THE TOLLY GROUP

No. 207204 APRIL 2007

Sifos Technologies, Inc.

Power over Ethernet (PoE) Evaluation

Using Sifos' PowerSync Analyzer to Compare Power Sourcing Equipment (PSE) Behavior and Functions

TOLLY Up to Spec CERTIFIED

Test Summary

Premise: *The increasing popularity of Power over Ethernet (PoE)-capable equipment like VoIP phones, wireless access points, security cameras, etc. is made possible by reliable Power Sourcing Equipment (PSE) to supply the necessary power. It is vital for network managers to be aware of the PoE characteristics of PSEs under consideration, as some PSEs that claim to be IEEE 802.3af compliant are, in fact, noncompliant, especially when evaluated as a system of many PoE-enabled ports.*

Sifos Technologies commissioned The Tolly Group to illustrate how its PowerSync Analyzer can measure key characteristics of power delivered by PSEs from multiple vendors.

Two PSEs were specifically selected from both ends of the spectrum — one device was from one of the largest networking equipment manufacturers, and the other from a relatively smaller vendor. The focus of the study was to illustrate the differences in what often is considered "commodity" PoE rather than to highlight the offerings of a given LAN switch vendor.

The tests used Sifos PowerSync Analyzer to examine various aspects of the power-sourcing behavior of the PSEs in accordance with the IEEE 802.3af PoE standard, such as startup behavior, power delivery in steady-state and transient conditions, power management, safety and Powered Device (PD) interoperability. Sifos PowerSync Analyzer PSE Conformance and Multi-Port Test Suite software was used.

Tests were performed in January 2007.

Test Highlights

- Can detect and report on Power Sourcing Equipment variations in Power Delivery and Power Management, as well as more refined categories such as Powered Device (PD) Interoperability and PD Start-Up Characteristics
- Accurately identifies significant differences in power delivery in any Ethernet switch or router
- Identifies critical power delivery differences often not acknowledged by PSE vendors

Sifos Technologies PowerSync Analyzer Power over Ethernet (PoE) Test Capabilities Validated	
Single and multi-port IEEE 802.3af compliance testing	✔
Single and multi-port PoE power capacity and management analysis	✔
Steady-state and transient power delivery measurement	✔
Detailed IEEE 802.3af standard conformance testing reports	✔
Custom test scripting, automation and sequencing	✔

Source: The Tolly Group, January 2007 Figure 1

Executive Summary

LAN switches offering PoE vary greatly in their power-sourcing characteristics, integrity and reliability. To obtain the full benefits of PoE, buyers must look beyond the data sheets.

PoE is not a commodity

Tolly Group engineers chose two representative products from different manufacturers to show how PSEs claiming to be 802.3af standard compliant could, in reality, be non-compliant, and/or could exhibit degraded PoE performance when multiple PSE ports are utilized.

- PSE "A" — a high-end chassis-based switch with PoE-capable line cards advertised to be IEEE 802.3af standard compliant, manufactured by one of the largest and most well-known network equipment manufacturers, aimed at medium to large enterprise customers.
- PSE "B" — a 24-port, "value-based" Fast Ethernet switch developed for small and medium enterprises.

Measurable and significant variations in power delivery and power integrity between commercially available Power Sourcing Equipment (PSE) should cause network managers to look very closely at PoE characteristics as part of their equipment selection process.

Both PSEs tested claim to deliver industry-standard 802.3af PoE. However, neither PSE tested to be 100% compliant to IEEE 802.3af. Furthermore, because this industry standard only dictates the PoE performance of a single PSE port, PSEs that consist of 24 or 48 powered ports must be further tested beyond the strict requirements of 802.3af to assure that power-sourcing characteristics are acceptable when many ports are in operation. Very significant differences were discovered between PSE "A" and PSE "B" when evaluating system power behaviors. *(Note: Some of these differences may be due to vendor interpretations of the IEEE 802.3af standard.)*

Testing was performed in the following basic categories: PSE Start-Up Behavior, PSE Power Delivery — Steady State, PSE Power Delivery — Transient Conditions, PSE Power Management Behavior, PSE-PD Interoperability, and PSE Safety and Protection. Test criteria applied by Sifos tools included both IEEE 802.3af parameters applicable to individual ports, as well as system test criteria that are extrapolated from "ideal" single-port criteria. A total of 50 parameters were evaluated with each PSE.

