

DTE Power via MDI task Force.

AC disconnect detection ad-hoc

Rev 003

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All the files containing the work of the ad hoc group located at:

<http://grouper.ieee.org/groups/802/3/af/public/may02/index.html>

(May 2002, 802.3af site area)

1. Scope of work

To demonstrate technical and economical feasibility of PSE based ac disconnect detection and determined if there is impact on previous functions in the draft.

2. Tests List/ A.I (done)

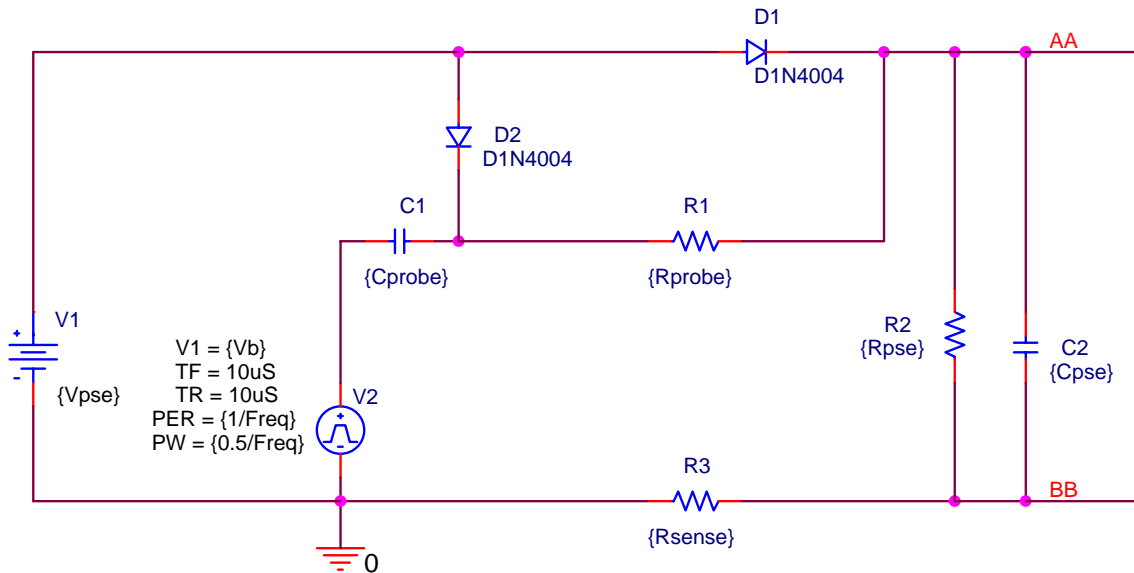
Item	Test Description	Owner	Status	Ends By
1	Test Setup Circuits and general requirements			
1.1	Send over the reflector to ad-hoc members the standard circuit for all testing	Yair, Dave, Thong	Done	
1.2	To prepare a specifications for ac disconnect to be used later in the spec or in test setup definitions	Yair	Initial version Done	April 30, 2002
1.3	Tests will done in order to confirm Table 12 by checking min/max parameters	All		April 30, 2002
2	Sensitivity Analysis, Setting Parameters Range			
2.1	To define the pulse spectrum of the ac signal (Resources: Simulations, single port)	Yair	Done	April 30, 2002
2.2	Effect on feedback loop of SMPS (Resources: 1 port, Simulations)	Yair	Done	April 30, 2002
2.3	To analyze the PD input ac impedance without DC current (Resources: Simulations, confirm with 2-3 phones, single port) Zac max over a freq band and the dc bias it is tested at, we need this with 37v-57v spec This should take into account the min/max L, C per table 12.	Yair, Dave, Fred	Done	April 30, 2002
2.4	To set the optimum probing frequency range (narrow the range) To perform sensitivity Analysis for the probing frequency and define the tolerance required (Resources: Simulations, confirm with 2-3 phones, single port)	Yair, Dave, Fred	Done	April 30, 2002
3	Audio Interference tests			
3.1	Audio interference with existing phones, LCD	Roger, Scott	Done	April 30, 2002
3.2	-Immunity tests - check specifically at line frequency (Resources: Phone and/or high power PD, Single port PSE)	Yair, Roger	Done	April 30, 2002
3.3	Sensitivity to line frequency and ringing interference with CAT 3 cable (Use florescent turn on/turn off to test sensitivity) (Resources: Phones, Ring generators, 1 ports PSE min)	Yair	Done	April 30, 2002
3.4	How port-to-port cross regulation, cross-talk affected by the ac circuit. (Resources: Lab tests, 3 port min look at the centered one)	Yair	Done	April 30, 2002
4	RF interference			
4.1	RF interference (Resources: Phone, Single port PSE)	Roger, Scott	Done	April 30, 2002
4.2	-EFT test (Resources: 2 port tests)	Roger	Done	April 30, 2002
4.3	EN55024 Need to specify the relevant tests (Resources: 2 port tests)	Scott	Done	April 30, 2002
4.4	EN55022/CISPR22/FCC NB30/MPT 1570 Need to specify the relevant tests (Resources: 4 port tests)	Roger, Yair	Done	April 30, 2002
5	Effects on other 802.3af functions			
5.1	Test how over-current affected by the ac disconnect pulses (Resources: Simulations, Lab tests, single port)	Yair, Dave	Done	April 30, 2002
5.2	Effects of PD load transient. (Resources: Lab test, single port)	Yair	Done	April 30, 2002
5.3	Test for PSE output voltage step Resources: Simulations, single port)	Dave, Yair, Thong	Done	April 30, 2002
5.4	To supply PD DC/DC Vout/Vin Ripple rejection ration as function of frequency	Yair	Done	April 30, 2002
6	Other tests			
6.1	Evaluate the impact of two Midspan PSE's with ac disconnect scheme.	Dan Dove	working	April 30, 2002
6.2	Roger tasks for 1000BT (Roger to pass to Broadcom?)	Roger	Done	April 30, 2002
6.3	Checking data impairment when PSE is trying periodically to detect another PSE. If the results will be OK, than they are OK for ac disconnect too. Parameters to consider: Frequency, Tr/Tf, Amplitude	Yair, Roger	Done	April 30, 2002
6.4	Economical feasibility study	All	Done	April 30, 2002

