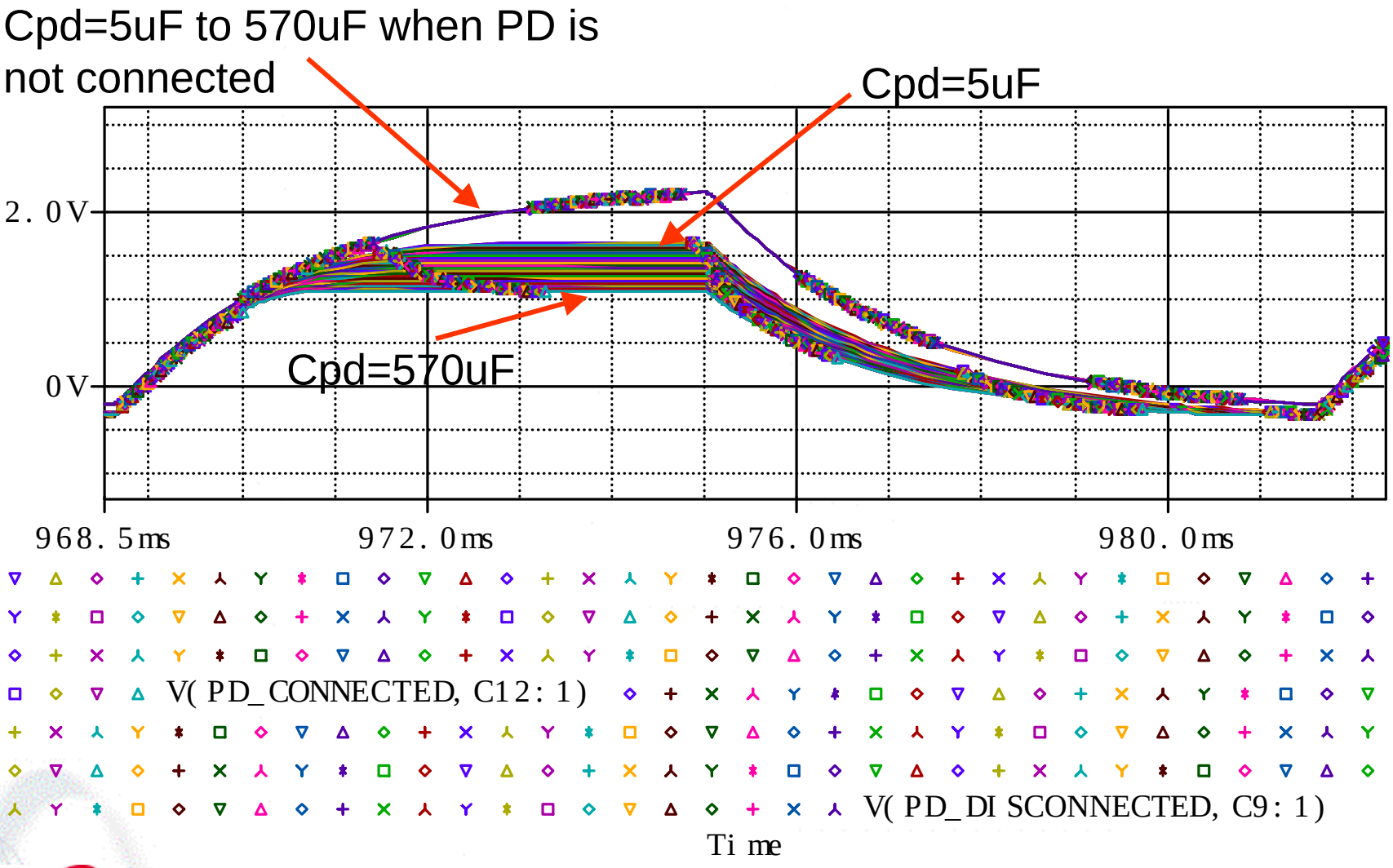
- Concept tested and works with:
  - 1Vpp < V_open < 5Vpp at PSE output port when PD is disconnected.
  - 0.125Vpp < V_port < 3Vpp when PD is connected w/o DC source.

