# Consolidated Answers to Questions Posed on the Little Box Challenge Website

**Question:** My question wasn't answered. Why not?

**Answer:** Many potential questions are answered in the terms and conditions of the competition and detailed inverter requirements documents. Any question clearly covered there will not be answered again. Some other questions are deemed off topic or do not pertain to a topic that the competition will comment on.

Note that many questions have been reworded or consolidated from the originally submitted questions, and therefore your question may well be reworded and answered below. Some questions submitted in one time period may be answered in a later time period.

Some questions submitted, especially detailed technical ones, will not be answered before the September 30, 2014 registration deadline. **We strongly encourage anyone considering participating in the competition to register before the deadline, even if you have some lingering questions**. Registering does not constitute an obligation to participate in later stages of the competition, but is a requirement for submitting an entry to the competition. Questions will continue to be answered throughout the course of the competition and we will be working with our testing partner NREL to provide more detailed technical responses over time as well. Please note, two questions submitted from December 6, 2014 to March 10, 2015 have had their answers changed from the original, they are highlighted in green. One question submitted from June 23, 2015 to July 6, 2015 has had its answer changed, it is highlighted in blue.

# Questions submitted and answered from July 22, 2014 to July 29, 2014

**Question:** Why can't residents of Italy, Brazil, Quebec, Cuba, Iran, Syria, North Korea, or Sudan take part in the competition?

**Answer:** Unfortunately, each of these countries/regions have laws or circumstances that complicate allowing their residents to participate in a competition such as this one.

**Question:** How many people can be on a team?

**Answer:** The minimum number is 1, a single point of contact (POC). The competition will record up to ten team members (up to 5 additional team members to the POC at the initial registration and 9 at the submission of technical approach and testing application) for purposes of sending email correspondence about the competition. However, this is not a restriction on the number of people who can assist in building the inverter.

As stated in the terms and conditions (T&Cs): "The prize money will be given in its entirety to the point of contact listed for the winning team." "Your Team may share your prize money and/or get input from as many people as you like, as long as it does not violate other clauses of these T&Cs."

**Question:** What is the minimum age to enter the competition?

**Answer:** Anyone listed as a point of contact on a team or listed as a team member must be above the age of majority in their country of residence (or above 20 in Taiwan). Furthermore, no team may share or promise to share their prize money with someone below the age of majority in that person's country of residence (or above 20 in Taiwan). No team may receive assistance in building their inverter from someone below the age of majority in their country of residence (or above 20 in Taiwan). Doing any of the above may result in the team's disqualification.

**Question:** Is the total harmonic distortion + noise (THD+N) measured across the AC output terminals of the inverter or across the load bank?

**Answer:** The THD+N will be measured at the AC output terminals of the inverter, on the inverter side of the isolation transformer.

**Question:** Will a protruding on/off switch be included in the overall volume calculation?

**Answer:** No.

**Question:** After correctly entering Capcha code and pressing "submit", I get "CSRF token missing".

**Answer:** A small number of users are getting this error. We apologize for this inconvenience and are working on fixing it. We will update this document when it is fixed. Please try registering again before the deadline, September 30, 2014 and submit another question if this error re-occurs.

**Question:** My "registration successful" email listed all of the dates as July 22, 2014. What is going on?

**Answer:** This was an error in the registration system that is now fixed. The correct dates for the competition are those listed on the website and in the terms and conditions. We apologize for any possible confusion.

# Questions submitted and answered from July 30, 2014 to August 6, 2014

**Question:** Where can I add members to my team?

**Answers:** Team members can be added when you first register. If you have already registered, a chance will be given to change or add team members other than the point of contact when you submit your technical approach and testing application requirement by July 2015. There is no need to change team members through the website until then.

**Question:** Does the academic member need to be necessarily the point of contact of the team or can this position be occupied by some other member of the team?

**Answer:** An academic applying for a grant need not be the point of contact for a team.

**Question:** Can a company/organization have more than 1 team of employees enter, wherein the respective team members are unique (no overlap)?

**Answer:** Yes.

**Question:** Are we allowed to use a DC-DC conversion stage in the inverter?

**Answer:** Yes.

**Question:** Does the efficiency measurement exclude the loss in the 10 ohm resistor?

**Answer:** Yes.

**Question:** Do participants have to provide a DC power source or isolation transformer for the inverter or is only an inverter required?

**Answer:** Only the inverter is required to be brought to the testing facility.

**Question:** Do teams have to use wide bandgap semiconductors?

**Answer:** No.

**Question:** In the Load Profile section it mentions that the load applied by the testers may vary in small (< 50 VA) increments, but at bottom of same paragraph you state that individual load jumps may be as high as 500 VA. Please explain this apparent inconsistency.

**Answer:** The load changes may be as small as < 50 VA and as large as 500 VA.

**Question:** Is forced air cooling, i.e. an internal fan, permitted if the inverter efficiency remains above 95% during testing conditions?

**Answer:** Forced air cooling, or other means of cooling which consume power are permitted as long as they do not violate any of the other rules or specifications for the competition. The power consumed by the active cooling method will be counted against the efficiency of the inverter, which must remain above 95% as described in the specifications.

