PSE Overload and Load Compliance Testing

With the ratification of the IEEE 802.3at specification for PoE+, PSE Conformance testing evolved to address modified and expanded requirements in the area of Load Compliance testing. The new specification includes several key features applicable to PSE severe overload processing and interaction with PD's:

- At startup, all PD's, even "Type 2" PD's that require up to 25.5 watts, must initially turn on with load levels equal to or less than PD's that are fully compliant to the 802.3af specification today. PD's must be given the permission by PSE's, either through a new physical layer classification signal, or through a link layer discovery protocol (LLDP), in order to draw more than "class 0" PD power (13 Watts at the PD, or 15.4 Watts at the PSE).
- Following startup, PSE's are required to furnish surge power up to the maximum surge power allowed by a PD while maintaining a minimum specified port voltage. Unlike 802.3af however, there is no overload specification "headroom" where a PD might draw a more than allowed surge current and have a reasonable chance that the PSE will not remove power. PSE requirements are now derived from power delivery to the PD meaning that peak load current requirements are a function of PSE output voltage.
- The 802.3at specification implicitly allows PSE's to fold back or remove power given a *severe* overload with minimum duration of **250 µsec** if that overload results in a PSE port voltage drop below the minimum required port voltage (44 volts for **Type 1** [15.4 Watt] and 50 volts for **Type 2** [30 Watt] PSE's). This is a significant departure from the requirements of 802.3af where a PSE was required to maintain power and to limit output current for a minimum of 50 msec during a large load surge.
- PSE's no longer need to limit output current during a short circuit condition in the traditional 400-450 mA band specified in 802.3af. **Type 2** PSE's are now responsible for tolerating a worst case possible PD overload of at least 684 mA (regardless of port voltage) for at least 10 msec while **Type 1** PSE's are required (as before) to tolerate at least 400 mA of load current for at least 50 msec. Above those current levels, the PSE may output current levels of up to 1.75 A for up to 75 msec as described in 802.3at Figure 33-14. The PSE must shut down before exceeding that upper limit. These changes, coupled with the ability to remove power upon low port voltage, enable a very wide range of PSE behavior in response to short bursts of extreme overloads.

These features of the 802.3at specification have led to divergence in overload and short circuit processing methods among PSE technologies, much like has already happened in the area of PD detection. Power-Up Inrush testing won't change very much since all PD's were required to act like 802.3af compatible PD's during startup, and the corresponding specification requirements in those areas are essentially unchanged. However, Short Circuit and Overload testing changed significantly to evaluate different specification limits while providing greater characterization and rating of PSE behaviors under a wider variety of overload circumstances.

802.3at Status

IEEE 802.3at was approved in 2009, updated 802.3 clauses 33 and 79.

Sifos PSA-3000

Sifos Technology supports 802.3at compliant PSE conformance testing with the PSA-3000 platform. This testing is also supported when older PSA-1200 chassis' are exclusively populated with newer PSA-3102 test blades.

Some key highlights of the PSA-3000 are:

- Programmable Static Load Current to 750 mA
- Programmable Load Transients to 2 amps
- PSE Foldback Suppression
- Programmable Mark and Transition Loads
- Programmable Layer 2 (LLDP) PD Emulation
- Noise Immune Waveform Triggering
- Higher Resolved Load Currents & Metering
- Improved Transient Load and Meter Response

PSE Load Compliance *for IEEE 802.3at*

PSE Conformance Test Coverage Modes

802.3at introduced the concept of a Type-2 PSE for high power delivery as well as the concept of PoE LLDP mutual identification, thus creating more than a single test configuration to consider. Type-1 PSE's, that is PSE's capable of 15.4W power output, are tested with Type-1 PD emulation. Type-2 PSE's, that is PSE's capable of 30W power output, must be tested both with Type-1 PD emulation to assure backward compatibility, as well as with Type-2 PD emulation to assure interoperability with Type-2 PD's. Type-2 PSE's are then sub-divided into those that provide 2-Event classification and those that use LLDP to grant full Type-2 power.