In addition see "May 2002 Interim" file titled "AC disconnect and more.." which summarized more of the issues discussed during the last two month.

Item 1.1- Test Setup Circuits and general requirements

Circuit # 1.

Description: The hardware to be used to inject the ac disconnect probing signal across PSE port. The circuit does not include the sensing hardware, which is implementation specific.



PARAMETERS:

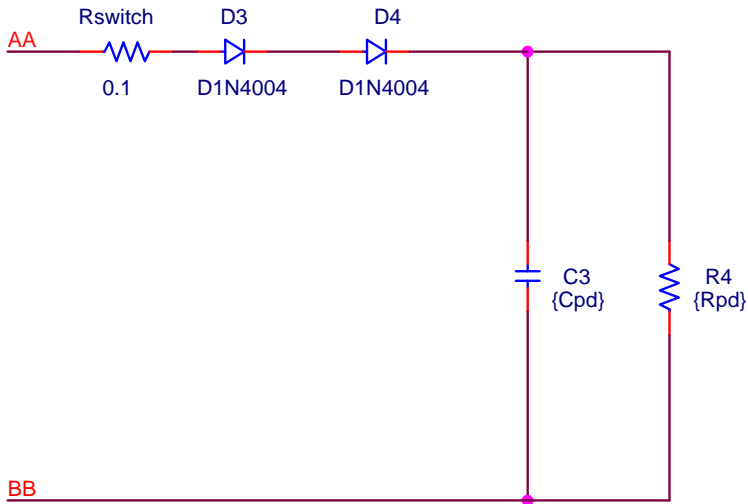
$Vb = 3.3$	See suggested specifications
$Rpse = 200k$	Implementation specific
$Cpse = 0.52\mu F$	Can be from zero to $0.52\mu F$
$Rprobe = 6.8K$	See suggested specifications
$Cprobe = 22\mu F$	Implementation specific
$Rsense = 2$	Implementation specific
$Freq = 77$	See suggested specifications
$Vpse = 50$	Implementation specific

D1,D2 can be any equivalent diode that's meets port voltage/current stress.

Circuit # 2.

Description: The hardware to be used to emulate the PD during normal powering mode. (Normal powering mode is the mode, which the PD is receiving power after successful detection and classification phase.

The circuit contains a switch at its input to be used for PD disconnection emulations.



PARAMETERS:

Cpd = 5uF Can vary from 5uF and up.

