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To: CA CEC and US DOE Battery Charging Specification Development Teams

We recently had the opportunity to share and review our concerns with Ken Rider (CA CEC), Victor Petrolati (US DOE), and Matthew Nardotti (Navigant Consulting) regarding the upcoming battery charger system efficiency requirements.

Please find enclosed feedback on each section of CA's Energy Efficiency Battery Charger System Test Procedure Version 2.2 (January 26, 2009). The focus of the comments is the test procedures and methodologies as they apply to mobile computing devices.

Intel is reviewing these concerns with other members of the computer industry through organizations such as the IT Industry Council (ITI). We have also identified potential conflicts with other international specifications, such as the Energy Related Products (ERP) Lot 6 requirements. We expect ITI to provide industry comments soon.

As discussed with Ken, the CA procedures are being referenced and utilized in upcoming US DOE rule making specifications on battery chargers and products that have battery charging embedded in their design. We believe it's important to resolve these concerns as soon as possible to prevent future issues in the US DOE rule making, CA specifications, and specifications being developed in other regions worldwide.

Thank you again for taking the time to review our comments and taking them into consideration for upcoming specifications. If you have any questions please feel free to contact myself or Jim Kardach at jim.kardach@intel.com

Sincerely,

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Feedback on the Energy Efficiency Battery Charger System Test Procedure Version 2.2, January 26, 2009

This is feedback on the Energy Efficiency Charger System Test procedure which is being intended for use in testing of Battery Charging Systems for upcoming California Energy Commission (CEC) and US Department of Energy (DOE) regulations.

Feedback by Section

Part 1, I.A, Table A: In the description for steps 2, 3, 4, 5, 6 7 and 8

The section reference appears to be wrong. They all reference section VI, but there is no section VI. I believe the correct sections are:

Step 2: Battery conditioning, Section III.A
Step 3: Prepare the battery for test, Section III.B
Step 4: Battery rest period, Section III.C
Step 5: Conduce Charge Mode and Battery Maintenance Mode Test, Section III.D
Step 6: Battery rest period, Section III.E
Step 7: Conduct Battery Discharge Energy Test, Section III.F
Step 8: Conduct No-Battery Mode Test and Off Mode Test, Section IV.A, B and C
Step 9: Compile data into report, Section V.B, C and D

Part 1, I.A, Table A: Steps 4 and 5

The table indicates no data taken, however the requirements require record of the rest period (in hr:min) and optionally the temperature of the electrolytes. These steps should report "*Yes*" in the "*Data Taken?*" column.

Part 1, I.B. Measuring Equipment.

The uncertainty due to the power meter is underestimated (result of a copy-paste from IEC 62301 Ed. 1); IEC 62301 Ed.2 (59/555/FDIS) has updated it to more realistic values, with an additional provision for loads with low Power Factor (PF) and/or high Crest Factor (CF).

- For measured power values of greater than or equal to 1.0 W, [...] 2 % of the measured power value For measured power values of less than 1.0 W, [...] 0.02 W

Above values apply when the load has a Maximum Current Ratio (MCR) < 10; for higher MCR values, corrective factors apply to increase the tolerance.

Feedback from the current IEC-62301 workgroup was:
Paragraph from the introductory note to 59/555/FDIS (the FDIS for IEC 62301 Edition 2):

"1/ Changes to the uncertainty requirements in Clause 4.4.1: Edition 1 of the standard had an uncertainty requirement of 2% at the 95% confidence level for power levels over 0.5W and an absolute uncertainty of 10mW for power levels of 0.5W or less. Detailed technical submissions on the CDV showed that even commonly used power measurement instruments with good specifications were unable to meet these requirements for certain types of load, typically those with very low power factor (less than 0.2) and/or those with a very high crest factor (typically >10 or more). Experiments conducted in Europe show that although it is possible for loads with a 'peaky' current waveform to exhibit this problem, the more common examples are found where the current and voltage are both sinusoidal but out of phase (typically due to the presence of X capacitors). Very detailed investigations showed that these "*difficult*" loads cannot be measured with the earlier limit on measurement uncertainty, even with sophisticated laboratory instruments. The FDIS includes a proposal to increase the permitted uncertainty in accordance with a new term (Maximum Current Ratio), which is a function of the permitted crest factor of the meter, the actual crest factor of the load and the power factor of the load. The uncertainty is only increased once these effects become quite large. The other significant change is the alteration of the threshold from a relative uncertainty of 2% to an absolute uncertainty: this has been altered from 0.5W (and 10mW) to 1.0W (and 20mW). This will not have many practical implications for most measurements under this standard, as 20mW is still quite a small uncertainty for small loads. The new requirements should not be considered a relaxation of the current requirements, but more of an adjustment of the technical requirements to make the specification more practical in its application."