PSE "A" performed reasonably well, but fell short on test criteria for eight parameters. PSE "B" did not fare as well — it missed the mark on 13 parameters. A more complete picture requires a detailed look at the types of measurements that failed for each PSE. Figures 2, 4, 5, and 6 present all of the tested parameters, target criteria, and test results for PSE "A" and PSE "B".

One example of a key difference in test results between PSE "A" and PSE "B" is seen in the test "8 Hr PSE Durability" shown in Figure 4. This is a simple stress test of the PSE where all ports are connected to hypothetical Class 0 PDs and loaded to 90% of maximum power

PSE Start-Up Behavior

Test	Description	PSE Goal (Seconds)	Sifos Test	Parameter	PD Emulation	Test Results	
						PSE A (48 ports)	PSE B (24 ports)
PSE Port Detection Backoffs	Time to complete a second valid detection following a failed detection.	< 4	**det_time**	Eff_Backoff_T_{dbo}_Eff *(MAX of 24 Ports)*	Class 0	0.104	0.46
Single Port Power-On Time	Maximum typical single port start-up time (Sum of three reported parameters)	< 5	**det_time** **pwrup_time**	Backoff_Time_T_{dbo} + Total_Det_Time + T_{pon} *(MAX of 24 Ports)*	Class 0	0.37	0.89
Multiple Port Connect and Power-Up Timing	Time to power up all PSE ports when simultaneously connected to class 1 PDs.	< 10	**mp_pwrup_time**	Total Time to Power	Class 1	0.8	9
Port Disconnect Restart-Timing	Time to power up all PSE ports when simultaneously disconnected and then reconnected to class 1 PDs.	< 11	**mp_discx_cycle**	Total Re-Power Time	Class 1	1.5	13

Note: [shaded box] indicates "failure" to comply with the specifications of the IEEE 802.3af standard for that parameter.

Source: The Tolly Group, January 2007

Figure 2

output capacity. During this test, PSE "B" recorded 408 spontaneous power dropouts over an eight-hour period while PSE "A" exhibited none. PSE manufacturers today will not generally specify the types of performance parameters tested within this study and in many cases, are unlikely to be aware of critical performance characteristics related to the delivery of power. They may also be overly reliant on claims of PoE component and subassembly manufacturers regarding PoE compliance and performance. The selection of PSEs should not be considered simple, as evidenced by the number of deviant or non-compliant test results in this study.

Network managers and specifiers can utilize this report to gain deeper insights into mission-critical PSE parameters that will rarely be specified or published by equipment makers, thus leading to better informed purchasing decisions.

Sifos PoE test tools — PSA (PowerSync Analyzer) 1200 hardware

Powered Device Classification Table

Class	Usage	Power Device Power (Watts)		Classification Current (million amperes -- mA)	
		MIN	MAX	MIN	MAX
0	Default	0.44	12.95	0	4
1	Optional	0.44	3.84	9	12
2	Optional	3.84	6.49	17	20
3	Optional	6.49	12.95	26	30
4	Not allowed	Reserved for future use		36	44

Source: IEEE, January 2007

Figure 3

PoE Definitions (Supplied by Sifos Technologies)