Rpd = 5K Can vary from $V_{port}^2/12.95$ to 5.7K

Rswitch represent phisical switch for simulation of connected or not connected PD

D3,D4 can be any equivalent diode that's meets port voltage/current stress.

Item 1.2 - AC Disconnect black-box suggested specifications

Table 33-5.1 – PSE port parameters for AC Disconnect-detection function

PSE side						
#	Parameter	Sym	Unit	Min	Max	Notes
1	Pulse parameters					
1.1	Port disconnect probing ac voltage when PD is disconnected	V _{open}	V _{pp}	Recommended min value above 1V _{pp} to overcome noise and ripple issues.	0.1*V _{dc}	1, 33, Include noise, ripple etc.
1.2	AC probing signal frequency	F _p	Hz	5	500	35
1.3	AC probing signal pulse width	pw	ms	1		34
1.4	AC probing signal slew rate	SR	V/us		0.1	7
2	Ac source output impedance					
2.1	Source output resistance of the AC probing signal	R _{sac}	KΩ	5		3
2.2	PSE port impedance during during resistor detection when measured form the link to the PSE port.	R _{rev}	KΩ	70		4, May be redundant
3	PSE port voltage during ac disconnect detection					
3.1	Port ac voltage when PD is Connected		V _{pp}		0.5	2, May be redundant
3.2	Port voltage when PD is disconnected	V _{port}	V _p		60	1
4	Disconnect detection thresholds					
4.1	"Shall not remove power from the port"		V _{pp}		0.4V _{open}	5
4.2	"May or May not Remove power"		V _{pp}	0.4V _{open}	0.8V _{open}	5,36
4.3	"Shall remove power from the port"			0.8V _{open}		5
4.2	Disconnect detection time	T _{pmdo1}	ms	300	400	6, May be redundant
5	AC power maintenance signature					
5.1	"Shall not remove power from the port"	Z _{ac}	KΩ		(33)	
5.2	"May or May not Remove power"	Z _{ac}	KΩ			
5.3	"Shall remove power from the port"	Z _{ac}	KΩ	(500)		
PD side						
Table 33-12.1 – PD power maintenance signature						
1	Input current	I _{in}	mA	10		
2	Input resistance	R _{pd_d}	KΩ		26.25	
3	Input capacitance	C _{pd_d}	uF	0.05uF		

Notes	
1	Safety standards defined a DC voltage as a voltage that has 10% max ripple content. To meet 60V max for SELV requirements the ac contents must not exceed 10% therefore 10% of 44V _{dc} is 4.4V _{pp} max. The 3V min was derived from the following reasons: a- If PSE and PD generate low frequency noise OF 0.5V _{pp} each, in phase that the total could be 1V _{pp} . b- The PD specified with 2V offset (2 diodes in series at low temperature). In order to forward bias them without the PSE DC bias, we need 2V min. The worst case from the above is 2V min. Having 0.5V _{pp} min margin for the detection action, adds up to 2.5V _{pp} 0.5V _{pp} as specified in table 5, draft 3.
2	
3	To set a minimum resistance in order to limit the ac current at short circuit condition
4	To be equivalent to Resistor Detection output source impedance, in order to limit DC current to ground from external DC source connected to the port. Meant to keep compatibility to Resistor detection interface.
5	Initial value. To be optimized.
6	As specified by TPMDO at table 5, draft 3.
7	According to A.I. 2.1
8	At PD input voltage from 37V to 57V
9	To get stabilization due to PD load changes, PSE port voltage transients etc.
10	Tested. Non-issue. Should be designed according to the IEEE802.3af spec.
33	Recommendations for min value: Op1: Option 1, which is technically good enough and due to the fact that it is minimum value, it is allow supporting op2 and yet leave the flexibility to the designer. Op2: Option 2, which is technically OK and force to be OK from the "other issue" Consider also the EFT tests results regarding this issue. TO BE DISCUSSED WITH THE GROUP
34	Final work shows that min pulse width is the important parameter and along with frequency it sets the duty cycle so no need to defined duty cycle. The pulse width is depend on PSE time constant when PD is disconnected.
35	Frequency range was set according the lab tests and theoretical analysis with large margin and keeping enough flexibility to the designer. Max 500Hz was set to limit the signal spectrum. 10Hz limit was set to allow 50Hz with ±30% tolerance + margin. In addition, 20Hz value can be practical if we want 2 pulses minimum within 100ms to support the 300ms min 400ms max disconnect time.
36	To be OK with the "other" issue threshold should be located above the value of actual V _{ac_close} (PD is connected) with out DC bias. This value is depend on PSE circuit parameters and frequency.
37	Recommended min value above 1V _{pp} to overcome noise and ripple issues.