**Question:** How do I submit the technical approach and testing application document?

**Answers:** Instructions on how to upload these documents will be provided via email to those who successfully registered for the competition sometime in Q1 or Q2 of 2015.

# Questions submitted and answered from August 6, 2014 to September 24, 2014

**Question:** I have had trouble registering, can you please confirm my registration?

**Answer:** If you have completed the registration process accurately, then you should receive an automated confirmation. If you do not receive an automated confirmation, please try again as there is no penalty for multiple registrations. There is a known error (see question below re CSFR token) which we are trying to resolve.

**Question:** Can we combine teams later in the competition?

**Answer:** Yes. It is permitted to combine teams in between the registration deadline (September 30, 2014) and the technical approach and testing application deadline (July 22, 2015). The new team must retain one of the original point of contacts and registration codes.

**Question:** Will Google pay for contestants to travel to the US and the testing facility?

**Answer:** No.

**Question:** I am receiving an error when registering that says “CSFR token missing”.

**Answer:** We have been trying to isolate this problem and have had difficulty reproducing it. We apologize for the inconvenience. We recommend attempting to refresh your browser or using a different browser to register.

**Question:** Can IEEE members participate in the competition?

**Answer:** Yes, IEEE members are allowed and encouraged to participate. IEEE employees are not allowed to participate.

**Question:** Does the case of the inverter have to be entirely metallic and conductive?

**Answer:** Yes, the case/enclosure must be made entirely of metal and be conductive. Per the instructions, it must be the case that a resistance of $< 1\ \Omega$ is measured between the chassis ground wire exiting the inverter and the case/enclosure of the inverter.

**Question:** Is there any requirement on unintentional DC voltage being present in the AC output of the inverter?

**Answer:** This was not in the original specification document, but will be in a revised version of the document to be posted in Q4, 2014 including input from our testing partner NREL. There will be a limit on the allowable DC voltage present between either AC phase and the ground of the transformer.

**Question:** What inverter safety and protection measures are required? What will be included in the safety questionnaire?

**Answer:** This was not in the original specification document, but will be in a revised version of the document to be posted in Q4, 2014 including input from our testing partner NREL.

**Question:** What is precisely meant by 'degree granting Universities'? Are technical universities and research & development institutes (that grant doctoral degrees) eligible to apply for grants and participate in the competition?

**Answer:** Yes, technical universities and research & development institutes that grant doctoral degrees are allowed and encouraged to apply for grants and participate in the competition.

**Question:** The specifications say that the input DC supply will be floating. Can we rely on the fact that the impedance between both terminals of the input source and ground is effectively infinite?

**Answer:** Yes, participants can rely on the fact that the impedance between both terminals of the input source and ground is effectively infinite.

**Question:** Does the inverter need to adhere to both conducted and radiated emissions requirements from FCC part 15 B (since it will not be grid connected)?

**Answer:** Yes, the inverter must adhere to both radiated and conducted emissions in FCC part 15 B. For testing purposes, we are not connecting the inverter to the grid in the competition, but we do want contestants to demonstrate the viability of their designs for future inverters that could be connected to the grid. More details on the electromagnetic compliance requirements and testing procedure will be included in a revised version of the specifications document to be posted in Q4, 2014 including input from our testing partner NREL.

**Question:** Do we have to build a device and test it in order to submit a technical approach and testing application, or is it sufficient to simulate it?

**Answer:** You must build a device, test it, and send pictures of it in order to submit a technical approach and testing application.

**Question:** Is there a typo in the load profile section where it says: "The load will be provided by an electronic load bank which can switch in and out a series of linear ***reactive***, inductive and

capacitive loads..."? Is this meant to be "which can switch in and out a series of linear ***resistive***, inductive and capacitive loads..."?

**Answer:** Yes, there is a typo. The word “reactive” should be replaced with “resistive” in line with the rest of the document. This will be corrected in a revised version of the specifications document to be posted in Q4, 2014.

# Questions submitted and answered from September 24, 2014 to December 5, 2014

**Question:** What safety rating/UL listing, etc must the internal components (capacitors, inductors, switches, etc.) have to meet?

**Answer:** There are no specific requirements about what components must be used or what their ratings should be. The inverter must perform as described according to the detailed inverter specifications and testing document. It is the responsibility of the participants to choose components that will ensure proper operation under these conditions.

**Question:** Will the input ripple current requirement (<20%) apply at all load levels? At small currents, the ripple by % could be very big due to various effects.

**Answer:** This specification is now revised. The input ripple current must remain below 20% between 25-100% of max load (500 VA - 2000 VA). For values below 25% of max load, the input ripple current must remain below 250 mA peak to peak. This change is now reflected in the detailed inverter specifications document.

**Question:** What is the THD+N current requirement at low loads? For small values of the current, the percentage THD+N can be very high.