- **PSE:** Power Sourcing Equipment - the Data Terminal Equipment (DTE) providing the Power over Ethernet (PoE).
- **PD:** Powered Device - the equipment drawing or requesting PoE from the PSE.
- **PD Detection:** The process by which the PSE determines whether a valid PD is connected at the end of the Ethernet cable.
- **PD Classification:** If a valid PD is detected by the PSE, it performs the PD classification process to determine the maximum power required by the PD during its normal operation. The power budget is determined by the amount of current drawn by the PD during the classification phase. See Figure 3 for the power and current ranges used for different classes of PDs. The purpose of PD classification is to support power monitoring and management. If the PSE does not support PD classification, the PDs are assumed to be Class 0 by default.
- **Class 0 PD:** See Figure 3 for classification criteria.
- **Class 1 PD:** See Figure 3 for classification criteria.
- **Class 2 PD:** See Figure 3 for classification criteria.
- **Class 3 PD:** See Figure 3 for classification criteria.
- **DC MPS:** After classification, the PSE should provide power to the PD within 400 milliseconds. After power has been applied to the PD, the PSE monitors the AC and DC MPS (Maintain Power Signature). The DC MPS is defined in terms of a minimum current and a duty cycle. The PSE maintains power to the PD as long as a valid DC MPS is detected.
- **AC MPS:** Similar to DC MPS defined above, the presence of AC MPS can be used by the PSE to determine if its needs to continue to power the PD.
- **Inrush:** Inrush current or input surge current represents the maximum, instantaneous input current drawn by an electrical device (PD) when first turned on.

PSE Power Delivery – Steady State							
						Test Results	
Test	Description	PSE Goal	Sifos Test	Parameter	PD Emulation	PSE A (48 ports)	PSE B (24 ports)
PSE Port Power Capacity	Power capacity of individual ports	15.4 Watts	**pwrup_pwrcap**	**P_{port}_Capacity** ***(MIN of 24 Ports)***	Class 0	17.6	14
PSE Port Capacity Spread	Difference between maximum and minimum port power capacities	< 2 %	**pwrup_pwrcap**	**P_{port}_Capacity** ***(MAX–MIN of 24 Ports)***	Class 0	7.7	0
Total PSE Power & Voltage – Class 0 PDs	Combined power output of all PSE ports into all Class 0 PDs	num. of PSE Ports * 15.4 Watts	**mp_cap_pwr**	**Total PSE Power**	Class 0	750	169.6
Minimum PSE Port Voltage	Average Port Voltage at Maximum Output Power	> 44 VDC	**mp_cap_pwr**	**Average Port Voltage**	Class 0	51.3	47.1
Eight Hr PSE Durability	Monitor all ports for spontaneous shutdowns over eight-hour period at 90% full-power capacity	0 power dropouts	**mp_dur_static**	**Shutdown Event Count**	Class 0	0	408

PSE Power Delivery – Transient Conditions							
						Test Results	
Test	Description	PSE Goal	Sifos Test	Parameter	PD Emulation	PSE A (48 ports)	PSE B (24 ports)
Port Overload Tolerance – Class 0 PD	Minimum cutoff current to a Class 0 PD	Class 0: > 350 mA	**pwrdn_overld**	I_{cut} *(MIN of 24 Ports)*	Class 0	350	320
Port Overload Tolerance – Class 1 PD	Minimum cutoff current to a Class 1 PD	Class 1: > 92 mA	**pwrdn_overld (c 1)**	I_{cut} *(MIN of 24 Ports)*	Class 1	350	320
Port Overload Time Tolerance	Minimum Overload Time Tolerance to Class 0 PD	> 50 msec	**pwrdn_overld**	T_{ovld} *(MIN of 24 Ports)*	Class 0	56.8	63.4
Port Short Circuit Tolerance	Minimum Output Limiting Current	> 400 mA	**pwrup_maxi**	**Min I_{lim}** ***(MIN of 24 Ports)***	Class 0	413	64
Port Short Circuit Time Tolerance	Minimum Current Limit Time Tolerance	Tlim > 50 msec	**pwrup_maxi**	**T_{lim}** ***(MIN of 24 Ports)***	Class 0	55.5	54.3
25 msec Short Circuit Tolerance	25 msec Short Circuit Response	Vport > 44	**pwrup_maxi**	**25msec Short V_{port}** ***(MIN of 24 Ports)***	Class 0	52.4	0.1
Open Circuit Time Tolerance	Minimum Disconnect Time Tolerance	> 300 msec	**mps_ac_pwrdn** **mps_dc_pwrdn**	T_{mpdo} *(MIN of 24 Ports)*	Class 0	343	311
Single Port Overload Isolation	Impact of an overload on one single port to line voltage on all other powered ports.	< .5 Volts (DVport)	**mp_iso_1port**	**Max Transient V_{pp}**	Class 0	0.2	0.2
Multi-Port Overload Timing Response (Minimum)	Multi-Port Minimum Shut-Down Time for Class 0 PD Overload 399 mA	> 50 msec	**mp_overld_time**	**First Power-Down Time**	Class 0	57	3
Multi-Port Overload Timing Response (Average)	Multi-Port Average Shut-Down Time for Class 0 PD Overload 399 mA	> 50 msec	**mp_overld_time**	**Avg. Power-Down Time**	Class 0	58	3
Port Overload Re-Start Behavior	Verify PSE Ports Re-Cycle Power following Overload Shutdown without Administrative Intervention.	Never Recycled Ports = None	**mp_overld_cycle**	**Never Recycled Ports**	Class 0	ALL	None