Suggested new wording for the draft:

Replace paragraph 33.2.10 with the following text:

33.2.10 PSE power removal

The PSE will monitor the link segment and shall disconnect the power from a port when a PD is removed or no longer maintains the power maintenance signature.

The PSE shall monitor either A or B or both components of the power maintenance signature. The PSE removes power if it detects either:

- A) The dc current is less than specified at table 33-5 item 6 or
- B) The ac impedance is higher than specified in table 33-5.1

The PSE shall remove power from the link segment within the limits of T_{PMDO} as specified in table 5.

Replace paragraph 33.3.5 with the following text:

33.3.5 PD power maintenance signature.

In order to maintain power, the PD shall provide a valid power maintenance signature at the MDI.

The power maintenance signature shall be both:

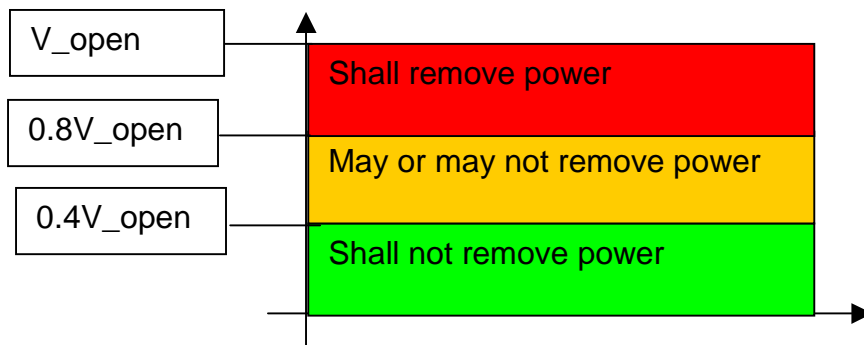
- a- Current draw equal or above the minimum current draw as specified in table 33-12.1
- b- Ac input impedance equal to or below the max impedance defined in table 33-12.1.

A PD that does not maintain any one of:

- a) The minimum input current as defined in Table 33-12.1 and
- b) A max ac input impedance as specified by table 33-12.1.

may be disconnected from power within the limits of T_{PMDO} as specified in table 33-5.

Powered PDs which no longer require power shall remove both components a and b of the power maintenance signature.



Item 1.3- Confirmation of table 12 with ac-disconnect spec.

All the following A.I. results confirm table 12 parameters as it is defined in draft 3 of IEEE802.3af.

For more details see all A.I. reports include in this document.

Item 2 - Sensitivity Analysis, Setting Parameters Range

Item 2.1 – defining the pulse spectrum of the ac disconnect probing signal

The pulse parameters of the ac disconnect signal has been specified:

See item 1.2 above for pulse parameters.

For more details see the following documents:

See document “AC Disconnect probing signal spectrum analysis - AD-HOC item 2_1”
For pulse parameter calculations.

See document “Optimizing disconnect detection ac probing signal Detection AD-HOC
item 2_4 rev 001”

See document “When PSE is periodically detecting A_I 6_3” that confirms the selected pulse spectrum with lab tests.

Item 2.2 - Effect on feedback loop of SMPS

Based on the work of item 5.4, it is obvious that there is no effect on the ability of PD power supply to handle 10-20mV ac up to 500Hz when PD is connected.

For more details see “PD power supply vout to vin noise rejection ratio - AD-HOC item 5_4” document.

Item 2.3 – Analyzing PD ac input impedance.

PD input impedance has been analyzed within the limits of table 12.

The main conclusions were:

- No need to change table 12 in IEEE802.3af draft.
- AC signal across the port is immune to external noise.
- Verified design equations suggested for PD input impedance in order to simplify and optimize PSE sc disconnect circuit parameters.
- Lab tests, simulations and equations support the above conclusions

For more details see “PD Input impedance - sensitivity analysis AD-HOC item 2_3” document

Item 2.4 – To set the optimum probing signal frequency and tolerance.

The purpose of this action item was to check if the frequency range can be narrowed or if there are concerns regarding the detected ac signal as function of frequency variations.