Prototype - Lab Results

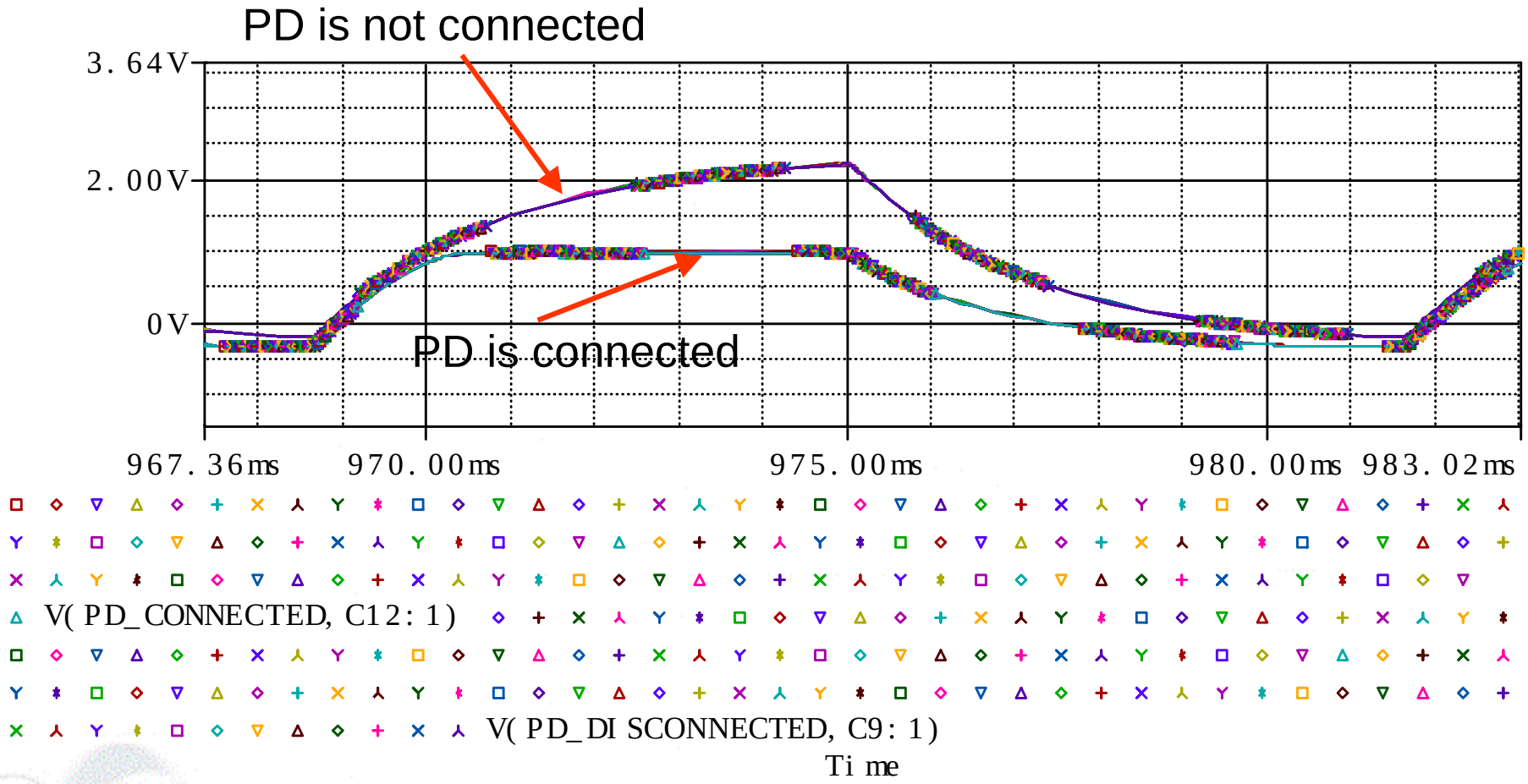
- Functional tests for single port = OK
- Functional tests for multi-port = OK
- DATA tests for single port = OK
- DATA tests for multi-port = OK
- EMI for single port = OK
- EMI for multi-port = OK

