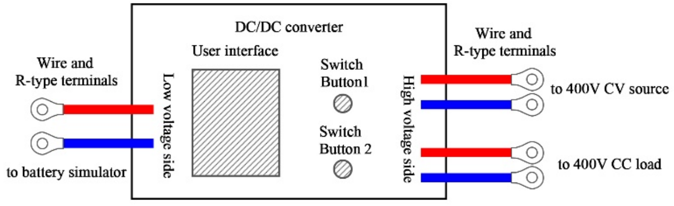
IFEC 2018 RFP requirements in comparison with test items (2018.4.25)

Detailed specifications and requirements in RFP	Test items (compulsory unless otherwise stated)	Further explanation
Power density : >1.5W/cm^3, the converter can be built with open frame. The volume will be calculated as volume=length*width*height	Volume	Length, width and height are the longest distance of the converter measured in x, y, z direction. User interface and charging/discharging switch buttons are not included in the volume.
Weight: Less than 1.5kg	Weight	User interface and charging/discharging switch buttons are not included in the weight.
Current ripple at low voltage side during battery charging <3% @100% load	Current ripple=I_{p-p}/I_{rms}	For charging mode, V_{LVout}=40V, I_{LVout}=25A is defined as 100% load, where V_{LVout} is set by battery simulator, I_{LVout} is controlled by user interface.
Efficiency requirements: higher than 96% at 100% load (charging mode)	Efficiency= P_{LVout} /P_{HVin} (charging mode)	For charging mode, V_{LVout}=40V, I_{LVout}=25A is defined as 100% load, P_{LVout}=V_{LVout}*I_{LVout}, where V_{LVout} is set by battery simulator, I_{LVout} is controlled by user interface.
Efficiency requirements: higher than 94% at 50% load (charging mode)	Efficiency= P_{LVout} /P_{HVin} (charging mode)	For charging mode, V_{LVout}=45V, I_{LVout}=11.1A is defined as 50% load, P_{LVout}=V_{LVout}*I_{LVout}, where V_{LVout} is set by battery simulator, I_{LVout} is controlled by user interface.
Efficiency requirement: higher than 92% at 25% load (charging mode)	Efficiency= P_{LVout} /P_{HVin} (charging mode)	For charging mode, V_{LVout}=48V, I_{LVout}=5.2A is defined as 25% load, P_{LVout}=V_{LVout}*I_{LVout}, where V_{LVout} is set by battery simulator, I_{LVout} is controlled by user interface.
The dc-dc converter is required to operate at constant-current* charging mode for batteries, and if the batteries are fully charged the dc-dc converter should shift to constant-voltage charging mode to protect the batteries.	Shift from CC charging mode to CV charging mode. *The expression 'constant-power charging mode' in RFP is not as accurate as 'constant-current charging mode'	CC charging mode is defined as V_{LVout}=48V, I_{LVout}=5.2A. CV charging mode is defined as V_{LVout}=50V, I_{LVout}=1A. In real test, V_{LVout} is set by battery simulator, I_{LVout} is controlled by user interface. In the charging process, V_{LVout} will rise slowly. For

User interface: Each design should include a clear user interface, which provides status monitoring and programming capability to support "battery-friendly" operation.	CC is short for 'constant-current' CV is short for 'constant-voltage'	converter, when V_{LVout}=50V is monitored by the converter, the shift should be made.
Voltage ripple at high voltage side during battery discharging <2% @100% load	Voltage ripple=V_{p-p}/V_{rms}	For discharging mode, V_{HVout}=400V, I_{HVout}=2.5A is defined as 100% load, V_{LVin}=48V. I_{HVout} is controlled by user interface.
Efficiency requirements: higher than 96% at 100% load (discharging mode)	Efficiency= P_{HVout}/P_{LVin} (discharging mode)	For discharging mode, V_{HVout}=400V, I_{HVout}=2.5A is defined as 100% load, $P_{HVout}=V_{HVout}*I_{HVout}$, V_{LVin}=48V. I_{HVout} is controlled by user interface.
Efficiency requirements: higher than 94% at 50% load (discharging mode)	Efficiency= P_{HVout}/P_{LVin} (discharging mode)	For discharging mode, V_{HVout}=400V, I_{HVout}=1.25A is defined as 50% load, $P_{HVout}=V_{HVout}*I_{HVout}$, V_{LVin}=48V. I_{HVout} is controlled by user interface.
Efficiency requirements: higher than 92% at 25% load (discharging mode)	Efficiency= P_{HVout}/P_{LVin} (discharging mode)	For discharging mode, V_{HVout}=400V, I_{HVout}=0.625A is defined as 25% load, $P_{HVout}=V_{HVout}*I_{HVout}$, V_{LVin}=48V. I_{HVout} is controlled by user interface.
Switching between charging mode and discharging mode: two buttons should be equipped with the dc-dc converter, in which one is used to control the connection switch between the converter and the Programmable dc Power Source and the other one is used to control the connection switch between the converter and the resistor load; During the charging/discharging mode switching test, the dc-dc converter should be disconnected with the Programmable dc Power Source first and then	Charging to discharging Discharging to charging	 On the HV side, a 400V constant voltage mode source will be provided, and it is only for the charging mode. On the HV side, a constant current mode load will be