PSE Type	PSE Power Range (*PD Type Emulation*)	Type-2 Power Grant (*30W Grant Type*)
Type-1	15.4W	NONE
Type-2 (2-Event)	15.4W	PHY
	30.0W	PHY
Type-2 (LLDP)	15.4W	LLDP
	30.0W	LLDP

Note! PSE's that utilize both 2-Event and LLDP should be tested as 2-Event because 2-Event allows full 25.5W power allocation at power-up and therefore preempts any subsequent LLDP negotiation.

PSE Overload and Load Compliance Tests

The remaining sections of this Application Note will address components of the PSA-3000 PSE Conformance Test Suite that are designed to address PSE transient loading responses and current limiting behaviors. Each of these tests is provided with full capability to adapt to the appropriate PSE Conformance Test coverage mode specified at run time. These tests include:

- Inrush Test: **pwrup_inrush**
- Voltage Test: **pwron_v**
- Short Circuit Test: **pwron_maxi**
- Overload Response Test: **pwron_overld**
- Overload Shutdown Test: **pwrdn_overld**

Power-Up Inrush Testing

Inrush testing covers PSE behaviors while in the POWER_UP state per figure 33-9 of 802.3at. Parameters in **green** will be tested to specified limits. Test limits in **gold** apply to **Type 1** PSE's, in **red** apply to **Type 2** PSE's. Other parameters will be generated for informational purposes. In many tests, the PSA-3000 will apply a **foldback suppression** capability designed to maintain port voltage above 30VDC when PSE is limiting output current.

PSE Characteristic	PSE Power Range	PD Class Emulation	Test Parameter	Description
Initial Power-Up Current Limiting Response	15.4 Watt or 30.0 Watt	Class 0	**Init_Inrush**	Maximum output current *after* 1 msec of a 3 msec, X mA load transient including foldback suppression. X determined in **Max_Init_Inrush** measurement below. (I_{inrush}) Limit: **≤ 450** **≤ 450** mA
Maximum Inrush Current	15.4 Watt or 30.0 Watt	Class 0	**Max_Inrush_c0**	Maximum output current in time interval from 1 to 75 msec given Class 0 signature and inrush overload of 500mA with foldback suppression applied. Limit: **≤ 450** **≤ 450** mA
	30.0 Watt	Class 4	**Max_Inrush_c4**	Maximum output current in time interval from 1 to 75 msec given Class 4 signature and inrush overload of 500mA with foldback suppression applied. Limit: **≤ 450** mA
Minimum Inrush Current	15.4 Watt or 30.0 Watt	Class 0	**Min_Inrush**	Minimum output current in time interval from 1 to 50 msec given Class 0 signature and inrush overload with foldback suppression applied. Limit: **≥ 400** **≥ 400** mA

PSE Characteristic	PSE Power Range	PD Class Emulation	Test Parameter	Description
Current Limiting Duration	15.4 Watt or 30.0 Watt	Class 0	Tinrush	Duration of current limiting until PSE removes power to Class 0 PD. (Use inrush overload with foldback suppression.) Limit Range: **50–75** msec **50-75** msec
25 mSec Inrush Overload Response	15.4 Watt or 30.0 Watt	Class 0	Inrush_25m	Port voltage after 50msec following 25 msec inrush overload given Class 0 PD. (Use inrush overload with foldback suppression.) Limit: ≥ **44** ≥ **50** VDC
Maximum Instantaneous Inrush Current	15.4 Watt or 30.0 Watt	Class 0	**Max_Init_ Inrush**	Maximum output current up to 1 msec given severe inrush overload (>> 500mA) with foldback suppression active. Limit: **N/A** **N/A** VDC.
PSE Port Voltage During Inrush Overload	15.4 Watt or 30.0 Watt	Class 0	**Vinrush**	Average Port Voltage coincident with **Tinrush** measurement. Limit: **30-57** **30-57** VDC.
PSE Inrush Strategy	15.4 Watt or 30.0 Watt	Class 0	Inrush_Strategy	Indicator flags if PSE inrush limiting uses "legacy_powerup" exception and any consequences thereof. 0= Inrush limiting timed by **Tinrush** (recommended) 1= Legacy: Current limited @ I_{lim}_1 for T_{lim}_1 2= Legacy: Current limited @ I_{lim}_1 for >T_{lim}_1(max) 3= Legacy: Current limited @ I_{lim}_2, no T_{inrush} or T_{lim} shutdown 4= Legacy: Current limited @ I_{liim}_1 + low voltage shutdown

