International External Power Supply Regulations

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1 International External Power Supply Regulations

For the past several years, various international organizations, spearheaded by the EPA's Energy Star® organization, issued different standards regarding efficiency and standby power consumption requirements for external power supplies. In 2014, the US Department of Energy formalized their newest mandatory standard and the EU's voluntary Code of Conduct version 5 took effect. This white paper briefly explains the US and EU's new standards and what they mean to power supply designers.

At a global level, mandates for power efficiency exist for most consumer electronics and home appliances. External power supplies have had regulations dating back to 2004, when the California Energy Commission created one of the first mandates for efficiency of external power supplies used to power appliances or consumer electronic devices. Since then, the US, European Union, China and other countries adopted both voluntary and mandatory external power supply standards as part of energy conservation legislation. Table 1 shows a breakdown of some of the current voluntary and mandatory standards by region. Japan has a mandatory energy efficiency standard and a voluntary program called Top Runner, but neither includes an external power supply specific standard.

Worldwide External Power Supply and Battery Charger Standards

Region/Country	Standard	Compliance	Covers[1]
US	EISA-2007	Mandatory	EPS
	New DoE Standard-February 2014	Mandatory	EPS and BC
EU	EC Commission Regulation 278/2009	Mandatory	EPS and BC
	EU Code of Conduct v4 (2009)	Mandatory	EPS
	EU Code of Conduct v5 (2013)	Voluntary	EPS
California (USA)	CeC	Mandatory	BC
China	National Development and Reform Commission (NDRC)	Mandatory	EPS
Korea	Minimum Energy Performance Standards	Mandatory	EPS
Israel	SI 4665.2	Voluntary	EPS

1. EPS: External Power Supplies
   BC: Battery Chargers

Table 1: Worldwide Voluntary and Mandatory External Power Supply Efficiency Standards.

2 US – California, Energy Star® and the Department of Energy

After California released its initial state regulation on external power supplies in 2004, Energy Star developed and released its first national standard for external power supplies. The specification was largely based on the original California specification, but eventually became the foundation for the first federal mandate, the Energy Independence and Security Act of 2007. The EISA 2007 act regulated all single-output external power supplies up to 250W of output power and stipulated minimum efficiency requirements for external power supplies, including standby power consumption at no load.

EISA 2007				
CLASS	**OUTPUT POWER**	**OUTPUT VOLTAGE**	**AC or DC**	**Direct/Indirect**
Class A	<250W	Any Single Output	AC or DC	Direct
Non-Class A	Single Output>250W; Multiple Output<250W	Any Multiple Output	AC or DC	Direct or Indirect

February 2014 Final Ruling EPS				
CLASS	**OUTPUT POWER**	**OUTPUT VOLTAGE**	**AC or DC**	**Direct/Indirect**
Class B	<250W	Any Single Output	DC	Direct
Class C	<250W	<6V; ≥550mA I_{OUT}	DC	Direct
Class D	<250W	Any Single Output	AC	Direct
Class E	<250W	<6V; ≥550mA I_{OUT}	AC	Direct
Class H	>250W	Any Single Output	AC or DC	Direct
Class X	<250W	Any Multiple Output	AC or DC	Direct
Class N	<250W	Any Single Output	AC or DC	Indirect

Tables 2a and 2b: Table 2a shows the EISA 2007 Classes. Table 2b shows the new Classes in the final DoE External Power Supply Energy Conservation ruling.

As part of the original specification started in 2009, the Department of Energy had included a dedicated battery charger specification, identifying 10 different battery charger classes, but this battery charger specification was removed from the final ruling. To see the full text of the final ruling, please click here.