Note: [shaded box] indicates "failure" to comply with the specifications of the IEEE 802.3af standard for that parameter.

Source: The Tolly Group, January 2007

Figure 4

PSE Power Management Behavior

Test	Description	PSE Goal	Sifos Test	Parameter	PD Emulation	Test Results: PSE A (48 ports)	Test Results: PSE B (24 ports)
PSE Power Capacity with Class 1 PDs	Total PSE Power Capacity given 100% Class 1 PDs	< 1.1 * num. of PSE Ports * 4 Watts	mp_cap_pwr	Total PSE Power	Class 1	837.2	169.6
PSE Power Capacity with Class 2 PDs	Total PSE Power Capacity given 100% Class 2 PDs.	< 1.1 * num. of PSE Ports * 7 Watts	mp_cap_pwr	Total PSE Power	Class 2	837.2	169.6
Class 3 PD Power Budgeting Behavior	Comparison of Inactive Ports reported by mp_cap_pwr and mp_pwrup_ports given 100% Class 3 PDs	Equivalent Inactive Port Counts (Diff. = 0)	mp_pwrup_ports mp_cap_pwr	Inactive Port Count vs. (Count of) Inactive Ports	Class 3	0	4
Accepted Ports vs Capacity Limited Full-Power Ports Given Class 1 PDs	Comparison of Active Ports Class 1 and Active Ports at Maximum Port Power	Equivalent Active Port Counts (Diff. = 0)	mp_pwrup_ports mp_cap_ports	Active Port Count vs. Active Port Count	Class 1	0	13
Accepted Ports vs Capacity Limited Full-Power Ports Given Class 3 PDs	Comparison of Active Ports Class 3 and Active Ports at Maximum Port Power	Equivalent Active Port Counts (Diff. = 0)	mp_pwrup_ports mp_cap_ports	Active Port Count vs. Active Port Count	Class 3	0	8
Equal Prioritization of Ports	Assess any intermittent port power behavior at PD Class 3 that would indicate port shutdowns as some ports are given priority.	Intermittent Ports = 0	mp_pwrup_ports	Intermittent Port Count	Class 3	0	20

PSE – PD Interoperability Metrics

Test	Description	PSE Goal	Sifos Test	Parameter	PD Emulation	Test Results: PSE A (48 ports)	Test Results: PSE B (24 ports)
Valid PD Signature Band	Resistance Range of Valid PD Signatures	< 19 KW	det_range	R_{good}_Min *(MAX of 24 Ports)*	Class 0	17	17
		> 27 KW	det_range	R_{good}_Max *(MIN of 24 Ports)*	Class 0	28	27
Powered Port Ripple	Maximum Low Frequency Ripple Voltage	< 500 mVpk-pk	pwrup_v	AC Ripple V_{pp} (low) *(MAX of 24 Ports)*	Class 0	31	16
Powered Port Noise	Maximum High Frequency Noise Voltage	< 200 mVpk-pk	pwrup_noise	AC Ripple V_{pp} (noise) *(MAX of 24 Ports)*	Class 0	3	10
Minimum Valid DC MPS Current (DC MPS PSEs)	Minimum PD Load Current to Maintain Power (*Only Pertinent To DC MPS PSEs*)	< 10 mA	mps_dc_valid	I_{min2} *(MAX of 24 Ports)*	Class 0	10	
Maximum Required DC MPS Valid Load Timing	Maximum Valid Load Requirement (Time or Duty Cycle) from PD (*Only Pertinent To DC MPS PSEs*)	< 55 msec	mps_dc_valid	T_{mps} *(MAX of 24 Ports)*	Class 0	10	
Minimum Invalid DC MPS Load	Minimum Invalid Load Level Imin1 (*Only Pertinent To DC MPS PSEs*)	> 5 mA	mps_dc_pwrdn	I_{min1} *(MIN of 24 Ports)*	Class 0	7	