Power-On Port Voltage Transient Response

PSE Power-On voltage testing combined static voltage over power measurements, AC peak-peak measurements in two frequency bands, and pulse load transient voltage response measurements. The table below describes the pulse load transient response parameters assessed by the **pwron_v** test. Test limits in **gold** apply to **Type 1** PSE's, in **red** apply to **Type 2** PSE's.

PSE Characteristic	PSE Power Range	PD Class Emulation	Test Parameter	Description
Maximum Port Voltage given Type-1 PD Transient	15.4 Watt	Class 0	Vtrans_max_1	Maximum Port Voltage measured during a 5msec load transient from 12mA to **Ipeak** and back measured over 10msec duration. (**Ipeak** determined from **Vport_pse**.) Limit: ≤ **57** ≤ **57** V
Minimum Port Voltage given Type-1 PD Transient	15.4 Watt	Class 0	Vtrans_min_1	Minimum Port Voltage measured during a 5msec load transient from 12mA to **Ipeak** and back measured over 10msec duration. (**Ipeak** determined from **Vport_pse**.) Limit: ≥ **44** ≥ **50** V
Maximum Port Voltage given Type-2 PD Transient	30.0 Watt	Class 4, Class 4 + LLDP	Vtrans_max_2	Maximum Port Voltage measured during a 5msec load transient from 10mA to **Ipeak** and back measured over 10msec duration. (**Ipeak** determined from **Vport_pse**.) Limit: ≤ **57** V
Minimum Port Voltage given Type-2 PD Transient	30.0 Watt	Class 4, Class 4 + LLDP	Vtrans_min_2	Minimum Port Voltage measured during a 5msec load transient from 10mA to **Ipeak** and back measured over 10msec duration. (**Ipeak** determined from **Vport_pse**.) Limit: ≥ **50** V

Short Circuit & Extreme Overload Testing

Under 802.3af, short circuit behaviors were very similar to inrush overload responses including requirements for limiting output current when loads exceeded a defined threshold. Under 802.3at, the "short circuit" region is actually ***below*** the current limiting region and takes on a new meaning related to short duration load transients. PSE's are permitted a broader range of valid responses to extreme overloads during the POWER_ON state (*see 802.3at figure 33-9*) including the unconditional ability to immediately remove power when the port voltage drops below the minimum value specified for a PSE. In the table below, parameters in **green** will be tested to specified 802.3at limits. Other parameters will be generated for informational purposes only. Limits in **gold** apply to **Type 1** PSE's, in **red** apply to **Type 2** PSE's.