The conclusions of this work item were:

- Vac_close and Vac_open are not sensitive to frequency change with in wide range +/-30% and more (less than 50mVpp) for a given set of PSE circuit's parameter values and frequency.
- Vac_close without DC bias is kept within narrow limits as function of PD load changes (250mVpp max)
- Threshold points should be set by PSE vendor according to his implementation and Vac_open value, probing frequency, ac source impedance etc.
- Successful Disconnect Detection has been achieved with 3 different PDs
- Good parameters tracking has been demonstrated for 3 different PDs

Bottom line:

- Sensitivity of ac probing voltage to its frequency is low enough to allow low cost implementation.
 - Tested for 50Hz to 150Hz span for a given set of PSE circuit's parameter values.
- Optimum nominal frequency should be selected according to PSE circuit parameters only.
- 500Hz should be absolute max value.

For more details see: "Optimizing disconnect detection ac probing signal Detection AD HOC item 2_4 rev 001" document

Item 3 - Audio Interference tests

Item 3.1 Audio Interference tests

The purpose of this A.I. was to test the effect of audio noise and other effects on PD performance due to ac disconnect detection signal and to confirms theoretical and simulated predictions.

The conclusions were:

- No issue for ac disconnect probing signal at frequencies up to 500Hz
- No issue for PSE power supply output ripple at 500mV/500Hz

Other report received(John Jetz) with similar conclusion:

Three different sets tested.

Conditions:

1. AC disconnect probing signal injected using circuit #1 of Item 1.1.
2. Signal pairs (1,2 and 3,6) and spare pairs (4,5 and 7,8) tested.
3. Zero loops.

Tests and Results:

1. Routine Functional tests - all passed.
2. LCD visual inspection - no noticeable effects.
3. Audio subjective test - no noticeable effects.
4. Audio spectral analysis - no noticeable effects.

In 3rd report we got numbers for Power supply rejection ration. Test results and conclusions support the findings that ac disconnect signal is not an issue for the PD in terms of audio interference.

For more details see the following documents:

1. "Audio Interference AD HOC item 3_1"
2. "PD power supply Vout to Vin noise rejection ratio - AD HOC item 5_4"
3. "Audio Interference (and other) Test Results A.I.3.1"

Items 3.2, 3.3 Immunity tests for line frequency and ringing signals.

The objective of these A.I.s were to check the following:

- Sensitivity of Vac_close to low-frequency electrical field
- Sensitivity of Vac_close to Telecom Ringing frequency
- Testing the immunity of the ac-disconnect detection concept to false disconnect detection

The conclusions of these tests were:

With the suggested spec parameters:

- Very low Sensitivity of Vac_close to low-frequency electrical field (24mVpp max for 240Vrms over 100m cable)
- Very low Sensitivity of Vac_close to Ringing voltages/Frequency (24mVpp max for 240Vrms over 100m cable)
- AC-Disconnect detection concept is not generating false disconnect detection

For more details see "Immunity tests AD HOC item 3 2 and 3 3" document.

Item 3.4 Cross Talk as function of ac disconnect signal.

Objectives

To verify that a port located between two other ports is not affected by ac disconnect signal.

To test the following conditions:

- Port N is ON and ports N+1, N-1 are connected to Vs
- Port N is OFF and ports N+1, N-1 are connected to Vs

Test setup and conditions

AC signal: 60Vpp, square wave 50% duty cycle, $t_r=t_f=250\mu s$.

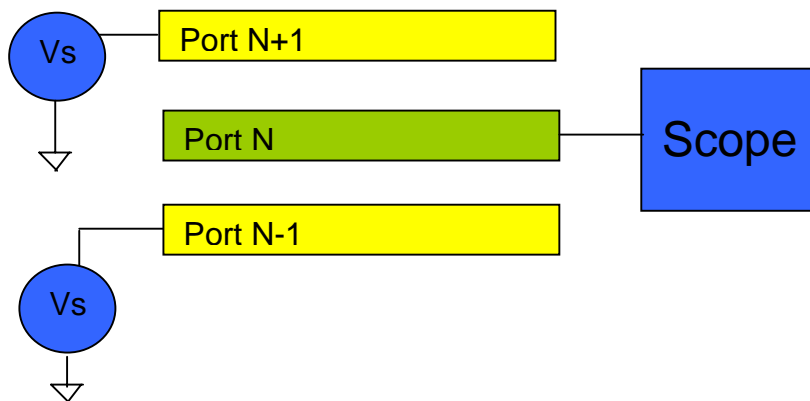
AC signal was connected to the port through 5K resistors.