Sensitivity Analysis

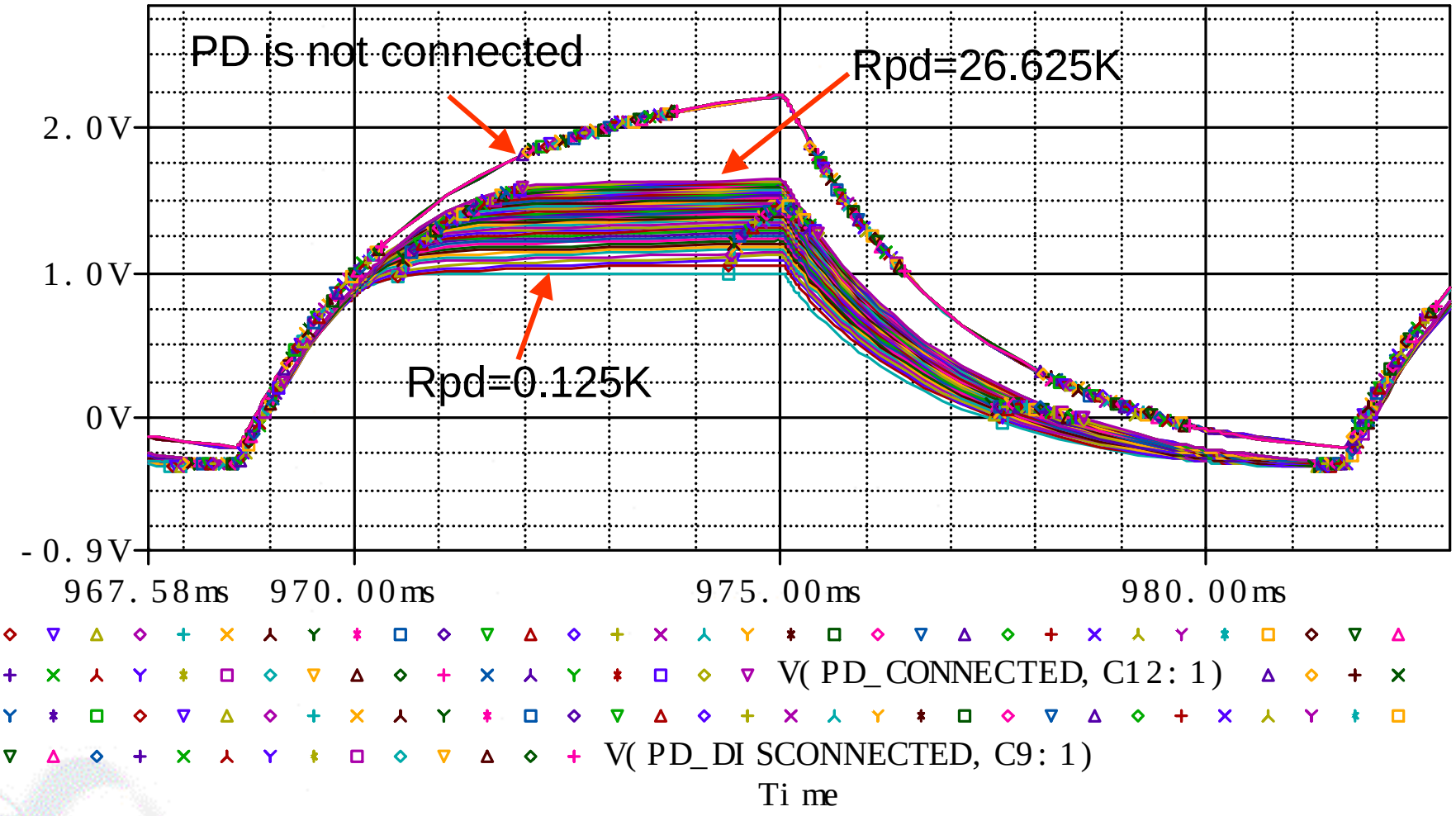
Sensitivity Simulations -1:
Rpd=26.5K. Cpd changes from 5uF to 570uF step 5uF.



Sensitivity Simulations - 2:
Rpd=125. Cpd changes from 5uF to 570uF step 5uF.