**Answer:** This specification is now revised. The THD+N current must remain below 5% between 25-100% of max load (500 VA - 2000 VA). For values below 25% of max load, the quantity defined here:

$$\sqrt{\sum_{j=2}^{j=\infty} I_j^{\,2} + I_{Noise}^{\,2}}$$

Must remain below 60 mA. This change is now reflected in the detailed inverter specifications document.

**Question:** What is the frequency range (bandwidth) over which the THD+N will be measured?

**Answer:** The THD+N will likely be measured up to approximately 50 kHz, but more detailed measurements at higher frequencies may be taken if abnormal behavior (such as high frequency switching with no filtering) is observed or suspected.

**Question:** Can you provide more details on the fuses, transformers, power supply, etc. that will be used in the testing set-up?

**Answer:** An additional appendix to this document will be added and updated in Q1, 2015 with relevant specifications for these and other testing devices that could affect the design of your inverter. If there is a specification you believe is crucial to know about a piece of testing equipment please submit a question about it and the spec will be uploaded if it is deemed to be relevant.

**Question:** Will the 450V DC source absorb current and energy?

**Answer:** No. The DC supply will only allow current to flow from its positive terminal to its negative terminal.

**Question:** My case is conductive, but will have an anodized coating on it, is this acceptable?

**Answer:** An anodized coating is acceptable, but it must still be possible to check that the resistance between the case and the ground/chassis wire on the AC output side is < 1 Ω. To this end, there must be an exposed conductive surface area of at least **0.1 inches$^2$** (anodization removed) on an upright face perpendicular to both the testing surface and the side where the ground chassis wire exits the enclosure which allows the testing facility to confirm that the ground chassis wire has less than < 1 Ω resistance to the enclosure.

**Question:** For the input ripple current specification, up to what frequency will you consider deviations from the waveform to be part of the input ripple current?

**Answer:** Deviations above 1 kHz will not be considered as part of the input ripple current specification. This is now in the specification document.

**Question:** Please provide more details on the EMC testing procedure.

**Answer:** The specifications document has been updated (December 2014) with details on the testing procedure.

**Question:** Regarding the on-off switch requirement: if the DC side voltage meets the requirement (> 300 V) for more than 5 seconds while the on-off switch is in the off position, should the inverter output to the AC side immediately when the switch is turned on, or should it wait 5 seconds?

**Answer:** The inverter should wait for 5 seconds after the dual condition of on-off switch being on and DC side voltage being > 300 V has been satisfied before outputting to the AC side.

**Question:** Is there any answer in the safety questionnaire that would disqualify the team?

**Answer:** The answers on the safety questionnaire must confirm that the inverter meets the requirements in the inverter self protection measures section and represent that the team has tested the fast and slow shutdown conditions listed. Regarding other answers we do not anticipate disclosures leading to a team's disqualification but the testing facility may use its discretion in determining if some component of the design presents an unacceptable safety risk. Participants must use their best judgement in ensuring that they are submitting a safe device for testing and operation.

**Question:** May clamp-on EMI filters be applied to external power leads?

**Answer:** No.

**Question:** What load profile will be used when looking for the maximum exposed hotspot of 60C?

**Answer:** The temperature of the device will be monitored throughout the approximately 100 hours of testing. Participants should assume that full load will be run for long enough to reach thermal equilibrium.

**Question:** By what method should the on/off switch stop the output of the device (e.g. mechanical, electrical, microcontroller actuated etc.)?

**Answer:** It is up to the participant the way to achieve the required specifications for the turn on and off of the device.

**Question:** The magnetizing current being fed into the transformer may lead to additional THD+N being added at the output of the inverter. How will this be incorporated into the measurement of the THD+N from the inverter?

**Answer:** THD+N will only be measured during steady state operation, therefore any inrush magnetizing current will not be counted in the measurement. For the steady state magnetizing current, the isolation transformer utilized for testing will be designed to minimize any voltage distortion at the terminals of the inverter. The specifications of this transformer will be posted in the specifications document in Q1, 2015. The inverter should be designed to meet the THD+N requirements even in the presence of this transformer.

**Question:** Please clarify the meaning of the 5mA ground current limit. Is this an average DC current or a RMS current? If the latter, is it to be measured over a particular frequency range?

**Answer:** DC + AC RMS current measurement. Neither quantity is permitted to be above 5 mA. The bandwidth of the AC measurement will likely be up to approximately 50 kHz, but the testing facility reserves the right to look at higher frequencies if anomalous behavior is observed or suspected.

**Question:** In the on/off switch section of the specifications document it is specified: “When the toggle switch is in the off position, no voltage or current is to be present on the AC side even when the DC side is live.” What is meant by “no” voltage and current?

**Answer:** < 5 Volts and < 10 mA. This is now in the specification document.

**Question:** What is the specification for unintentional DC voltage on the AC terminals?

**Answer:** There must be less than 1.2 Volts DC present between the two AC terminals.

# Questions submitted and answered from December 6, 2014 to March 10, 2015

**Question:** Does the remote disable connection need to be galvanically isolated from the power circuit?

**Answer:** The remote disable connection does not need to be galvanically isolated from any control circuits in the inverter, however no more than 250 Vrms may be present between the two leads and no more than 1 A of current may flow along the leads at any time. This is now reflected in the specification.