The most obvious difference between the EISA 2007 standard and the new standard is in the no-load power consumption maximums. Tables 3a and 3b show the original Class A efficiency standards from the EISA 2007 mandate and the recently approved standard for what used to be Class A and is now divided into 4 new classes, Class B, C, D and E. It is immediately clear that the new standard reflects a significant decrease in the allowed standby power for most of the high volume applications. When analyzing the load profile for the majority of Class B and Class C power supplies, they spend a large portion of their usable life in standby. By significantly reducing the maximum allowable no-load power consumption, the energy savings is substantial. The minimum active mode efficiency requirements also will be stricter, but the differences are not obvious without putting them into practical, real world terms. This will be analyzed later in the article.

CLASS A – Single Output AC-DC and AC-AC External Power Supplies		
P_{NO}	Active Mode	No Load
0W to ≤1W	$0.5*P_{NO}$	0.5W
1W to 51W	$0.5+(0.09*\ln(P_{NO}))$	0.5W
>51W	0	0.5W

Table 3a: Minimum Efficiency and Maximum No-Load Power Consumption from EISA 2007 Standard.

CLASSES B-D – Single Output Voltage, Basic (B & D) and Low-Voltage (C & E)				
Nameplate Output Power (P_{NO})	Active Mode Minimum Efficiency Class B & D	Active Mode Minimum Efficiency Class C & E	No Load Max Power Class B & C	No Load Max Power Class D & E
0W to <1W	$\geq(0.5*P_{NO})+0.16$	$\geq(0.517*P_{NO})+0.087$	0.1W	0.21W
>1W to ≤49W	$\geq(0.071*\ln(P_{NO}))-(0.0014*P_{NO})+0.67$	$\geq(0.0834*\ln(P_{NO}))-(0.0014*P_{NO})+0.609$	0.1W	0.21W
>49W to ≤250W	≥0.88	≥0.87	0.21W	0.21W
>250W	0.875	0.875	0.5W	0.5W

Table 3b: Minimum Efficiency and Maximum No-Load Power Consumption Levels – Feb 2014 Final Ruling External Power Supplies, Classes B – E.

3 EU - European Commission Ecodesign and Code of Conduct Standards

The European Union has two different standards running in parallel, the Commission Regulation (EC) Ecodesign Directive 278/2009, which is mandatory for any product manufactured or imported for sale within the EU, and the Code of Conduct, which is a voluntary standard set at a much stricter level.

Table 4a shows the current EC Directive 278/2009, the mandatory EU standard. Tables 4b and 4c show the new voluntary standard, the EU's Code of Conduct, version 5, tiers 1 and 2. Table 4d shows the breakdown of the no-load power consumption specified in the CoC, version 5. The no-load power consumption levels are divided differently than the minimum efficiency requirements, and therefore are called out separately. The CoCv5 goes a step further than the DoE specification by incorporating two new specifications, one for efficiency at 10% load (see Tables 4b and 4c) and a separate no-load power consumption spec for 8W power supplies or below (see Table 4d). Very specifically for mobile phone wall chargers, the no-load standby power consumption specification for power supplies at less than 8W of maximum output power reduces the maximum power consumption to 75mW, half the value of the current Tier 1 level and on-par with the stricter Tier 2 requirement. The second is a full set of efficiency standards for 10% of rated output power. All specifications, both EU and US standards, are based on taking an average of 25%, 50%, 75% and 100% of the nominal output power. When looking at a typical switch-mode power supply efficiency curve, most power supplies reach max efficiency above 20% and maintain a fairly flat efficiency curve out to 70-80% of nominal output power when the efficiency begins to decrease again. The

EU's new standard includes a 10% efficiency rating, bridging the existing efficiency standards and the no-load standby power consumption. For the complete EU CoC v5 document, please see the standards page which can be found here.