Part 1, I.D. Input Reference Source: Input Voltage and Input Frequency.
Most ITC equipment never sees 115V in the USA because the line voltage is 120V and most information uses line conditioners which would bring the voltage back to 120V (if it happens to drop). Hence requiring testing at 115V requires Mfg. to optimize the design of equipment to a voltage (115V) that most end-users will never experience (versus the 120V line voltage standard).

Part 1, II.C.2).
Next to last paragraph "In Table C, below, each row represents a mutually exclusive charger type. Each of these batteries shall be tested at each applicable input voltage and each applicable charge rate, as specified by Part 1, Sections 1.D and II.A.

In reference to Table C. Battery Selection for Testing, Type of charger, please clarify or address multi-voltage.

In column 1 of Table C,"*Type of charger. Multi-voltage?*" is a confusing term, and could be confused with the output voltage of a battery pack, versus the "*input voltage*" description in Section 1.D (the AC input voltage to the charger or EPS). Additionally there is a definition "*AA. Multi-voltage Charger*" which defines this concept as a charger which supports a variety of battery packs with different rated battery voltages.

In previous sections, it was shown that the references were inaccurate, this definition can either mean "*different BCS input voltages*" as in running off either (115V AC or 230V AC, as referenced by section 1.D) or supporting a "*variety of battery with different rated battery voltages*" (as defined in definitions).

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It is suggested that the term used to specify the "*BCS input voltage*" be added to definitions and defined. Have this term used in section 1.D, and for this paragraph and Table C to refer to the appropriate term. If the reference to section 1.D is no longer consistent, then this should be updated.

The second issue is the reference to section II.A and the written reference in the paragraph to "… each applicable charge rate". The actual Section II.A reference is for "General Setup", which doesn't make any sense. We think this is probably a broken reference Section III.F Table D, which has the different discharge rates enumerated. Please confirm and clarify.

Part 1, II.C. Table C.

Table C uses the term "*Multi-capacity*", but the term is not defined in the definitions (where "*Multi-Voltage*" and "*Multi-Port*" are defined). Both "*single-capacity*" and "*multi-capacity*" are, however, defined elsewhere in section II.c. We suggested that these definitions be moved to the definition section.

Part 1, II.D. Other Non-Battery Charger Functions

There is a concern for many devices which have integrated battery chargers that the non BCS power (which can't be switched off) will impact the battery efficiency assessments. This is true for Notebook, tablet and cellphone (computer) systems where the level of integration is so high that the ability to shut off these other systems will not be possible.

Additionally, these systems use an EPS where the required efficiencies (via DOE requirements) may not be operating in their optimum efficiency ranges. This is because the rated Pmax of the EPS will be much higher than what is required to charge the battery from an off state (efficiencies are required at an average Pmax of 25%, 50%, 75% and 100% of Pmax).

However, these devices are already regulated through their no-load power (via EPS requirements) . Additionally, new "off mode" requirements (like the ErP Lot 6 requirements) will already require off mode power to be less than 0.5W.

Part 1, IV. No-Battery Mod and Off Mode Tests

As noted previously, (computer) systems with integrated battery chargers have non-battery charging functions that would impact battery charging efficiency calculations. Therefore, it is important to distinguish three different types of average power for integrated chargers (like those found in notebook computers).

1. *No-Load Power*: The average power of the power supply under no load
2. *No-Battery Power/Off Power*: The average power of the device where none of the energy is going to the battery or battery charging system
3. *Maintenance Power*: The average power of the device when its performing the battery maintenance function

