Level VI DoE Rules And Regulations For External Power Supplies—Where To Find Them

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The United States Department of Energy (DoE) has published regulations on the efficiency of external power supplies (EPSs). These rules and regulation were started by the California Energy Commission and have been taken over the DoE. The standards applied to EPSs have evolved over the years and been given level designations to indicate which version of the standard is being applied. The DoE standard currently in effect for energy efficiency in EPSs is known as level VI and the deadline for compliance with this standard was February 10, 2016. In other words, any external power supply manufactured on or after that date must comply with the DoE's Level VI requirements rather than the less stringent Level V.

Although we have seen a number of articles stating the rules in some form, they do not provide a reference to where the rules are located. This may seem like a small matter, but there are many details concerning the application of the DoE rules that are usually omitted when third parties republish the Level VI requirements. Moreover, even if you locate the DoE web page on external power supplies, you may waste time sorting through the various links before locating the actual section you're seeking. This article provides the URL where designers can actually find the Level VI energy efficiency rules with some discussion on related information.

What You've Seen

When the DoE specifications for energy efficiency are published, you typically see the following type of chart shown in Fig. 1. This particular chart gives an overview of the test limits for the various levels from I through VI. While this chart is informative, it's incomplete and doesn't provide all the details that you will find by going to the DoE website.

There are actually a few links that you'll want to know about. First, there is the one pointing to the DoE page on "Appliance and Equipment Standards Rulemakings and Notices" (Fig. 2). The link for this page is https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=1. This page provides links to a number of documents relating to EPSs. One thing you'll learn on this page is that this ruling on Level VI has been in the works since 2007. Though not stated here, many of the older regulations go back to 2004. Another thing you will find on this page is information concerning the Final Rule, as shown in Fig. 3.

Looking at this chart, you'll see there are links to several pages that will mostly give you detailed historical information on the development of the Level VI standard—most likely more information than you will need to qualify a power supply. However, it's worth noticing that this section indicates two important dates concerning Level VI. One is the compliance date mentioned above, February 10, 2016. The other is the date the Level VI requirements were formally finalized on May 16, 2016.

But to get to the standards requirements, keep scrolling past the chart in Fig. 3 and you'll quickly come to the section on "Current Standard" as shown in Fig. 4. Here you will find a hot link for 10 CFR 430.32W, which takes you to the actual page containing the Level VI regulations. In case you want to go there directly, the URL for this page is as follows:

https://www.ecfr.gov/cgi-bin/text-idx?SID=c9dbafe3c54ecf1ee3bbb502608fca50&mc=true&node=se10.3.430_132&rgn=div8 .

When you get there, you'll see the title "e-CFR Electronic Code of Federal Regulations" and as you begin to scroll you will see it covers much more than just the EPS requirements. Requirements for all types of appliances are provided here. But if you scroll most of the way down the page to section (w), you'll find the requirements for the EPSs. Fig. 5 shows a screen capture of the charts you will see here, but these are followed by many notes on the requirements.