EC 278/2009 – Tier 2 – Basic Voltage AC-DC and AC-AC			
P_{NO}	**Active Mode**	**No Load (AC-DC)**	**No Load (AC-AC)**
≤1W	0.48*P_{NO}+0.14	0.3W	0.5W
>1W to ≤51W	0.622+(0.063*ln(P_{NO}))	0.3W	0.5W
>51W	0.87	0.5W	0.5W

EC 278/2009 – Tier 2 – Low Voltage (<6V, >550mA)			
P_{NO}	**Active Mode**	**No Load (AC-DC)**	**No Load (AC-AC)**
≤1W	0.497*P_{NO}+0.067	0.3W	0.3W
>1W to ≤51W	0.561+(0.075*ln(P_{NO}))	0.3W	0.3W
>51W	0.86	na	na

Table 4a: EC278/2009 Minimum Efficiency and Maximum No-Load Power Consumption as Mandated by the EU.

EU Code of Conduct, Version 5, Tier 1 Basic Voltage AC/DC and AC/AC Power Supply Minimum Efficiency		
P_{NO}	**Standard**	**10% P_{NO}**
0.3W<P_{NO}<1W	0.5*P_{NO} + 0.146	0.5*P_{NO} + 0.046
1W<P_{NO}≤49W	0.646+(0.0626*ln(P_{NO}))	0.546+(0.0626*ln(P_{NO}))
49W<P_{NO}≤250W	0.89	0.79

EU Code of Conduct, Version 5, Tier 1 Low Voltage AC/DC and AC/AC Power Supply Minimum Efficiency		
P_{NO}	**Standard**	**10% P_{NO}**
0.3W<P_{NO}<1W	0.5*P_{NO} + 0.086	0.5*P_{NO}
1W<P_{NO}≤49W	0.586+(0.0755*ln(P_{NO}))	0.500+(0.072*ln(P_{NO}))
49W<P_{NO}≤250W	0.88	0.78

Table 4b: EU Code of Conduct, Version 5, Tier 1. Became effective, January 2014.

EU Code of Conduct, Version 5, Tier 2 Basic Voltage AC/DC and AC/AC Power Supply Minimum Efficiency		
P_{NO}	**Standard**	**10% P_{NO}**
0.3W < P_{NO} < 1W	0.5*P_{NO} + 0.169	0.5*P_{NO} + 0.060
1W < P_{NO} ≤ 49W	0.67+(0.071*ln(P_{NO})) - (0.00115*P_{NO})	0.57+(0.071*ln(P_{NO})) - (0.00115*P_{NO})
49W < P_{NO} ≤ 250W	0.89	0.79

EU Code of Conduct, Version 5, Tier 2 Low Voltage AC/DC and AC/AC Power Supply Minimum Efficiency		
P_{NO}	**Standard**	**10% P_{NO}**
0.3W < P_{NO} < 1W	0.517*P_{NO} + 0.091	0.517*P_{NO}
1W < P_{NO} ≤ 49W	0.609+(0.0834*ln(P_{NO})) - (0.0011*P_{NO})	0.518+(0.0834*ln(P_{NO})) - (0.00127*P_{NO})
49W < P_{NO} ≤ 250W	0.88	0.78

Table 4c: EU Code of Conduct, Version 5, Tier 2. Becomes effective, January 2016.

EU Code of Conduct, Version 5 - No Load Power Consumption		
	Tier 1	**Tier 2**
≥ 0.3W and < 49W	0.150W	0.075W
≥ 49W and < 250W	0.250W	0.150W
Mobile, Handheld Battery Driven and < 8W	0.075W	0.075W

Table 4d: EU Code of Conduct, No-Load Power Consumption, Version 5, Tiers 1 and 2. Tier 1 is now effective and Tier 2 becomes effective January 2016.

4 Real World Impact of the New Standards

Earlier, we saw the obvious differences in no-load power consumption, but the efficiency formulas in the standards don't give that much clarity as to the active-mode efficiency differences, so the best way to understand what this actually means is to calculate some differences in minimum efficiencies comparing the current standards and the newly proposed standards.