**Question:** The listed specification from the December update, for the remote disable connection that the inverter must be on for values < 1 Ω and off for > 1 Ω, is hard to meet. Could you provide a band in between the on and off values instead?

**Answer:** This specification is now changed and updated in the inverter specification document. The specification now reads: When the two wires have less than **5 Ω** of resistance between them, the inverter is permitted to operate as normal. When the two wires have greater than or equal to **10 kΩ** of resistance between them, the inverter should cease to energize the AC load (**< 5 Volts** and **< 10 mA**) within 5 line cycles. When the wires have between **5 Ω** and **10 kΩ** the inverter may or may not energize the AC load (either is acceptable).

**Question:** After a shutdown condition has been initiated, should the inverter come back on automatically after a certain amount of time?

**Answer:** The inverter should not come back on until the power switch (on/off) has been cycled: switched first to off, and then back to on. This is now reflected in the specification.

**Question:** Regarding the fast and slow shutdown conditions, the specifications say you will only feed in 450 V DC through a 10 Ω resistor. As long as you do this, our inverter will never put out above 500 V AC, or have excessive input or output current. Therefore, do we have to bother with these shutdown conditions?

**Answer:** Yes. The shutdown conditions are required in order to protect the inverter and environment in the possible event of i. A failure on the part of the inverter under test that could lead to a high voltage or high current condition and/or ii. An unintentional testing condition where a higher voltage or current condition is applied to the inverter from the testing setup or environment. The testing facility does not plan on applying a higher voltage or current than listed here, but unforeseen circumstances and events may arise and the inverter must protect itself so as to not allow such an event to lead to damage either to itself or the testing environment.
**Question:** For all the shutdown conditions, may the inverter respond sooner and faster than indicated in initiating the shutdown? For example, the slow shutdown condition requires a

shutdown after 8 A for 2 seconds. However, to meet your load specs the inverter should be putting out no more than between 5 and 6 amps. Therefore, could I have the shutdown condition be 6.5 A for 1 second?

**Inverter:** Yes. Each of the specifications for the shutdown conditions requires that the inverter shutdown when that condition is reached, but it also allows for the inverter to shutdown at lower current and voltage values as long as the other specifications required (power output, etc.) are also met.

**Question:** If no entry achieves the electromagnetic compliance (EMC) target, how will you trade-off power density vs. EMC in determining the winner?

**Answer:** If one or more teams of the teams downselected for EMC testing hits all targets including the EMC spec, then the highest power density among those will win regardless of the other non-EMC compliant entries' power density. If no entries meet the EMC requirements and/or other inverter specs, the judges will make a determination at their discretion to award the prize, or award no prize at all, based on power density and other factors as they deem appropriate in the spirit of the prize.

**Question:** Are we allowed to have other indicator lights on the exterior of the box for other purposes than the ones required for the competition? If so, will their volume be included in the calculation to determine the winner?

**Answer:** Yes, you are permitted to have additional external LEDs on the surface of the enclosure, as long as their function is marked and understood by the testing facility. Documentation describing the function of the LEDs should accompany the submission of the Technical Approach/Testing Application as an additional appendix and, if the inverter is selected for testing, the final submission when brought to the testing facility.

**Question:** The specifications state that the inverter should output no voltage or current when the DC side is outputting < 300V. However, at 300 V DC input my inverter won't be able to put out 450 V AC. What voltage should the inverter output when it is being fed between 300 V and 450 V DC?

**Answer:** There is no requirement for what the inverter should output when the input is just above 300 V DC, there is only a requirement that there should be no voltage or current output (< 5 Volts and < 10 mA) on the AC side when the input voltage is below 300 V DC. This is a safety specification and not a performance specification. The performance of the device will only be tested when there is 450 V DC through a 10 Ω resistor being placed on the input of the inverter. In between these voltages, the inverter output will not be considered in the competition, as long as it does not pose a safety concern to the testing facility.

**Question:** Can we just always implement a fast shutdown condition (e.g. always shutdown after 5 line cycles of an over voltage/over current condition)?

**Answer:** A longer wait time for the slower shutdown condition is intended to prevent unintended shutoffs due to transient conditions. Participants are free to implement faster shutdown thresholds than listed in the specifications, however, if the inverter is tripping off for unknown reasons possibly due to a very low time threshold, it may be removed from the competition. Participants should use their best judgement in this regard.

**Question:** Is the fuse configuration such that we need to put an inrush limiting circuit in the inverter?

**Answer:** No. An inrush current limiting circuit at output of the DC supply will be provided by the testing laboratory. This inrush current limiting circuit will provide additional resistance for a total of 110 ohm which will limit in-rush to 4.5 A, essentially in the nominal range of operation. This is now reflected in the specification.

**Question:** How much capacitance is present between the floating 450 V DC power supply leads and the grounded chassis of the 450V power supply?