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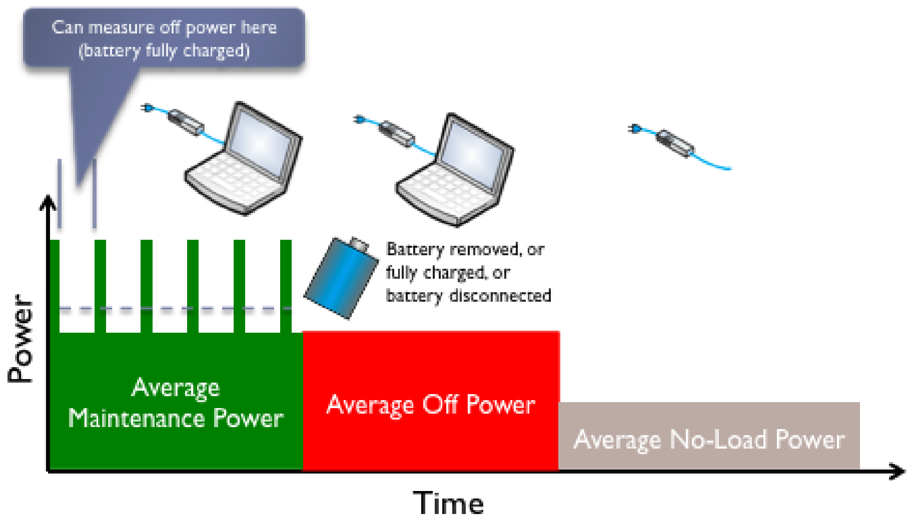
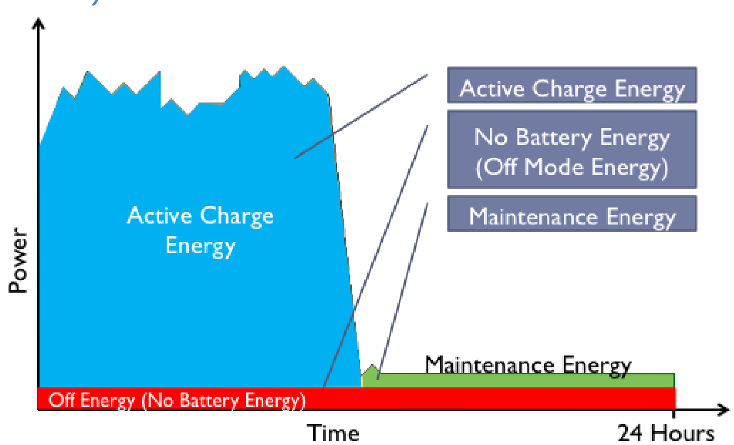
These modes are illustrated in the following diagram depicting the differences between the *Maintenance Power, Off Power* and *No-Load Power*.



As highlighted, the *Maintenance Power* and the *Off Power* (i.e. *No-Battery Power*) are different. The intent of the *No-Battery* test is to capture a meaningful representation of the power for system functions. For Category 3 devices, the testing procedure does not capture this, and would estimate a much lower power value using *Average No-Load Power*.

For notebooks, *Maintenance Power* is an issue because this power level varies across the different battery chemistries employed. As a result, it's important to separate *Off Power* from *Maintenance Power* to measure the efficiency of the system. The current test procedure, however, would end up measuring the *No-Load Power* instead of *Average Off Power* or *Average Maintenance Power*

Why does distinguishing *Off Power, Maintenance Power, and No-Load Power* matter? The 24 hour (non-active) energy of a notebook (or other integrated battery charger device) could be described as follows:



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In the current measurement methodology the *Off* energy is captured as part of the Maintenance energy and active charge energy. As the primary function of the device is not battery charging (it's supporting the computer or some other main function) this energy ends up causing the charge efficiency calculations appear low. For a representative value for charging efficiency, *Off* energy should really be subtracted out or accounted for in the limit.

From the graph, true 24 hour charge energy is simply the measured charge energy minus the average off power times 24 hours, or

24hr Chg Energy (24CE) = [Measured 24 hour energy] – 24 hr*[average off power].

Therefore, if *Off Power* (i.e. *Average No-Battery Power*)is not measured, *Off Power* is mistakenly equated to the *No-Load Power* (the current issue with the test procedure). Without the *Off Power* assessment you cannot adjust for the non-charging related energy in the integrated devices to determine battery charging efficiency.

In the testing procedure, the definition of the Category 3 products (which notebooks falls into) ends up measuring the EPS *No-Load Power* and not the *Off Power* (i.e. *No-Battery*). We suggest that the testing procedure be amended to reflect how ENERGY STAR for computers and Ecma-383/IEC-62623 measures off power

- With the battery removed, or
- With the battery fully charged (if the battery can't be removed)

The average power is measured over 5 minutes, which makes it highly unlikely that the maintenance charger system would kick in (for the battery fully charged case).

We recommend making the following changes to the "IV. No-battery Mode and Off Mode Tests, A. Setup for Category 3 products.

"

Category 3 Products

Both the no-battery mode and off mode tests shall be conducted on products in category 3. After completion of the Battery Charging and Maintenance Mode Test, set up the product for the no-battery mode test as follows:

- If the product has a charging base: the portable device shall be removed from the charging base and the charging base shall be connected to the input power. If the charging base uses an EPS, the EPS shall be connected to input power and to the charging base.
- If the product does not have a charging base but does have an external charger or an EPS: the product shall be disconnected from the charger or the EPS. The charger or EPS shall be connected to input power.