Note: [shaded] indicates "failure" to comply with the specifications of the IEEE 802.3af standard for that parameter.

Source: The Tolly Group, January 2007

Figure 5

with PSA Conformance Test Suite and PSA Multi-Port Test Suite software — provided an easy, fully automated, and user-friendly means to testing and documenting the PoE performance and IEEE 802.3af compliance behaviors of the PSEs studied.

PSE Rating Categories

PSE Start-Up Behavior

PSE Startup Behavior relates to actions, particularly timing, of the PSE when powering a PD. Ideally, power is always instantaneously available at any PoE connection. Testing included individual PD connections, multiple PD power-ups (such as following a true power outage), and PD reconnections.

PSE Safety and Protection

Test	Description	PSE Goal	Sifos Test	Parameter	PD Emulation	Test Results	
						PSE A (48 ports)	PSE B (24 ports)
Open Socket Voltage Peak	Maximum Open Circuit Detection Voltage	< 30 Volts	det_v	V_{oc} (MAX of 24 Ports)	Class 0	20.1	5.1
Open Socket Current Limit	Maximum Detection Current Flow	< 5 mA	det_i	Det_Current_I_{sc} (MAX of 24 Ports)	Class 0	0.23	0.41
Maximum Voltage	Maximum Powered Port Voltage	< 57 VDC	pwrup_v	V_{port} (MAX of 24 Ports)	Class 0	54.2	48
Peak Port Voltage during Disconnect	Maximum Port Voltage following a PD Disconnect	< 57 VDC	mps_ac_voff	Peak Disc. V_{port} (MAX of 24 Ports)	Class 0		
			mps_dc_pwrdn	Max V_{open} (MAX of 24 Ports)	Class 0	65.5	53.2
Maximum Port Current	Maximum Port Current Flow from Current Limiting Overload	< 450 mA	pwrup_maxi	Max I_{lim} (MAX of 24 Ports)	Class 0	444	427
Maximum Port Overload Time Tolerance	Maximum Duration of Current Limiting Overload	< 75 msec	pwrup_maxi	T_{lim} (MAX of 24 Ports)	Class 0	61.7	58.6
	Maximum Duration of Powered Overload	< 75 msec	pwrdn_overld	T_{ovld} (MAX of 24 Ports)	Class 0	60.8	65.2
Maximum Start-Up Current Flow	Maximum Port Current Flow from PD Startup	< 450 mA	pwrup_inrush	Max_Inrush (MAX of 24 Ports)	Class 0	442.5	426.5
Maximum Port Startup Time Tolerance	Maximum Duration of Current Limiting Overload during Startup	< 75 msec	pwrup_inrush	Inrush_T_{lim} (MAX of 24 Ports)	Class 0	59.4	56.3
IEEE Powered Device Recognition Integrity	Minimum Allowed PD Signature Resistance	> 15KW	det_range	Rgood_Min (MIN of 24 Ports)	Class 0	13	16
	Maximum Allowed PD Signature Resistance	< 33KW	det_range	Rgood_Max (MAX of 24 Ports)	Class 0	31	29
	Maximum Allowed PD Signature Capacitance	< 10mF	det_range	C_{good}_Max (MAX of 24 Ports)	Class 0	0.14	0.14
Port Disconnect Power-Down Time	Maximum Time to Power Down following PD Disconnect	< 400 msec	mps_dc_pwrdn	T_{mpdo} (MAX of 24 Ports)	Class 0	352	354
			mps_ac_pwrdn				
PSE-to-PSE Power-Up Risk	Reverse Input Impedance of PSE port	> 45 KW	pwrdn_time	Output Load R_p (AVG. of 24 Ports)	Class 0	1164	45.7
Minimum PSE Overload Cool-Down Interval	Minimum time for Port Power Re-Cycle following an overload shutdown	> 750 msec	pwrdn_v	T_{ed} (MIN of 24 Ports)	Class 0	5000	5000
Multi-Port Power-Up Independence	Verification that power-ups on any port do not cause unexpected power-ups on any	= 0 Coupled Ports	mp_pwrup_idp	Coupled Port Count	Class 1	0	0
Multi-Port Disconnect Integrity	Verification that PSE ports shut down when PDs are simultaneously disconnected. Class 1 PDs used to maximize powered ports. DC MPS PSEs will experience 1mA disconnect load.	= 0 Powered Ports	mp_discx_ports	Stuck Powered Count	Class 1	0	0
		= 0 Intermittent Ports	mp_discx_ports	Intermittent Count	Class 1	4	0
Multi-Port Disconnect Timing	Maximum Port Shutdown Time following cluster disconnect. Class 1 PDs used to maximize powered ports.	< 500 msec	mp_discx_time	Total Power-Down Time	Class 1	645	357
Multi-Port Overload Timing	Maximum Port Shutdown Time following cluster overload	< 75 msec	mp_overld_time	Total Power-Down Time	Class 0	61	4