**Answer:** Less than 200 nF.

**Question:** Please provide more information on the transformer, fuses, electronic load bank, power supply, 10 Ω resistors etc.

**Answer:** More information regarding the transformer and other equipment will be posted in near future (likely April). If you require information about other components of the testing setup please submit a question and we will, if deemed appropriate, include the requested information in a future update.

**Question:** Your last update indicates that only a subset of entries will be selected for electromagnetic compliance (EMC) testing. Does that mean that if we are EMC compliant but are not the most power dense, someone who is not EMC compliant but has a higher power density may win?

**Answer:** Yes. However, if none of the (max 6) downselected entries for EMC testing achieve satisfactory EMC according to the judges (which may or may not mean full FCC part 15B compliance) the judges may, at their discretion, elect to go back and test additional units to see if they reach or approach the EMC spec.

**Question:** What kind of electronic-load will be used to test the efficiency?

**Answer:** This sentence has been clarified in the specification. It is not an electronic load in the sense of elements simulated by power electronics, but rather a more accurate description is “the load will be provided by a passive load bank with switched resistive, inductive, and capacitive elements”.

**Question:** In the conducted emissions electromagnetic compliance (EMC) test, will the DC source have a low pass filter going into it before going to the inverter, as in the radiated emissions test?

**Answer:** Yes, a low pass filter between the DC supply and the inverter will be present for both conducted and radiated emissions tests. This is now reflected in the specification.

**Question:** Is the volume of the LED(s) and toggle switch included in the volume calculation?

**Answer:** No. The specification is now changed to include:  The volume added by the LED(s) and toggle switch will not be counted towards the volume requirement, as long as they are not unreasonably large and possibly housing other equipment.

**Question:** Do we have to add separate strain relief for each wire, or can we use combined strain relief for multiple wires?

**Answer:** Each individual wire must have adequate strain relief. This shall be provided either by a single strain relief device (e.g., cable gland) for each individual wire or a device designed to provide strain relief to multiple individual conductors at the same time (e.g., cable glands with multiple penetrations for individual conductors that are then simultaneously tightened are available for this application). For example, a single cable gland with one large hole would not adequately strain relief 5 individual wires running through it. We recommend using multi-conductor cabling (one for DC wires and one for AC wires) that can be easily strain relieved using a single typical cable gland (please see our recommendations for wiring added to the latest version of the specifications document for other suggestions).

**Question:** Does the quality of the technical approach document influence who the winner of the competition will be?

**Answer:** The technical approach document must reach a high enough bar of quality to enable the inverter to be selected for final testing (up to 18 inverters will be selected for this) as described in the specifications document. Once it reaches this bar, the quality of the technical approach document will no longer be taken into account.

**Question:** Will the electronic load dynamically readjust the load to always be at a given power (kVA) output based on the output voltage, or will it be at a static impedance regardless of where in the tolerance band 240 V +/- 12 V AC that the inverter is outputting at?

**Answer:** The load bank will employ static impedances, though these static impedances may be changed to achieve 2 kVA at whatever voltage is present. Participants must ensure that their inverter is capable of outputting 2 kVA and we advise against trying to gain an advantage by operating near an extreme (e.g. 228 V) of the voltage range.

**Question:** Can an entrant voluntarily withdraw after submission but prior to the announcement of the winner (January 2016)?

**Answer:** Yes. An entrant may withdraw from the competition at any time, doing so would forfeit any possible prize money. Once the technical approach document is submitted, Google reserves the right to make this document public, even if the team withdraws afterwards.

**Question:** Given that the DC supply will be floating, the level that it floats to above chassis ground will be determined, in part, by the inverter configuration. Given this, is there a limit for how high the DC supply can be made to float above chassis ground?

**Answer:** Yes. ~~The supply may never be made to float beyond +/- 1000 V from chassis ground. That is, neither the DC + or DC - outputs of the supply may be made to float more than +/- 1000 V from chassis ground. This is now reflected in the specification.~~ The supply's negative terminal must remain between +/- 350 V RMS with respect to ground, where RMS is the total root mean square quantity, as measured over the course of one 60 Hz line cycle (0.016667 s).

**Question:** The self protection measure that the inverter shuts off if it ever gets to 60 °C seems problematic, given that this is the max allowable temperature of the enclosure in the specification. Requiring a safety shut off below that point does not allow us to approach the specification. Can you change the specification to be slightly above 60 C?

**Answer:** Yes. The specification is now changed. The safety shut off due to temperature is now 65 °C.

**Question:** How quickly must the inverter enter the off state (voltage < 5V, current < 10mA) when the power switch is toggled or when there is < 300 V DC present on the DC input side?

**Answer:** The inverter should cease to energize in the same amount of time specified for the inverter self protection--within five 60 Hz ac line cycles.

**Question:** Does the bottom face of the enclosure have to be large enough to support the "pillars", that is 1x1 inch? or can it be minimum size 0.5 x 0.5 inch?

**Answer:** Yes, the bottom face must be large enough to support the pillars, each dimensions must be a minimum of 1 inch.