"

We also recommend making the following changes to avoid measuring the wrong power for devices with integrated battery chargers.

"

Category 3 Products
Both the no-battery mode and off mode tests shall be conducted on products in category 3. After completion of the Battery Charging and Maintenance Mode Test, set up the product for the no-battery mode test as follows:

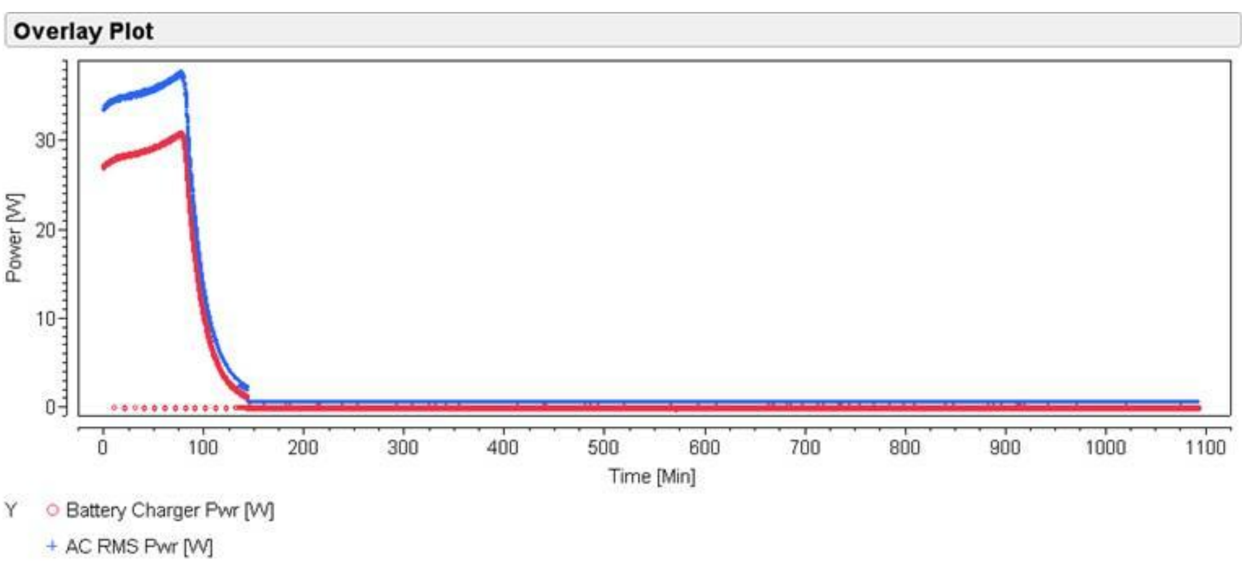
- If the product has a charging base: the portable device shall be removed from the charging base and the charging base shall be connected to the input power. If the charging base uses an EPS, the EPS shall be connected to input power and to the charging base.
- If the product does not have a charging base but does have an external charger ~~*or an EPS*~~: the product shall be disconnected from the charger or the EPS. The charger ~~*or EPS shall*~~ be connected to input power.
- *If the product does not have a charging base but only has an EPS: The EPS shall be connected to input power. AND either*
    - *If the battery can be removed, then remove the battery, or*
    - *If the battery CAN NOT be removed, then ensure the battery is fully charged.*

"

As an example, we recently conducted battery charging tests on a notebook resulting in the following characteristics:

No-Load Power (of the EPS): 0.18W
Off Power (notebook, battery removed): 0.59W
Maintenance Power (average power on last 4 hours of 24 energy test): 0.59W

A plot of power verses time (note the red line is the power at the input to the battery charger, blue at the wall) is shown below



This computer system has a Li-ion power, therefore, the maintenance power and off power are approximately the same (Li-Ion have very slow self-discharge rates and maintenance power is not impacted). For non-Lithium chemistries (we didn't have a system to illustrate the point) the off power and maintenance power would be different (Ni-Cd, Ni-MH, etc…). With different power levels for various chemistries, maintenance and off power levels are important to calculate the battery energy (efficiency).

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Part 1, II.E: Duration of the Charging and Maintenance Mode Test
States "*The charging and maintenance mode test, Part 1, Section III.D, shall be 24 hours or longer, as determined by the items below, in order of preference:*"

Is this assuming that this is simply the time required for the test and ***not*** the time interval to calculate the energy required to charge the battery (note that many batteries could be fully charged after the first hour)?