In order to determine if a power supply meets the new proposed power supply ratings, a set of international testing standards exist to determine the efficiency of the power supply. For a power supply with a maximum rating of 10W, for example, that power supply is said to have a Nameplate Output Power of 10W. The international testing standard states to measure input power and output power at 25%, 50%, 75% and 100% loads and calculate the arithmetic average efficiency of those four points in order to determine whether or not the power supply meets the standard. Table 5 shows the actual efficiency requirements for the DoE and EU standards for four different power supply output power ratings.

				New Standards - EU and DoE			
P_{NO}	Class A (EISA 2007)	EU Ecodesign (278/2009)	CoC v4	CoC v5 (Tier 1)	CoC v5 (Tier 2)	DoE (Class C)	DoE (Class B)
No Load (10W)	0.5W	0.3W	0.3W	0.15W	0.075W	0.21W	0.1W
1W	50.00%	62.00%	62.00%	64.60%	66.90%	60.40%	66.00%
10W	70.70%	76.70%	76.60%	79.00%	82.20%	78.70%	83.00%
60W	85.00%	87.00%	87.00%	89.00%	89.00%	87.00%	88.00%
120W	85.00%	87.00%	87.00%	89.00%	89.00%	87.00%	88.00%

Table 5: Minimum Efficiency and No-Load Requirements for Representative External Power Supplies as Regulated by Each Standard (EU CoCv5, 8W No-Load Power Consumption = 75mW, Not Included).

When you look at the results of the actual efficiency numbers by nameplate output power, the intention of the new rulemaking proposal is clear. The original efficiency standards established strict efficiency requirements for medium-high power applications (>50W). Lower power applications were allowed lower efficiency levels. With the new proposals, efficiency targets at lighter loads are increasing in order to save energy on a broader scale. The CoC includes in their new standard a 10% of nameplate output power efficiency requirement. The difference in efficiency for the 10% number is a flat 10% from the CoCv5, Tier 2 requirements shown in Table 5.

These regulations started as a part of larger plans to reduce wasted energy and combat environmental problems caused by the ever increasing energy demands. According to the Department of Energy, by increasing the efficiency requirements by the amounts shown in the new EPS standard, the cumulative emissions reduction from 2013 – 2042 is estimated to be 43 metric tons of CO_2 and 35.5 metric tons of NOx. This is in the US alone. This reduction in greenhouse gases results in a cumulative savings to the consumer of up to $2.7BN in just CO_2 reduction alone. Besides the reduction in greenhouse gases and their effect on the economy, the new proposal also reduces the amount of electricity that needs to be generated, and therefore also passes savings along to the consumer. By the year 2042, the annual electricity savings from the new standard and its impact on the external power supply market will be greater than 3TWh on average. When monetized, the combination of greenhouse gas reductions plus the simple energy savings by using more efficient electronics can save the consumers up to $7.5BN over a 30 year period.

The impact to the power supply community is also clear. The era of poor efficiency, low cost solutions is over for the external power supply market. The DoE, as part of their study for implementing the new standard, published a large study on the cost impact of the higher efficiency standards. According to this study, the manufacturing cost and resale price for these power supplies will increase significantly, but with the energy savings over time, the consumer will see a net benefit because of the reduced energy consumption in their home. The power supply manufacturers and power supply control IC manufacturers have the real challenge in making cost-effective power supply components that can meet both active-mode efficiency minimums while meeting the no-load power consumption mandates.

5 International Marking Standards

In order to identify if an external power supply complies with a certain minimum efficiency level, a set of markings were established and accepted internationally. With the introduction of the new DoE standard in 2014, the markings standard was updated to include a 6th level, indicated by a roman numeral “VI”. Any manufacturer that meets the DoE’s new standard will be able to use the Roman Numeral VI marking. The CoCv5 Tier 2 standard also meets the Roman Numeral VI levels, but Tier 1 does not, as the no-load power consumption level in Tier 1 is above the maximum level set in the international marking standards.

For a complete explanation of the international marking protocol and all of its variations, please see the US Department of Energy marking protocol PDF found here.