**Question:** Would you consider allowing 12 AWG (or other gauge) in addition to the 10 AWG? We are having difficulty finding all the colors in 10 AWG and it easier to find in 12 AWG.

**Answer:** No, 10 AWG wiring must be used. This is because we have not specified the exact type of wire and/or termination temperature ratings to be used and in some particular wiring type and configuration combinations, 10 AWG is the absolute minimum adequate size of wiring. However, we have relaxed the wiring color requirements such that black wire with colored tape can be used for hot conductors and white wire for neutral conductors. Also, please see our recommendations for wiring added to the latest version of the specifications document for other suggestions.

**Question:** Will any changes be allowed between the paper submission (July 22) and delivery of the device for testing (October 14-21)?

**Answer:** Changes are permitted in between these periods as the participants see fit. However, the materials submitted by July 22nd must be a faithful representation of the capabilities of the inverter. The inverter received for final testing at the testing facility must reach the power density described in the paper submission or greater. If a team submits an inverter for testing that is larger volume/lower power density than in the paper submission, this could be grounds for disqualification. If an inverter selected for final testing has changed substantially, dimensions or otherwise, a new testing application document must be submitted before, or at the same time that, the inverter is delivered to the testing facility. The testing facility may reject the inverter based on this new testing application, or lack thereof, and not proceed to testing. Beyond that, the testing and performance of the inverter will be measured against the standards of the competition and not what was submitted in the technical approach/testing application.

**Question:** How do I cancel my participation in the challenge?

**Answer:** There is no need to explicitly cancel participation. If you registered for the competition, but fail to submit a Technical Approach/Testing Application your participation will be automatically cancelled. If you no longer wish to receive emails, there is a link at the bottom of emails you receive to unsubscribe.

# Questions submitted and answered from March 11, 2014 to June 22, 2015

**Question:** How do I submit the technical approach and testing application (due July 22, 2015) for my team's entry to the competition?

**Answer:** A form will be put on the website allowing for the submission of these documents. A link will be placed on https://www.littleboxchallenge.com and an email will be sent to people who registered for the competition in 2014 when the form is live.

**Question:** I completed the registration process and received confirmation, but have not been receiving the email updates that have been going to other members of the competition. Can you help me receive this information?

**Answer:** A small number of registered participants are having emails rejected from our mailing list. In this round of emails and subsequent ones, we are re-sending emails, using other means, to addresses we can see are having emails rejected. However, this may not be successful in all instances. We recommend checking the website on a regular basis.

**Question:** I registered but have lost my registration code. Can you please resend it to me?

**Answer:** If this has happened, please submit your request as a question on the website with the email you registered from. Your email address will be checked and if matching a registration in our records, your code will be sent to that address.

**Question:** If none of the <= 6 finalists chosen for electromagnetic compliance (EMC) testing achieve or come close to achieving the EMC specs, will you consider testing additional units for EMC compliance?

**Answer:** The judges may or may not elect to test the EMC compliance of additional units in the situation described above, based on their assessment of the merits of the units tested.

**Question:** Is the file size of the technical approach/testing application documents limited?

**Answer:** Yes. The technical approach document and the testing application document will be limited to 9 MB each.

**Question:** What happens to the registered team if the point of contact team member abandons the team? Can any of the other team members become the new point of contact?

**Answer:** To submit a testing approach and testing application, the submission form must match the original email and registration code of the original point of contact (PoC). If the entry is selected for testing, the original PoC may transfer the point of contact to another member of the team prior to bringing the unit to NREL.

**Question:** The testing application submission states it requires 1 s readings over 3 hours. This is a lot of data to submit. Is that the correct resolution required?

**Answer:** Yes. The data is to be submitted as an image of a plot as shown in the instructions.

**Question:** I submitted a question regarding the details of a particular testing component, where can I find the answers to that?

**Answer:** A number of component specifications have been added to Appendix C in the "Detailed Inverter Specifications, Testing Procedure, and Technical Approach and Testing Application Requirements for the Little Box Challenge" document.

**Question:** What is the voltage range that the input DC supply will have around 450 V DC before going into the 10 Ω resistor?

**Answer:** This voltage will be accurate to within +/- 1%.

**Question:** What is the definition of the term "testing surface" used in the specifications manual?

**Answer:** The testing surface is the top of a table that the inverter will be located on top of. Its top surface is parallel to the ground.

**Question:** Will the reactive load (capacitance and inductance) be used in series or parallel with the resistive load?

**Answer:** Parallel.

**Question:** Are all of the specifications verified immediately after startup time?

**Answer:** There will be a 10 second grace period after startup before the specifications will be verified.

**Question:** Will the volume of the head of screws used to close the housing be counted towards the volume requirement of the inverter?

**Answer:** The volume of the heads of standard screws (within reason) will not count towards the total volume calculated for the inverter.

**Question:** Can there be any exceptions for small sections of the enclosure to the rule that it be all conductive and metal? For example, for fans it would be helpful to be able to place a plastic or 3-d printed grill on the side of the fan for safety reasons, for communication with the controller non-conductive ports may be needed, and thermoelectric cooling may not be compatible with this requirement.