PSE Characteristic	PSE Power Range	PD Class Emulation	Test Parameter	Description
PSE Upperbound Template Current	15.4 Watt 30.0 Watt	Class 0	**Ilim_Peak**	Maximum output current from PSE over 8 - 75 msec given a 1.8 Amp overload pulse with foldback suppression applied. Limit: **≤ 1.75** **≤ 1.75** Amp
Minimum Required Output Current	15.4 Watt	Class 0	**Ilim_Min_1**	Minimum output current up to 50 msec with 402 mA load pulse and foldback suppression applied. Limit: **≥ 400** **≥ 400** mA
	30.0 Watt	Class 4, Class 4 + LLDP	**Ilim_Min_2**	Minimum output current up to 50 msec with 686 mA load pulse and foldback suppression applied. Limit: **≥ 684** mA
Power Removal Timing for **Ilim_Min**	15.4 Watt	Class 0	**Tlim_1**	Time to port shutdown in response to 402 mA overload. Limit: **≥ 50-75** msec **≥ 50** msec (no upper limit)
	30.0 Watt	Class 4, Class 4 + LLDP	**Tlim_2**	Time to port shutdown in response to 684 mA overload. Limit: **10-75 msec**
PSE Port Voltage During Short Circuit Region Overload	15.4 Watt	Class 0	**Vlim_1**	Average port voltage coincident with **Tlim_1** measurement Limit: **44-57** **50-57** V
	30.0 Watt	Class 4, Class 4 + LLDP	**Vlim_2**	Average port voltage coincident with **Tlim_2** measurement Limit: **50-57** V
Instantaneous Voltage Response to **Ilim_Min** Load Transient	30.0 Watt	Class 4, Class 4 + LLDP	**Ktran_lo**	% excursion below 50V given 250usec max overload at **Ilim_Min** (684 mA) Limit: **≥ 92.4 %Vport_pse**
Maximum Output Current above PSE Lowerbound Template	15.4 Watt	Class 0	**Ilim_Max_1**	Maximum output current from 1 to 75 msec given 700 mA load pulse with foldback suppression Limit: **≤ 1.75** **≤ 1.75** Amp
	30.0 Watt	Class 4, Class 4 + LLDP	**Ilim_Max_2**	Maximum output current from 1 to 75msec given 860 mA load pulse with foldback suppression. Limit: **≤ 1.75** Amp
Low Voltage (Current Limiting) Tolerance	15.4 Watt	Class 0	**Ilim_Low_V_Tol_1**	Time to low-voltage shutdown given 100 msec overload = 460mA from a Type-1 PD with foldback suppression inactive (**Vport** < 44V). **≥ 50** **≥ 50** msec
	30.0 Watt	Class 4 + LLDP	**Ilim_Low_V_Tol_2**	Time to low-voltage shutdown given 100 msec overload = 1000mA from a Type-2 PD with foldback suppression inactive (**Vport** < 50V). **≥ 10** msec
Short Burst Transient Tolerance (*Type-2 PSE's only*)	15.4 Watt	Class 0	**Ktran_lo_1**	%**Vport_min** (50V) given 250usec max overload (686 mA). **≥ 92.4% of V_{Port_PSE} (Min)** (=50V)
	30.0 Watt	Class 4 + LLDP	**Ktran_lo_2**	%**Vport_min** (50V) given 250usec max overload (686 mA). **≥ 92.4% of V_{Port_PSE} (Min)** (=50V)

Load Transient Headroom Analysis

The **pwron_overld** test assesses the ability of the PSE port to meet and exceed minimum requirements for PD power transients under 802.3at. Under 802.3at, the handling of load transients has been transformed from load current requirements at the PSE to peak power delivery requirements at the PD. Consequently, PSE Port Voltage plays a role in determining what transient current levels are required of a PSE port. In the table below, limits in **gold** apply to **Type 1** PSE's and limits in **red** apply to **Type 2** PSE's.