PSE port capacitance=0uf

Cable length: 0.1m to 140m

Load at the end of the cable: 0, 100 Ohm, 5K, 70K.

Test results: Can't be measured due too very low signal below noise level.



Conclusion:

Cross Talk is not an issue under the above conditions with very large margin.

Item 3.4.1 Cross Regulation effects on ac disconnect signal.

The same results has been received with DC disconnect method. No effect on detected ac signal.

Conclusion:

All timing parameters as defined by Table 12 Draft 3, applicable to ac disconnect method. (Disconnect time 400ms max. Not remove power if interruptions are detected for less than 300ms.) See also related topic A.I. 5.2 and 5.3

Item 4- RF interference

It was demonstrated that the ac disconnect detection concept is immune to low frequency field. High frequency field is not an issue due to the fact that it is out of ac disconnect signal band. The effective impedance at the high frequency starting at 150Khz is much lower than the ac impedance at the low frequency field.

The following tests were considered:

Standard	Subject	Relevancy for ac disconnect concept	Reasoning
EN55024	Addressed the following list of tests		
IEC 61000-4-2	Electrostatic discharge	NA	Out of frequency band
IEC 61000-4-3	Immunity to radiated electromagnetic field	NA	Out of frequency band
IEC 61000-4-4	Immunity to EFT	NA if proper counter measures is taken. See full report.	Out of frequency band
IEC 61000-4-6	Immunity to conducted electromagnetic field	NA	Out of frequency band
IEC 61000-4-8	Immunity to power low frequency modulated on electromagnetic field	NA	-Relevant to specific devices as listed in the standard. - Out of frequency band
IEC 61000-4-11	Immunity to voltage dips short interrupts etc.	Applicable only at ac signal band.	See other tests in this document that covers this requirement.
CISPR 22	Radio disturbances	NA	Out of frequency band

Test results and conclusions of full system report:

The above tests were conducted for the Resistor Detection concept and for DC disconnect method in which lower thresholds voltages are required and all tests passed successfully (full system with sense circuits).

Test results and conclusions of circuit #1 and #2 reference model:

1. Potential exists for EFT to result in false disconnects; should be considered in AC disconnect signal sensing implementations
2. Impact of conducted and radiated disturbances appears relatively minor; AC disconnect-specific countermeasures likely not required
3. End products should be subjected to full EN55024 test suite

For more details see "P802.3af EN55024" document.

Item 5-Effects on other 802.3af functions

5.1 – “AC disconnect” Effect on current sensing

Objective:

To check the effect of AC Disconnect signal on current sense circuits Overload and Underload functions as specified by IEEE802.3af Draft 3, Table 12.

Test Setup

1. AC disconnects circuits integrated into single port PSE. The PSE was loaded with a PD with minimum and maximum load.
2. Verifying that the current sensing functions are not affected by the ac disconnect signal.

Prediction:

AC signal is specified to be 4.4Vpp through 5K minimum resistor.
Max current contributed by the ac signal is $4.4V_{pp}/5K < 1mA$.

% of measured current:

Min load: $1/10 ==> 10\%$
Max load: $1/350 ==> 0.3\%$

Test results:

Load	Minimum load	Maximum load
Measure		
Results	Threshold point was not changed	Threshold point was not changed

Conclusion:

Current sensing circuits and Over-load / Under-load functions are not affected by the presence of AC disconnect probing signal of 4.4Vpp.
Sensitivity of the above functions is implementation specific and can easily achieved.

Confirmed by other report as well.

Item 5.2, 5.3 – Effects of PD load and PSE voltage transients.

The objectives of these A.I. were to test for:

- Immunity to load transients
- Immunity to PSE voltage transients
- Sensitivity of Vac_close to load changes
- Sensitivity of Vac_close to PSE voltage transients

Summary

- Stabilization time is similar to the results received in DC disconnect concept.
- Timing vs. min/max load and
- Timing vs. min/max capacitance and min load values as specified in table 12, are still valid.
- Disconnect time =400ms max
- Shall not remove power if Vac_open>Vth for < 300ms

For more information see:

“Immunity to load and PSE voltage transients AD HOC item 5_2 and 5_3” document.

Item 5.4- PD DC/DC Vout/Vin Ripple rejection ratio as function of frequency.