**Answer:** Small, non-conductive elements with prescribed purposes such as those listed above may be included on the outside of the enclosure as long as they are completed surrounded by the metal enclosure and do not remove more metal than is necessary. **If such elements are included, an appendix must be added to testing application describing their purpose.** The testing facility at NREL may disqualify the entry if they determine that these elements pose a possible safety risk or if they compromise the ability to test the proper grounding of the unit. Any distance that the elements extend out from the metal enclosure will be added to the volume calculation.

**Question:** The voltage output specification requires a return to a +/- 12V band within 0.1 seconds. The THD specification requires that it must return to within spec in 1 second. These may be in conflict (e.g. high THD may affect Vrms measurements), which takes precedence?

**Answer:** To eliminate confusion, the voltage output specification has been changed to match the THD requirement: The voltage output must be **240 V** RMS single phase AC, within a **+/- 12 V** band. After a transient change in the load the voltage should return to within acceptable bands in **1 second** or less and not leave the band again until the next load change. This is now reflected in the specification.

**Question:** Does the ground current limit also apply during load transients?

**Answer:** There will be a 1 second grace period on the ground current limit during transients after a load change. This is now reflected in the specification.

**Question:** How will the inverter self protection measures be tested?

**Answer:** These measures are expected to be in place to protect the inverter and the test environment. The testing laboratory will verify that the unit has proper self protection measures at its discretion.

**Question:** Please specify the direction of the LISN ports.

**Answer:** The AC output of the Inverter gets plugged into the "Device under test" port of the LISN. The "Mains" side of the LISN will go to the transformer and load bank.

**Question:** What resolution bandwidth (RBW) will you use for the EMI measurements?

**Answer:** For conducted emissions, 150 kHz to 30 MHz, a 10 kHz RBW will apply. For radiated emissions, 30 MHz to 1,000 MHz a 100 kHz RBW will apply.

**Question:** How does the input current ripple requirement change with the power factor?

**Answer:** The input ripple current limit of 20% ($I_{pk-pk}$ / $I_{avg}$) will apply at a power factor 1. The ripple current will be monitored between power factors 0.7 and 1. A drastic (> 2x) increase in the absolute size of the ripple current (in amps peak-peak) may result in disqualification. This is now reflected in the specification.

**Question:** Will the inverter be subject to a significant radiative load (e.g. direct exposure to photons from the sun)?

**Answer:** No. The inverter will be tested indoors and subject only to normal indoor lighting radiative heat loads.

**Question:** Will the external device which will control the remote control wires provide bidirectional current flow?

**Answer:** Yes.

**Question:** The specifications document states in one place that the biographical information appendix should be 1 page, in another that it must be no more than 3 pages. Which is correct?

**Answer:** 3 pages. This is now corrected in the specification.

**Question:** In the specification it says that load jumps of 500 VA are possible. If this jump is entirely reactive, it could be a big shock to the system. Will large jumps only be resistive or could they also be reactive?

**Answer:** The largest load jumps up to 500 VA will only be resistive. Capacitive or inductive load jumps will be more gradual, with a gradual ramp consisting of steps of no more than 100 VA. This is now reflected in the specification.

**Question:** If the capacitance of the power supply leads to ground can be as high as 200 nF, it will be difficult to meet the ground current limit of 5 mA. Will the ground current specification be modified, or will the maximum capacitance of the power supply be lowered?

**Answer:** The maximum ground current limit has been modified from 5 mA to 50 mA. This is now reflected in the specification. The expected capacitance (120 nF) of the power supply that will be used for testing is higher than originally anticipated and thus the ground current limit has been revised.

# Questions submitted and answered from June 23, 2015 to July 6, 2015

**Question:** Regarding the recent change on the ground current limit from 5 mA to 50 mA, our team spent a lot of effort and sacrificed some power density to design a solution that would achieve < 5 mA ground current even with a power supply that had up to 200 nF of capacitance to ground. This change late in the competition means we will either be at a disadvantage compared to teams who did not work hard to achieve the ground current requirement, or that we will have to do a crash program to redesign our inverter in a short amount of time. Can anything be done about this?

**Answer:** We sympathize with teams who are in this situation. The specification was only changed after extensive deliberations. Upon further investigation of the power supply and discovering its capacitance would be higher than anticipated (we expected it to be far below < 200 nF, but it ended up being ~ 120 nF) and inquiries from a number of the teams saying it would be problematic to hit the ground current limit given this, we decided it would be best not to eliminate teams who had made a lot of headway on the other challenges in this competition due to this specific requirement.

For those teams who believe that they have sacrificed power density in order to achieve the ground current limit, we suggest the possible following course of action that is in line with the existing rules of the competition:

1. Submit the Technical Approach and Testing Application (due July 22, 2015) based on your existing inverter design that achieves the < 5 mA ground current limit.