Note: [shaded box] indicates “failure” to comply with the IEEE 802.3af standard for that parameter.

Source: The Tolly Group, January 2007

Figure 6

PSE Power Delivery – Steady State

The most basic function of the PSE is to provide power. This testing evaluated the PSEs to assess steady-state power delivery characteristics. It is recommended to compare these characteristics to any relevant information in associated data sheets of the products.

Power Delivery: Transient Conditions

Closely related to the steady state power delivery characteristics of PSEs would be transient and overload power-handling capabilities. These traits describe how well a PSE will hold up with suddenly varying port power loads that might be introduced by a wireless access point or a security camera motor. Also considered are port loads that temporarily drop to zero for short periods of time. (PSEs should strive to keep such devices powered if at all possible and should not penalize by powering down) other devices such as telephones that share the same PSE.

PSE Safety and Protection

Not far behind power delivery in terms of importance is a PSE's characteristics relative to safety and equipment protection. PSEs are required to conform to IEEE 802.3af. This specification has a number of provisions that relate to assuring that safety hazards associated with PoE technology are minimized, as are risks of damage associated with connections between PoE and non-PoE equipment.

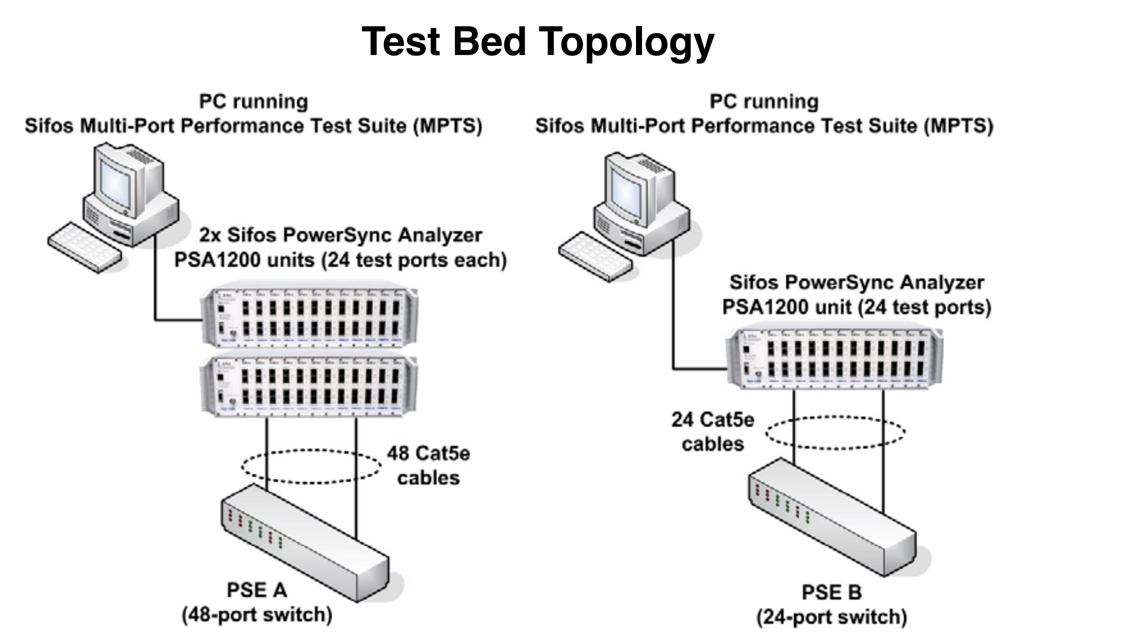
Power Management Behavior

One of the benefits of PoE technology is the theoretical ability to regulate power delivered to a device based upon the up-front stated ***need*** of that device. PSEs can then distribute a fixed budget of power as it is needed with a minimum of over-supply to any one device. Most current-generation PSEs have capability to read the PD's classification, or requested power level. However, only a few present generation PSEs were actually using this information to either restrict power-ups, manage total supply capacity, or to enforce PD classification integrity.

Many PSEs manage power in a manner that is optimized for steady-state PDs and highly vulnerable to variable load PDs such as wireless access points and camera motors. As PSEs evolve, logic to regulate power across all powered ports will become more robust and allow users to purchase only the power they need for the PD types being powered and maintain it.

PSE Specification Margins Relevant to PD Interoperability