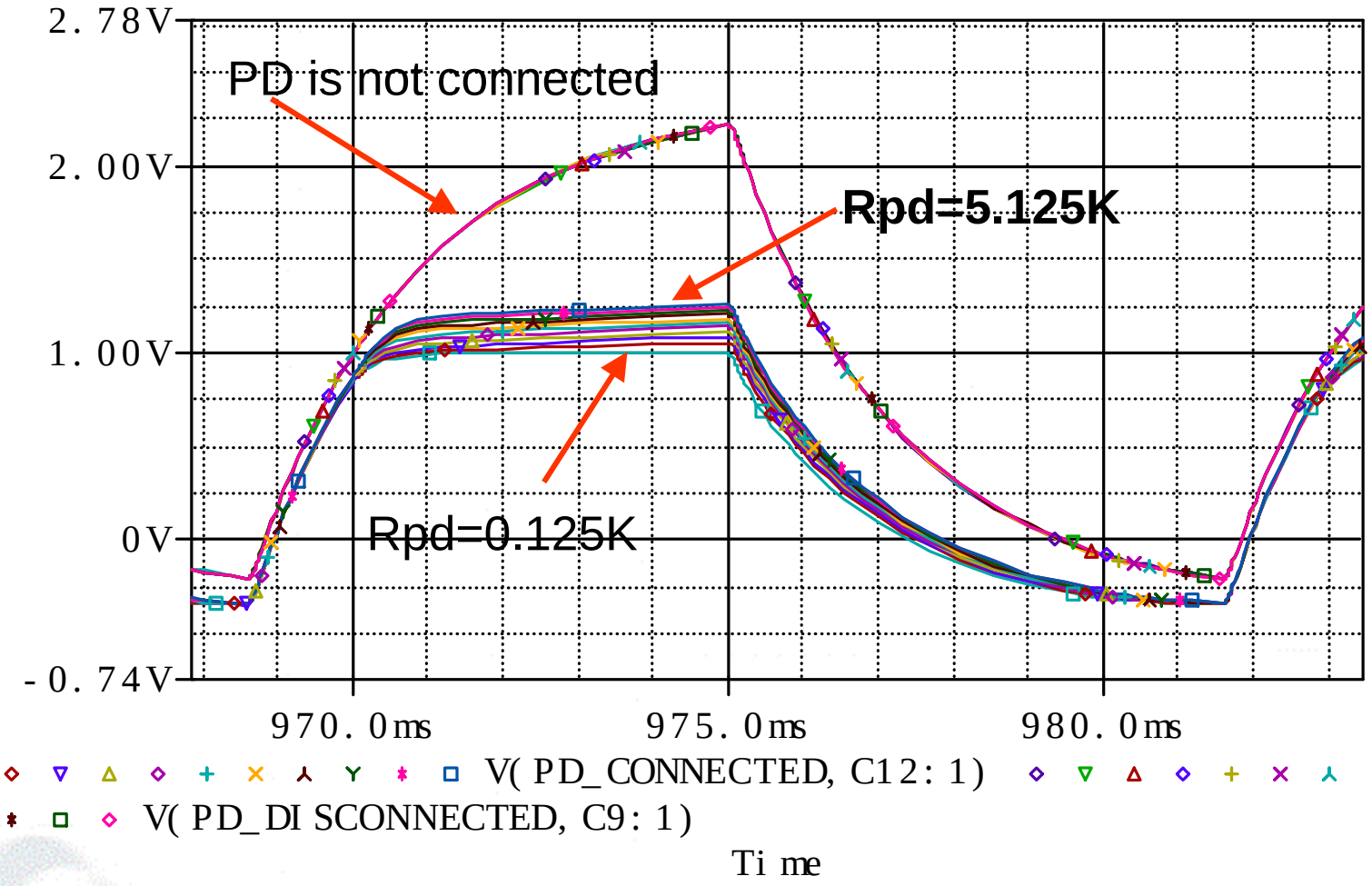


Sensitivity Simulations - 3:
Cpd=5uF. Rpd changes from 0.125K to 26.625K step 0.5K