Mark	Performance Requirements				
	Nameplate Output Power (P_{no})[2]	No-Load Mode Power[3]	Nameplate Output Power (P_{no})	Average Efficiency in Active Mode[4]	Power Factor
I	Used if none of the other criteria are met.				
II	0 to ≤ 10 W	≤ 0.75	0 to < 1 W	≥ 0.39 * P_{no}	Not Applicable
	> 10 to 250 W	≤ 1.0	1 to < 49 W	≥ 0.107 * ln(P_{no}) + 0.39	
			> 49 W	≥ 0.82	
III	0 to < 10 W	≤ 0.5	0 to 1 W	≥ 0.49 * P_{no}	Not Applicable
	10 to 250 W	≤ 0.75	> 1 to 49 W	≥ 0.09 * ln(P_{no}) + 0.49	
			> 49 to 250 W	≥ 0.84	
IV	0 to 250 W	≤ 0.5	0 to < 1 W	≥ 0.5 * P_{no}	Not Applicable
			1 to 51 W	≥ 0.09 * ln(P_{no}) + 0.5	
			> 51 to 250 W	≥ 0.85	
V	0 to < 50 W	AC-DC: ≤ 0.3 AC-AC: ≤ 0.5	0 to ≤ 1 W	Basic Voltage: ≥ 0.480 * P_{no} + 0.140 Low Voltage[5]: ≥ 0.497 * P_{no} + 0.067	EPSs with ≥ 100 watts **input** power must have a true power factor ≥ 0.9 at 100% of rated load when tested at 115 volts/60Hz.
			> 1 to ≤ 49 W	Basic Voltage: ≥ 0.0626 * ln(P_{no}) + 0.622 Low Voltage: ≥ 0.0750 * ln(P_{no}) + 0.561	
	≥ 50 to ≤ 250 W	≤ 0.5	> 49 to 250 W	Basic Voltage: ≥ 0.870 Low Voltage: ≥ 0.860	
VI	Single-Voltage				Not Applicable
	0 to ≤ 49 W	AC-DC: ≤ 0.100 AC-AC: ≤ 0.210	0 to ≤ 1 W	Basic Voltage: ≥ 0.5 * P_{no} + 0.16 Low Voltage: ≥ 0.517 * P_{no} + 0.087	
			> 1 to ≤ 49 W	Basic Voltage: ≥ 0.071 * ln(P_{no}) − 0.0014 * P_{no} + 0.67 Low Voltage: ≥ 0.0834 * ln(P_{no}) − 0.0014 * P_{no} + 0.609	
	> 49 to ≤ 250 W	≤ 0.210	> 49 to ≤ 250 W	Basic Voltage: ≥ 0.880 Low Voltage: ≥ 0.870	
	> 250 W	≤ 0.500	> 250 W	≥ 0.875	
	Multiple-Voltage				
	Any	≤ 0.300	0 to ≤ 1 W	≥ 0.497 * P_{no} + 0.067	
			> 1 to ≤ 49 W	≥ 0.075 * ln(P_{no}) + 0.561	
			> 49 W	≥ 0.860	
VII	Reserved for future use.				

Fig. 1. Wattage and energy efficiency limits for EPSs. This chart is the most common re-publication of DoE requirements for external power supplies. Note that it only summarizes the test requirements for the six levels of the standard that have been introduced to date.

Appliance and Equipment Standards Rulemakings and Notices

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External Power Supplies

As defined in the Code of Federal Regulations (CFR), "external power supply" means an external power supply circuit that is used to convert household electric current into DC current or lower-voltage AC current to operate a consumer product. 10 CFR 430.2 Manufacturers have been required to comply with the U.S. Department of Energy (DOE) energy conservation standards for external power supplies since 2007.

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Current Standard | Current Test Procedure | Ongoing Rulemaking for Standards | Ongoing Rulemaking for Test Procedure | Helpful Links

Recent and Ongoing Activities

For the latest information on the planned timing of future DOE regulatory milestones, see the current Office of Management and Budget Unified Agenda of Regulatory and Deregulatory Actions. All planned dates are preliminary and subject to change.

Fig. 2. DOE site for Current Standard, Current Test procedures, and others items.

Final Rule	• External Power Supplies Energy Conservation Standard Final Rule, *79 FR 7846* (February 10, 2014) • Technical Support Document • International Energy Efficiency Marking Protocol, Version 3.0 • Compliance Date: February 10, 2016 • Notice of Final Rule, 81 FR 30157 (May 16, 2016)

Fig. 3. The DoE's links to Final Rule information on the EPS energy efficiency standard. This section shows two important dates: Feb. 10, 2016 when the Level VI requirements went into effect and May 16, 2016 when the requirements were finalized.

Current Standard

External power supplies manufactured and distributed in commerce, as defined by 42 U.S.C. 6291(16), must meet the energy conservation standards specified in the Code of Federal Regulations at 10 CFR 430.32(w).

Fig. 4. This section of the DoE's section on External Power Supplies points you to the actual level VI requirements in the link for 10 CFR 430.32W.

(w) *External power supplies.* (1)(i) Except as provided in paragraphs (w)(2) and (5) of this section, all Class A external power supplies manufactured on or after July 1, 2008, shall meet the following standards:

Active Mode	
Nameplate output	**Required efficiency (decimal equivalent of a percentage)**
Less than 1 watt	0.5 times the Nameplate output.
From 1 watt to not more than 51 watts	The sum of 0.09 times the Natural Logarithm of the Nameplate Output and 0.5.
Greater than 51 watts	0.85.
Not more than 250 watts	0.5 watts.