Since the IEEE 802.3af ultimately defines conditions for interoperability of all PSEs and PDs in a network system, PSEs can enhance the overall interoperability and reliability of the powered network by offering margins between certain performance characteristics and the minimum specification requirements.



Source: The Tolly Group, January 2007

Figure 7

Test Methodology

PSE Power Delivery – Steady State

Sifos-automated **PSE Conformance** and **PSE Multi-Port** tests were run using one or more Sifos PSA-1200s. All test data for this section was taken directly from the spreadsheets produced by those test programs. The PSE Port Capacity Spread required one additional calculation in the PSE Conformance Test spreadsheet report to determine spread of PSE port power capacities.

PSE Power Delivery Transient Conditions

Sifos-automated **PSE Conformance** and **PSE Multi-Port** tests were run using one or more Sifos PSA-1200s. All test data for this section was taken directly from the spreadsheet reports produced by those test programs. Additionally, a special sequence of the **pwrdn_overld** PSE Conformance Test was repeated utilizing Class 1 PD Emulation in order to assess Port Overload Tolerance for Class 1 PDs.

PSE Safety and Protection

Sifos-automated **PSE Conformance** and **PSE Multi-Port** tests were run using one or more Sifos PSA-1200s. All test data for this section was taken from the spreadsheet reports produced by those test programs. Four of the five Multi-Port Tests were run utilizing Class 1 PDs, with the remaining Multi-Port Test run with a Class 0 PD emulation.

PSE Start-Up Behavior

Sifos-automated **PSE Conformance** and **PSE Multi-Port** tests were run using one or more Sifos PSA-1200s. All test data for this section was taken from the spreadsheet reports produced by those test programs. A calculation row was added to the PSE Conformance Test spreadsheet to calculate net Single Port Power-On Time.

PSE Power Mgmt. Behavior

Sifos-automated **PSE Multi-Port** tests were run using one or more Sifos PSA-1200s. All test data was taken directly from the spreadsheet reports produced by those test programs. The count of inactive ports associated with the **mp_cap_pwr** test was determined by simply counting the reported inactive ports. The various Multi-Port tests utilized in this section were run with Class 1, Class 2, and Class 3 PD emulation.

PSE – PD Interoperability Metrics

Sifos-automated **PSE Conformance** Tests were run using one or more Sifos PSA-1200s.

All test data for this section was taken directly from the spreadsheet reports produced by those test programs.

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