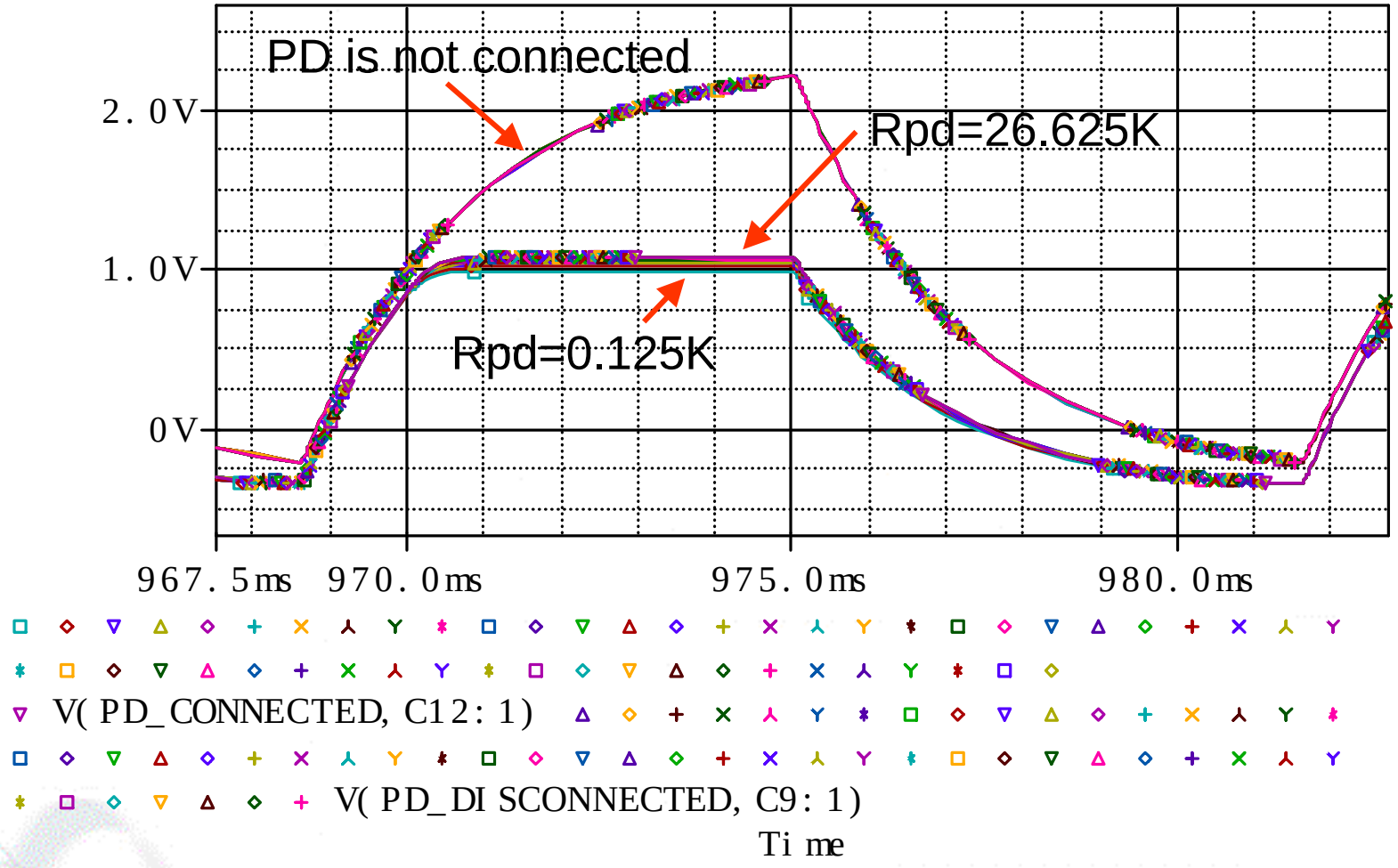
Sensitivity Simulations - 4:

Cpd=5uF. Rpd changes from 0.125K to 5.125K step 0.5K



Sensitivity Simulations - 5:

Cpd=570uF. Rpd changes from 0.125K to 26.625K step 0.5K



Summary and Conclusions

- Zpd max at normal powering mode = 5K max.
  - Equivalent to table 12 requirement
- Cpd min =5uF , Cpd max =No limit.
  - Equivalent to table 12 requirement
- 2 diode in series or 2V offset at PD input.
  - Equivalent to PD detection requirements
- Draft 3, Table 12: No need to be changed.

Summary

- **Pros**
  - Independent of PD load DC current
  - Based on AC probing voltage signal
  - AC probing signal can be turned on and off only when a disconnect detection is initiated.
  - Simple and robust method
  - Inherent EMI free.
  - Inherent zero effect on Data integrity
  - PD min input cap, 5uF min is OK.
  - Using table 12 parameters as it is defined now.
- Cons
  - 0.27W max additional power loss at 15.4W at max load.
    - Using Shotkey Diode may reduce it to <0.15W at max load.
  - Add 2 components to each port (Diode+Resistor)
  - Adds AC source + cap + diode common to all ports

What Next?

- No need to insert a detailed electrical scheme into the draft.
  - Although specifying PSE port parameters limits during disconnect detection has some value in minimizing PSE vendor R&D time and helping PSE – PD interoperability.
- The current wording in the standard allows any disconnect method to be used in the PSE.
- Table 12 contains all the parameters required to be as a must during normal powering mode and can be used as the disconnect detection parameters.
- Actually we can close the disconnect issue with minimal effort.
- Closing the technical details at the PSE level is implementation specific and can be accomplished off line by PSE vendor.

Suggested Wording to IEEE8023.af draft 3.

- PSE PART
- Paragraph 33.2.10
  - As suggested in Jan 2002 meeting.
- Table 5 (nice to have but not a must):
  - Add the following place-holders with initial values
    - Item 3: Specify ac amplitude up to 500Hz at no load condition=5Vpp max.
    - Disconnect detection ac voltage amplitude, V_open=5Vpp max. 3Vpp min.
    - Disconnect detection ac voltage source series impedance: 5K min.
    - Disconnect detection ac voltage frequency: 77Hz typical. Min/Max= TBD
    - Disconnect threshold min =0.7xV_open, max=0.8xV_open

Suggested Wording to IEEE8023.af Draft 3.

- PD PART
- Paragraph 33.3.5
  - a) No change.
  - b) Delete and replace with:
  - “Max PD input impedance of 5K when tested at PD port input at normal powering mode.”