(ii) Except as provided in paragraphs (w)(5), (w)(6), and (w)(7) of this section, all direct operation external power supplies manufactured on or after February 10, 2016, shall meet the following standards:

Single-Voltage External AC-DC Power Supply, Basic-Voltage		
Nameplate Output Power (P_{out})	**Minimum Average Efficiency in Active Mode** *(expressed as a decimal)*	**Maximum Power in No-Load Mode [W]**
$P_{out} \leq 1$ W	$\geq 0.5 \times P_{out} + 0.16$	≤ 0.100
1 W < $P_{out} \leq 49$ W	$\geq 0.071 \times \ln(P_{out}) - 0.0014 \times P_{out} + 0.67$	≤ 0.100
49 W < $P_{out} \leq 250$ W	≥ 0.880	≤ 0.210
$P_{out} > 250$ W	≥ 0.875	≤ 0.500
Single-Voltage External AC-DC Power Supply, Low-Voltage		
Nameplate Output Power (P_{out})	**Minimum Average Efficiency in Active Mode** *(expressed as a decimal)*	**Maximum Power in No-Load Mode [W]**
$P_{out} \leq 1$ W	$\geq 0.517 \times P_{out} + 0.087$	≤ 0.100
1 W < $P_{out} \leq 49$ W	$\geq 0.0834 \times \ln(P_{out}) - 0.0014 \times P_{out} + 0.609$	≤ 0.100
49 W < $P_{out} \leq 250$ W	≥ 0.870	≤ 0.210
$P_{out} > 250$ W	≥ 0.875	≤ 0.500
Single-Voltage External AC-AC Power Supply, Basic-Voltage		
Nameplate Output Power (P_{out})	**Minimum Average Efficiency in Active Mode** *(expressed as a decimal)*	**Maximum Power in No-Load Mode [W]**
$P_{out} \leq 1$ W	$\geq 0.5 \times P_{out} + 0.16$	≤ 0.210
1 W < $P_{out} \leq 49$ W	$\geq 0.071 \times \ln(P_{out}) - 0.0014 \times P_{out} + 0.67$	≤ 0.210
49 W < $P_{out} \leq 250$ W	≥ 0.880	≤ 0.210
$P_{out} > 250$ W	≥ 0.875	≤ 0.500
Single-Voltage External AC-AC Power Supply, Low-Voltage		
Nameplate Output Power (P_{out})	**Minimum Average Efficiency in Active Mode** *(expressed as a decimal)*	**Maximum Power in No-Load Mode [W]**
$P_{out} \leq 1$ W	$\geq 0.517 \times P_{out} + 0.087$	≤ 0.210
1 W < $P_{out} \leq 49$ W	$\geq 0.0834 \times \ln(P_{out}) - 0.0014 \times P_{out} + 0.609$	≤ 0.210

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49 W < $P_{out} \leq 250$ W	≥ 0.870	≤ 0.210
$P_{out} > 250$ W	≥ 0.875	≤ 0.500
Multiple-Voltage External Power Supply		
Nameplate Output Power (P_{out})	**Minimum Average Efficiency in Active Mode** *(expressed as a decimal)*	**Maximum Power in No-Load Mode [W]**
$P_{out} \leq 1$ W	$\geq 0.497 \times P_{out} + 0.067$	≤ 0.300
1 W < $P_{out} \leq 49$ W	$\geq 0.075 \times \ln(P_{out}) + 0.561$	≤ 0.300
$P_{out} > 49$ W	≥ 0.860	≤ 0.300

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(iii) Except as provided in paragraphs (w)(5), (w)(6), and (w)(7) of this section, all external power supplies manufactured on or after February 10, 2016, shall meet the following standards:

	Class A EPS	**Non-Class A EPS**
Direct Operation EPS	Level VI: 10 CFR 430.32(w)(1)(ii)	Level VI: 10 CFR 430.32(w)(1)(ii).
Indirect Operation EPS	Level IV: 10 CFR 430.32(w)(1)(i)	No Standards.

Fig. 4. The e-CFR Electronic Code of Federal Regulations provides the charts shown above for the EPS Level VI energy efficiency requirements.

Power Supply Labeling

In addition to the rules on power supply performance, the EPS requirements specify how compliance with Level VI is to be indicated on power supply labeling.

As listed above in Fig. 3, The DoE has published a ruling "International Energy Efficiency Marking Protocol, Version 3.0," which takes you to the following page: https://www.regulations.gov/document?D=EERE-2008-BT-STD-0005-0218.