connected to the resistor load by clicking the button manually; The reverse test (discharging to charging) should have the similar manual operation procedure.		provided, and it is only for the discharging mode. On the LV side, a battery simulator will be provided. The switch process is trigged manually by each team, and the testing equipment will respond to that.
No live electrical elements are to be exposed when the unit is fully configured.	Safety	Test shall not begin without safety confirmation.
The system is intended for safe, routine use by non-technical customers. After the dc-dc converter shut down, the dc bus voltage should decrease to be less than 60 V within 5 seconds.	<60V in 5sec	Shut down instruction will be set manually on user interface. Shut down is defined as electrical disconnection between converter and DC bus on both HV and LV sides. Timing begins when the high voltage side voltage is lower than 390V. Timing ends when the high voltage side voltage is lower than 60V.
The system should shut down if the high voltage side current exceeds 5A (instantaneous value). No damage caused by output short circuit and open circuit.	Over current <60V in 5sec (optional test item to get extra points)	Damage including but not limited to: Causing automatic protection of testing equipment, burning or explosion of circuit elements, or other destructive consequences which can be seen, heard or smelled. The high voltage side current should equal 0 after shut down. Timing begins when the high voltage side current exceeds 5A. Timing ends when the high voltage side voltage is lower than 60V.
Over current, over voltage, short circuit and open circuit. If the operation outside voltage limit is attempted, the current should be 0.	Over voltage Low voltage (optional test item to get extra points)	Over voltage is defined as V_{LVout} is larger than 52V. Low voltage is defined as V_{LVout} is smaller than 35V. Test will only be done in charging mode. The low voltage side current should equal 0 after shut down.

Thermal consideration: The operating temperature range -20 to 50 °C.	No specific test will be done.	No temperature chamber will be provided.
Acoustic noise: No louder than conventional domestic refrigerator. Less than 50 dBA, measured 1.5 m from the unit.	Acoustic noise	No static sound chamber will be provided. This test item is less important and will be checked by YES or NO.
User interface: The following interface settings are required: modes "Battery mode" or "Power supply mode" or "Test mode".	No specific test will be done, depending on the unforeseen fault each team will be facing when testing and which part of the converter functions can still work.	For a robust converter design, test will only include “Battery mode”. "Battery mode": Testing with battery simulator. "Power supply mode" and "test mode": Without battery simulator to test unidirectional performance or bidirectional performance, if somehow the converter is unable to connect the battery simulator or potential damage will be caused doing so. In conclusion: “Power supply mode” and “Test mode” are all backup modes for testing when the converter fails to operated in “Battery mode”.

IFEC 2018 standard testing procedure

Time	Test items	Consideration for team	Consideration for referee
0-1min	Volume, weight	The team leader shall confirm the measurement data and sign his/her name.	The referee shall confirm the measurement data and sign his/her name.
1-2min	Safety		Safety assessment shall be done by referee and confirmation signature is needed.
2-4min		Mechanical connection with 400V CV source and CC load on the HV side, battery simulator on the LV side.	Confirm the connection is right and test equipment is ready. A confirmation siganture is needed.
4-5min		Electrical connection for charging mode with 400V CV source and then with battery simulator.	Enable output of 400 CV source and then wait for initialization of the converter.
5-6min		I_{LVout} is set to 25A by user interface at 5min.	V_{LVout} is set to 40V by battery simulator at 5min and then wait for steady state.
6-7min	Current ripple, efficiency @100% load (charging mode), acoustic noise	I_{LVout} is set to 11.1A by user interface at 6min30sec.	V_{LVout} is set to 45V by battery simulator at 6min30sec and then wait for steady state.
7-8min	Efficiency @50% load (charging mode)	I_{LVout} is set to 5.2A by user interface at 7min30sec.	V_{LVout} is set to 48V by battery simulator at 7min30sec and then wait for steady state.
8-9min	Efficiency @25% load (charging mode)	Shift to “Battery-friendly mode” manually by user interface at 8min30sec, automatic monitoring and response by converter is considered as a better approach.	For battery simulator, shift form constant current mode to constant voltage mode at 8min30sec and slowly raising V_{LVout} to 50V in 10sec.
9-11min	Shift from CC charging mode to CV charging mode.	The team leader shall confirm the measurement data and sign his/her name.	The referee shall confirm the measurement data and sign his/her name.