Part 1, II.F: Access to the Battery for Discharge Test
Some batteries use "*smart battery circuits*" to control the charging of the batteries and to allow discharge of the battery. It may require a special harness between the battery analyzer and the battery to support discharging of these sorts of batteries and this should be noted in the test procedure.

Also there is a paragraph which states that you can connect to the battery through different terminals such that the protective control circuits do not consume any energy (or is not measured). We don't believe this is possible. Either the "*protective circuits*" are in series with battery cells within the battery, or connected in parallel across the batteries. In either case, unless the "*protective circuits*" are cut out of the battery circuit, they will consume energy. Furthermore, it may not be safe for the circuits to be removed.

As stated in this section (Part 1, II.F) this can be a destructive process (removing the battery from the system in order to discharge it), and this can cause issues with the ordering of the tests as outlined in Part 1, I.A, Table A: Test Sequence (which will be described in comments on Part 1, III.B "*Preparing the Battery for testing*").

Part 1, III.A: Conditioning of the Battery
Please define the term "100% DOD". We cannot the definition anywhere in the document

Part 1, III.B: Prepare the Battery for Testing
This section states:
"*Prior to testing the battery shall be discharged. This discharge shall be done using a battery analyzer that draws a constant discharge current of 0.2C. When the battery voltage reaches the end-of-discharge voltage for that battery chemistry or the UUT circuitry terminates the discharge, the discharge shall be terminated by opening the battery circuit.*"

As noted in "*Part 1, II.F: Access to the Battery for Discharge Test*", the battery discharge test can be destructive (by taking the battery out), especially to systems with integrated BCS and/or integrated batteries. Therefore, requiring the battery to be initially charged and discharged by a battery analyzer prior to the "*Charge Mode and Battery Maintenance Mode Test*" may make it impossible to conduct the test.

It should also be noted that most Notebook batteries are only discharged to about 5% of their capacity to support a hibernate buffer (when the battery gets 95% discharged, it reserves the last 5% to do a suspend to disk in order to not lost the end-user's data/context). Hence, if the battery can't be removed or the battery reprogrammed to support 100% discharge (as required by conditioning) by an external battery analyzer, it might be the case that the battery is starting with a 5% charge on the "*Charge Mode and Battery Maintenance Mode Test*".

It should also be noted that most Notebook batteries are "*smart*" in that the battery communicates to the charger how to charge it and when to stop. (This is done to remove any battery chemistry dependency on the charger. The battery tells the charger when it needs charging and when it is done charging.) As a result, "*smart*" battery systems may have a problem if they are required to stop charging the battery when the voltage reaches the "*End-of-Discharge Voltage*" values in Table D. We suggest that the language be modified to allow an "*appropriate voltage for the 'end of discharge voltage'* ". While we can't speak for other industries, we believe that a fixed 2.5V end-of-discharge voltage for Li-Ion cells is not correct for all cases. In practice, the voltage may vary widely depending on different factors (i.e. load, chemistry, etc …).

Part 1, III.D: Charge Mode and Battery Maintenance Mode Test

Step 1) requiring the battery to have been conditioned may be problematic for integrated batteries which require destruction of the system to gain access to the battery, and with smart battery systems where the battery analyzer would have to reprogram the battery as to allow it to be discharged fully (see above comments).

Step 7) Shouldn't the reference for the *'Record the input power for the duration of the "Charging and Maintenance Mode Test" period, as determined by Part 1, Section II.E*' be a reference to Part 1, Section 1.D *Input Reference Source: Input 'Voltage and Input Frequency'* "?

Part 1, III.E: Battery Discharge Energy Test

Page 19 indicates that the battery analyzer for constant discharge current of 0.2A and the end-of-discharge voltage in Table D for the relevant battery chemistry.

Please note again what we stated on "smart" battery controls for the section IIe. Most Notebook batteries are "smart" in that the battery communicates to the charger how to charge it and when to stop. (This is done to remove any battery chemistry dependency on the charger. The battery tells the charger when it needs charging and when it is done charging.) As a result, "*smart*" battery systems may have a problem if they are required to stop charging the battery when the voltage reaches the "*End-of-Discharge Voltage*" values in Table D. We suggest that the language be modified to allow an "*appropriate voltage for the 'end of discharge voltage'* ". While we can't speak for other industries, we believe that a fixed 2.5V end-of-discharge voltage for Li-Ion cells is not correct for all cases. In practice, the voltage may vary widely depending on different factors (e.g. load, chemistry, etc…).

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