Objective:

To check the following:

1. How the ac signal across the port will be attenuated by the PD power supply.
2. We spec the PSE port for 500mVpp at normal powering mode. Is it OK in terms of audio interference to the sensitive hardware in the PD?

Summary

- Better than 30dB output/input rejection
- Typical 40-50dB rejection for 48V to 5V DC/DC converter.
- With 10-20mV ac disconnect input signals, No audio interference is expected.

For more details test results verifications, see the following documents:

1. PD power supply vout to vin noise rejection ratio - AD HOC item 5_4
2. Audio Interference AD HOC item 3_1

Item 6- Other Tests

Item 6.1- Evaluate the impact of Midspan with two PSE's connected to the same link. The 1st link section A is separated for the 2nd section B by isolating capacitor.

Will be presented by Dan Dove at the meeting.

Test results were presented showing no problems caused by AC disconnect detection concept.

Item 6.2- Demonstration on 1G system

The purpose of this test is to confirm that ac disconnect signals are not affecting 10/100/1000MB/s

The test results confirmed the following conclusions:

AC disconnect signal as specified in the test setup is not affecting 1G system.

Resistor detection with 30Vp ac signal, continuous, periodic across the port is not affecting the system performance as per A.I. 6.3

For more info see the following documents:

1. AC disconnect detection- Demonstration on 1G system ad hoc item 6_2
2. When PSE is periodically detecting A_I 6_3

Item 6.3 - Testing data when PSE is periodically detecting other PSE. Probing signal spectrum measurements and more.

Test objective:

Checking data impairment when PSE is trying periodically to detect another PSE.
If the results will be OK, than they are OK for ac disconnect too.

Parameters to consider:
Frequency, Tr/Tf, Amplitude

To determine the signal spectrum limitations for zero data errors at the following operating modes:

AC disconnect detection probing signal
Resistor Detection probing signal
To confirm the calculated results as analyzed in A.I. 2.1.

Background:

In some implementations AC disconnect signal required to be applied to the port most of the time.

Resistor Detection uses min 2-point measurements, which is very low frequency ac signal constrained by other circuit parameters.

Resistor detection may run continuously generating up to 30Vpp low frequency signal across the port PSE is trying to detect other PSE/Non-compliant PD

The target of the following work is to support the theoretical analysis conclusions that implies that no data degradation is expected and we have huge margin.

Conclusions

Data integrity is kept, with large margin for the following conditions:

69Vpp/1MHz through 5K min
Any practical cable length (1m to 120m tested)
Loads from zero to 75K
For dual voltage source or single voltage source

Suggested probing signal spectrum:

Amplitude: 30V max as defined by IEEE802.3af
Rise/Fall time: currently 10us specified, meets data error free requirements
o Changing to $dv/dt < 0.1V/us$ for no EMI.
Frequency: up to 500Hz
Periodically detecting (Signature or Disconnect) with the suggested probing signal spectrum is not generating data errors nor EMI.
Suggested probing signal spectrum meets IEEE802.3 limits with huge margins

For more information see: "When PSE is periodically detecting A I 6 3" document

Item 6.4 - Economical feasibility

PD side:

No effect on PD cost.

PSE side:

Function of the approach taken:

Option 1:

Disconnect circuit is implemented per port.

Option 2:

Using part of the circuit to support few ports in parallel

Option 1 detail:

Signal source: a single pin from controller: 1-2 cents

Diode type 1: 5 cents

Diode type 2: 2 cents

Capacitor, Aluminum 1u – 10u/100V: 2-3 cents

Resistor: 1cent

Sensing circuit: 6 cents if it is additional part to the port, 0 cents if the port voltage is already monitored to support other functions.

Total: 10 cents to 18 cents as function of implementation

Option 2 details:

Number of ports in the group=N

For a group:

Signal source: a single pin from controller: 1-2 cents

Driver: 5 cents

Diode type 2: 2 cents

Capacitor, Aluminum 22 – 50u/100V: 4-5 cents

Total for a group: 14 cents

Per port:

Diode type 1: 5 cents

Resistor: 1cent

Sensing circuit: 6 cents if it is additional part to the port, 0 cents if the port voltage is already monitored to support other functions.

Total: 6 cents to 12 cents as function of implementation

Total per port: $(6+14/N)$ to $(12+14/N)$.

For multi port system: $N \gg 1 \implies$ cost per port 6 to 12 cents max.