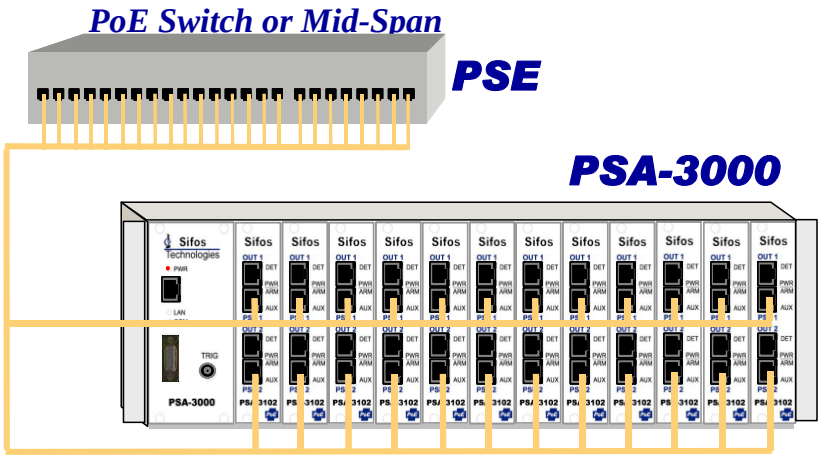
PSE Characteristic	PSE Power Range	PD Class Emulation	Test Parameter	Description
Transient Peak Load Capacity as %**Ipeak**	15.4 Watt	Class 0	%Ipeak_1	Percent of required **Ipeak_1** current that is supported over 50msec duration where **Ipeak_1** required is defined by Equation 33-4 given Type-1 PD and channel. Limit: ≥ 0 ≥ 0 %
	30.0 Watt	Class 4, Class 4 + LLDP	%Ipeak_2	Percent of required **Ipeak_2** current that is supported over 50msec duration where **Ipeak_2** required is defined by Equation 33-4 given Type-2 PD and channel. Limit: ≥ 0 %
Minimum Port Voltage given Ipeak overload transient	15.4 Watt	Class 0	Vport_Ipeak_1	Min Port Voltage at 100% **Ipeak_1** transient pulse Limit: ≥ 44 ≥ 50 V
	30.0 Watt	Class 4, Class 4 + LLDP	Vport_Ipeak_2	Min Port Voltage at 100% **Ipeak_2** transient pulse Limit: ≥ 50 V
Minimum Port Voltage given 5% Duty Cycle **Ipeak** Transients	15.4 Watt	Class 0	Ilim_Min_1	Min Port Voltage over 5 seconds with 50 msec **Ipeak_1** pulse transients separated by 1 second (5% duty cycle) Limit: ≥ 44 ≥ 50 V
	30.0 Watt	Class 4, Class 4 + LLDP	Ilim_Min_2	Min Port Voltage over 5 seconds with 50 msec **Ipeak_2** pulse transients separated by 1 second (5% duty cycle) Limit: ≥ 50 V

Overload Threshold and Timing Tests

Under 802.3at, the concept of a load current threshold for overload detection that is below and distinct from a current limiting threshold has become an optional feature of any PSE. Hence, there is no assurance that a PSE will remove power until it goes into a current limiting mode or finds that its output voltage is suddenly below the minimum required voltage for that type of PSE. In practice, most PSE's do implement an "**Icut**" overload threshold that produces a shutdown before the PSE goes into current limiting. The overload threshold test will report if an overload threshold exists and will report the shutdown timing **Tcut**. In the table below, parameters in **green** will be tested to specified 802.3at limits. Other parameters will be generated for informational purposes only. Limits in **gold** apply to **Type 1** PSE's, in **red** apply to **Type 2** PSE's.

PSE Characteristic	PSE Power Range	PD Class Emulation	Test Parameter	Description
Overload Cut-Off Current	15.4 Watt	Class 0	Icut_1	Smallest load current of duration equal to **Tcut_Max**, or 75 msec, that causes immediate or delayed power removal given a Type-1 or Type-2 PSE. Will report **Icut**= -1 and **Tcut**= 9999 if no such level is discovered below **ILIM_min**. Type-2 PSE's may use Type-2 overload thresholds for Type-1 PD's. Limit: -1-1750 -1-1750 mA
	30.0 Watt	Class 4, Class 4 + LLDP	Icut_2	Smallest load current of duration equal to **Tcut_Max**, or 75 msec, that causes immediate or delayed power removal given a Type-2 PSE. Will report **Icut**= -1 and **Tcut**= 9999 if no such level is discovered below **ILIM_min**. Limit: -1-1750 mA
Overload Shutdown Timing	15.4 Watt	Class 0	Tcut_1	Time from start of transient until power removal but not exceeding 75msec, the duration of the applied load transient. Limit: ≥ 50 ≥ 50 msec (*no upper limit*)
	30.0 Watt	Class 4, Class 4 + LLDP	Tcut_2	Time from start of transient until power removal when measuring Icut_2 Limit: ≥ 10 msec (*no upper limit*)

Test Configuration



For more information on the Sifos Technologies' Power over Ethernet test & measurement solutions look us up at:
www.sifos.com

Sifos Technologies, Inc.
1061 East Street
Tewksbury, MA 01876
sales@sifos.com