11-15min	Smooth switching between charging mode and discharging mode.	1st: Charging to discharging at 11min30sec by switch buttons. 2nd: Discharging to charging at 13min by switch buttons. I_{LVout}=11.1A is set by user interface at 13min05sec. 3rd: Charging to discharging at 14min30sec by switch buttons.	1st: I_{HVout}=1.25A is set by user interface at 11min31sec, while V_{LVin}=48V is set by battery simulator at the same time, and then wait for steady state. 2nd: V_{LVout} is set to 45V is set by battery simulator at 13min06sec and then wait for steady state. 3rd: I_{HVout}=2.5A is set by converter at 14min31sec, while V_{LVin}=48V is set by battery simulator at the same time, and then wait for steady state.
15-16min	Voltage ripple, efficiency @100% load (discharging mode), acoustic noise		I_{HVout}=1.25A is then set by converter at 15min30sec and then wait for steady state.
16-17min	Efficiency @50% load (discharging mode)		I_{HVout}=0.625A is then set by converter at 16min30sec and then wait for steady state.
17-18min	Efficiency @25% load (discharging mode)	The team leader shall confirm the measurement data and sign his/her name.	The referee shall confirm the measurement data and sign his/her name.
18-19min		Team leader shall decide whether to take optional tests or not. And the decision shall determine how will the converter be shut down.	Safety assessment of testing equipment and converter shall be done by referee and confirmation signature is needed before moving on. For converter which is not suitable for further test, the referee has the right to stop the test.
19-20min	Over current shut down/ manually shut down, <60V in 5sec	Taking optional tests means shutting down by over current test. Not taking optional tests means shutting down by setting manually by user interface at 19min.	I_{HVout}=5.5A is set by CC load at 19min. Timing begins when the high voltage side current exceeds 5A (instantaneous value) or shut down instruction is set manually.

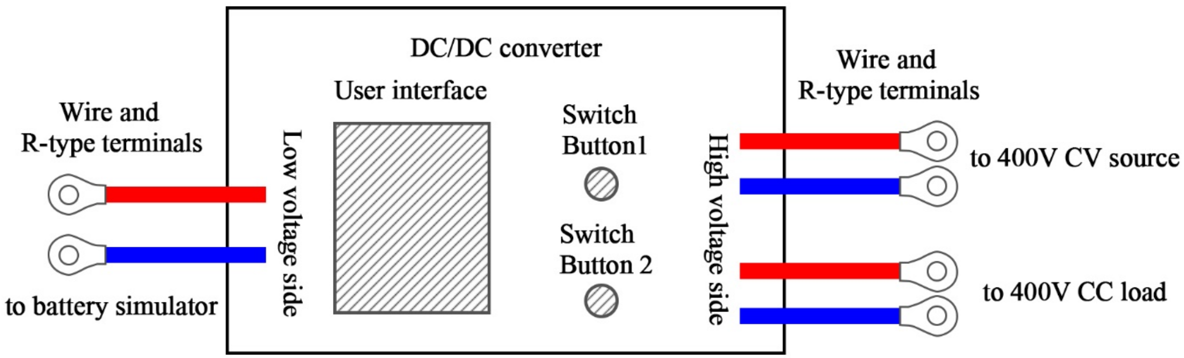
20-22min		Step1: Electrical connection for charging mode with 400V CV source and then with battery simulator. Step3: I_{LVout} is set to 12.5A by user interface.	Step2: Enable output of 400 CV source and wait for initialization of the converter. Step4: V_{LVout} is set to 40V by battery simulator and then wait for steady state.
22-23min	Over voltage, <60V in 5sec		V_{LVout} is set to 55V by battery simulator at 22min30sec. Timing begins when the low voltage side voltage (instantaneous value) exceeds 52V.
23-25min		Step1: Electrical connection for charging mode with 400V CV source and then with battery simulator. Step3: I_{LVout} is set to 12.5A by user interface.	Step2: Enable output of 400 CV source and wait for initialization of the converter. Step4: V_{LVout} is set to 40V by battery simulator and wait for steady state.
25-26min	Low voltage, <60V in 5sec		V_{LVout} is set to 30V by battery simulator at 22min30sec. Timing begins when the low voltage side voltage (instantaneous value) is less than 35V.
27-29min		The team leader shall confirm the measurement data and sign his/her name.	The referee shall confirm the measurement data and sign his/her name.
29-30min		Mechanical disconnection with 400V CV source and CC load on the HV side, battery simulator on the LV side.	Confirm all the data is saved and all the signatures are signed.