Here you'll find a three-page PDF file that provides details on how to format the label used for product marking in terms of typography and how to place the label on the power supply. The example provided, which is repeated here in Fig. 5, is Level V. There are additional rules and websites listed on the last page. Also notice on page 2 the chart of EPS wattage and energy efficiency limits shown above in Fig. 1. So now you know where that commonly seen chart comes from.

Format:	Roman numeral: I, II, III, IV, V, VI, etc.
Font:	Times Roman preferred (or other plain serif fonts).
Size:	Legible and indelible.
Color:	Text to contrast with the nameplate background, unless incorporated in the case molding.
Placement:	Preferably on the EPS nameplate; however, placement on the product packaging or accompanying documentation is also acceptable. The exact location is at the discretion of the manufacturer. The text "Efficiency Level" shown in the example below is optional.

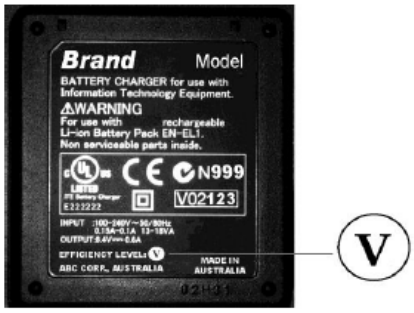

Fig. 5. Energy efficiency level marking.

Exclusion Of Medical Devices

The DoE published a final ruling defining devices that are exempt from the energy efficiency requirements for EPSs. Medical devices are excluded as stated in the following passage, which is taken from page 34 of the 255 page final rule document found at https://www.energy.gov/sites/prod/files/2014/02/f7/eps_ecs_final_rule.pdf:

"The Class A definition excludes any device that either (a) requires Federal Food and Drug Administration listing and approval as a medical device in accordance with section 513 of the Federal Food, Drug, and Cosmetic Act (21 U.S.C. 360(c)) or (b) powers the charger of a detachable battery pack or charges the battery of a product that is fully or primarily motor operated. See 42 U.S.C. 6291(36)(C)(ii)."

Conclusion

It is hoped that this article is helpful for many engineers and marketers who want to know where the rules are located for Energy Efficiency Level VI. There is no cost to downloading the rules since they are published by the United States Department of Energy. There is also a special section for recording and reporting not shown in this summary article.

About The Authors

Kevin Parmenter is an IEEE Senior Member and has over 20 years of experience in the electronics and semiconductor industry. Kevin is currently vice president of applications engineering in the U.S.A. for Excelsys, an Advanced Energy company. Previously, Kevin has served as director of Advanced Technical Marketing for Digital Power Products at Exar, and led global product applications engineering and new product definition for Freescale Semiconductors AMPD - Analog, Mixed Signal and Power Division based in Tempe, Arizona.

Prior to that, he worked for Fairchild Semiconductor in the Americas as senior director of field applications engineering and held various technical and management positions with increasing responsibility at ON Semiconductor and in the Motorola Semiconductor Products Sector. Kevin also led an applications engineering team for the start-up Primarion where he worked on high-speed electro-optical communications and digital power supply semiconductors.

Kevin serves on the board of directors of the PSMA (Power Sources Manufacturers Association) and was the general chair of APEC 2009 (the IEEE Applied Power Electronics Conference.) Kevin has also had design engineering experience in the medical electronics and military electronics fields. He holds a BSEE and BS in Business Administration, is a member of the IEEE, and holds an Amateur Extra class FCC license (call sign KG5Q) as well as an FCC Commercial Radiotelephone License.

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For many years, he worked as a field applications engineer (FAE) for Motorola Semiconductor, On Semiconductor, Cirrus Logic, and Active Semiconductor, assisting customers in using semiconductors. He published numerous application notes and conference papers at a variety of conferences: APEC, ECCE, IAS, and PCIM. Topics included power factor correction, lighting, and automotive applications. As an FAE, he traveled internationally giving switch-mode power supply seminars in Australia, Hong Kong, Taiwan, Korea, Japan, Mexico, and Canada.

Jim has a Master's Degree from Northern Illinois University (NIU), and was a PhD candidate at Illinois Institute of Technology (IIT). He taught senior and first-level graduate student classes: Survey of Power Electronics, Fields and Waves, and Electronic Engineering at IIT and Midwest College of Engineering.

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