2. Add an appendix (no more than 2 pages) to the Testing Application document (due July 22, 2015) that explains how achieving this ground current limit has made the power density lower than it otherwise would have been. Include an estimate and credible explanation of how much more power density could be achieved if the inverter was modified with the higher ground current limit. This appendix will be considered as a mitigating factor at the judges' discretion, based on the quality of the explanation given, when selecting the final inverters (up to 18) that will be brought to NREL for testing.

3. In between the application deadline (July 22) and the date that the final inverters are due (mid October) teams may modify their inverters to try to achieve a higher power density, given the higher allowable ground current limit. As has been previously specified in this document, this is permissible if (i) The inverter brought to NREL has a higher power density (smaller volume) than the one described in the original testing application document and (ii) a new testing application document is submitted prior to or at the time the unit is brought to NREL.

To be clear, including this appendix with the testing application and/or modifying the inverter to achieve a higher power density is no guarantee that the unit will be selected for final testing. Teams must make the decision about whether to proceed with this extra work while running the risk that they may not be selected for final testing at NREL.

**Question:** We have a similar question to that above, but regarding the input ripple current requirement. We sacrificed power density to meet the input current ripple requirement at all power factors from 0.7-1.

**Answer:** You may follow the same procedure as above, substituting the 50 mA ground current with the input ripple current in the suggestion. If you wish to suggest that improvements are possible due to both the revised ripple current and ground current requirements, please submit 1 appendix to the testing application that describes both the ground current and ripple current modifications and keep it to a maximum of 2 pages.

**Question:** The inverter specifications document references a maximum current on the chassis ground connection, but says that it could be measured either directly or as the difference between the two AC connections. However, the difference in the current on the two AC connections will measure the current on the power ground (the wire that bonds the center of the split-phase isolation transformer (Grounding Configuration 1) or the neutral conductor (Grounding Configuration 2) to ground), not the chassis ground current. Can you clarify?

**Answer:** The ground current on both the chassis ground and the power ground will be measured. Both must be below 50 mA. This language has now been clarified in the specification.

**Question:** The recent Q&A and elsewhere in the specifications document state that the DC supply must have its DC negative output remain between -300 and +300 V DC. However, the voltage input section says both terminals must remain between +/-1000 V DC. Can you clarify?

**Answer:** The DC supply must have its DC negative output remain below ~~-300 and + 300 V~~ 350 V ~~DC~~ RMS (see explanation in the answers from 7/7/2015 to 7/14/2015 section below). The +/-1000 V DC reference was due to an error in not updating that section to be in line with the other references in this document; it is now corrected in the specification.

# Questions submitted and answered from July 7, 2015 to July 16, 2015

**Question:** The new DC power supply isolation voltage limits are confusing as written. In some places in the Q&A (this document) and specification it is written that the DC power supply negative output voltage with respect to ground must remain between +300 and -300 V DC and elsewhere it is written that the limit is that the negative DC output of the supply must remain between +300 and -300 V RMS. Depending on the interpretation and value of this limit, this could cause problems with inverter configurations that, with the specified AC grounding configuration, necessarily result in the DC supply negative output to ground voltage being beyond -300 V DC for portions of a switching period. Please clarify.

**Answer:** We apologize for the confusion. The proper specification was meant to be that the DC supply negative output voltage with respect to ground must remain below 300 V RMS, where RMS is the total root mean square quantity as measured over the course of one 60 Hz line cycle (0.016667 s). We recognize that many possible inverter configurations that may be used by participants would cause the power supply's negative output voltage with respect to ground to spend some portion of each AC line cycle below -300 V DC and that, for certain configurations, this could result in an RMS value (measured over one 60 Hz line cycle) of up to just beyond 300 V RMS (though for many potential configurations the RMS voltage remains below 300 V RMS). Therefore, the specification has been changed so that the DC supply negative output voltage with respect to ground must remain below 350 V RMS, where RMS is the total root mean square quantity as measured over the course of one 60 Hz line cycle (0.016667 s). Additionally, neither the DC negative output voltage with respect to ground or the DC positive output voltage with respect to ground may exceed +/- 700 V(peak). Per the ground current specification already mentioned, the common-mode current drawn from the input DC power supply must be less than 50 mA RMS, given the <200 nF (120 nF expected) common-mode capacitance.

**Question:** As previously noted in the specifications, the load used for testing will be a passive load of parallel resistive-inductive-capacitive configuration. With this load configuration, and in the absence of any series resistance, in-rush current from the inverter output to the capacitive elements of this load could be present if capacitive elements are switched during non-natural points in the AC phase (e.g., at the top of the sine voltage when the initial voltage across the capacitor is zero). Will there be a resistive element in series with this load configuration to prevent this issue?

**Answer:** There will be no explicit resistive element provided in series with the load configuration. However, the non-negligible impedance of the AC output wiring and especially the interconnection transformer, combined with the limited (small) capacitive step sizes that will be used, will keep any in-rush current to manageable values.

**Question:** Will the technical approach and testing applications be released to the public and/or other competitors between the technical approach and testing application deadline (July 22, 2015) and the deadline for the inverters to be brought to NREL (October, 2015)?

**Answer:** No. During that time period they will only be used for the purpose of choosing the inverters for final testing at NREL.