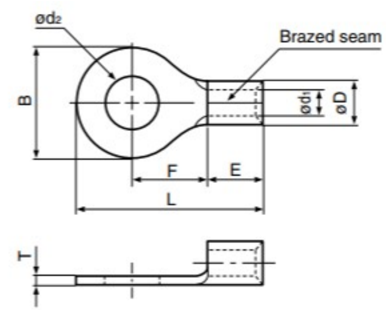
IFEC 2018 electrical connection diagram

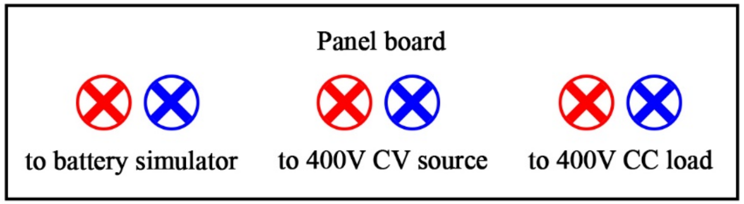
Table 1 Equipment for final test

Equipment	Prameters	Usage
Chroma 17020 (Figure on right)	60V/62.5A/2.5kW/4 Channels	1 Channel for low voltage side battery simulator. The rest 3 Channels to spare.
	500V/13A/2.5kW/4 Channels	1 Channel for high voltage side CV source. 1 Channel for high voltage side CC load. The rest 2 Channels to spare.
Chroma 66204 	600V/4 Channels	1 Channel for low voltage side,1 Channel for high voltage side, to measure the Effeciency. 2 Channels to spare.
Tektronix MDO 3014 	200Mhz/4 Channels	1 Channel for low voltage side, to measure current ripple. 1 Channel for high voltage side, to measure voltage ripple. 2 Channels to spare.

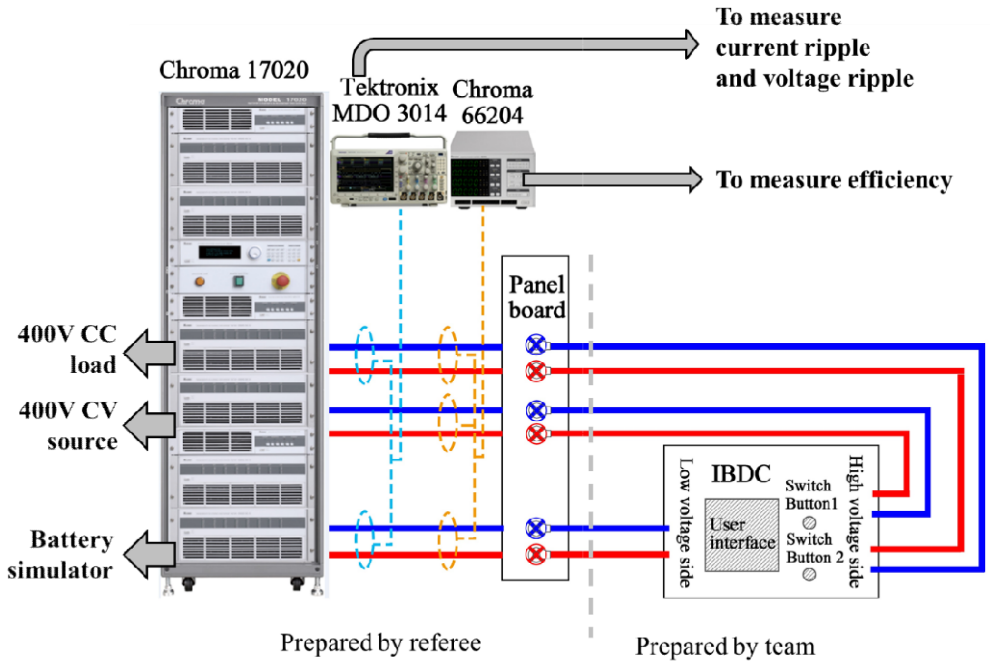
Table 2 Electrical connection ports for final tests and electrical connection diagram

<table>
<tr><th>Prepared by team</th><th>Further explanation</th></tr>
<tr><td>


</td><td rowspan="3">The wires prepared by team should meet safety and dimentional requirements. The length of wire is at least 0.5m, at most 1m.


The R-type terminals prepared by team should meet safety and dimentional requirements. $\emptyset d_2$ should be less than stud size (M6 in Metric or 1/4" in Imperial).
Screws (stud size M6 or 1/4") will be provided by referee to fix R-type terminals and testing equipment.</td></tr>
<tr><td>Prepared by referee</td></tr>
<tr><td>


</td></tr>
<tr><td>Electrical connection diagram</td><td>Further explanation</td></tr>
</table>


Chroma 17020
Tektronix MDO 3014
Chroma 66204
To measure current ripple and voltage ripple
To measure efficiency
Panel board
400V CC load
400V CV source
Battery simulator
IBDC
Low voltage side
High voltage side
User interface
Switch Button1
Switch Button 2
Prepared by referee
Prepared by team