**Customer Project XXXX**

**AC-DC/DC-DC charger**

**Electric test requirement**

|  |  |
| --- | --- |
| **Customer:** | XXX |
| **Project Name:** | xxxx |
| **Inventus Project Number:** | xxxx |
| **Prepared by:** | EE |
| **Checked by:** | EE Manager |
| **Date:** | Mon-DD-YYYY |

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1. Introduction

This document specifies the electrical performance testing requirements for AC-DC or DC-DC charger. These tests are designed to ensure the safety, reliability, and performance of the AC/DC charger.

1. Testing Equipment

* AC source
* DC source
* Electronic Load
* Multimeter
* Oscilloscope
* Analog battery
* Loop analysis tester
* Environmental chamber

1. Electrical Performance Tests
   1. Input inrush current (Cold test &Hot test)

3.1.1 Cold start

* **Test Objective**: Verify the bridge rectifier and AC input fuse I2T within the datasheet specification.
* **Test Conditions:** The PSU is turned on from a low impedance line at 90degree phase of input 240AC and the input current is caught and plotted.
* **Pass/Fail criteria**:The inrush current: 37A max.(example only)

3.1.2 hot start

**Test condition**: Warm up PSU over 1 hours then turn off 3 seconds. And then the PSU is turned on from a low impedance line at 90degree phase of input 240AC and the input current is caught and plotted.

* **Pass/Fail criteria:** The inrush current of the power supply under all conditions of switch on is less than the rating of its critical components.

**Test results: Pass**(use relay to do this test for 100 times, and no damaged was found)

|  |  |  |  |
| --- | --- | --- | --- |
| **Critical components** | **Rating** | **Measured** | **Pass/Fail** |
| Bridge (RS405L) | 200A/8.3ms | 32.8A | Pass |
| Fuse (T4.0A/250V) | 100A²s min. | 1.506A²s | Pass |

* 1. Input current and Power Factor Correction
* **Test Objective**: Verify the input current and PF value can meet the SPEC requirement.
* **Test Conditions:** While output is full load rated load, the input current is measured.
* **Pass/Fail criteria:** Maximum input current at 100Vac and 240Vac, 50Hz is 2.0A.

## Test result(example)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Input AC** | **Output Power** | **Input power** | **Input current** | | **Power Factor Correction** | |
| **Spec. max.** | **Measured** | **Spec. min.** | **Measured** |
| 100Vac | 100.36W | 110.7W |  | 1.599A |  |  |
| 240Vac | 100.34W | 107.6W | 2.0A | 0.678A |  |  |

* 1. Efficiency at Full load VS AC/DC line change, power factor checking:
* **Test Objective**: Verify the charger efficiency, PF whether can meet the SPEC requirement.
* **Test Conditions: Set the charger charging at max CCV, max CC current, measure the input voltage**
* **Input current, input power, output voltage, output current.**
* **Pass/Fail criteria:** The charger efficiency is better than 88% at full load and 115Vac input voltages.
  1. Blue Angel Requirement (DOE):
* Test condition: At no load condition, the input power is recorded.
* **Pass/Fail criteria:** The input power should be less than 0.3 Watts at 230Vac , 0.1W at 115Vac.
* Test result: Pass/Fail

|  |  |  |
| --- | --- | --- |
| **Vin (Vac)** | 115 | 230 |
| **Pin (W)** | 0.1 | 0.2 |



* 1. Line regulation
* **Test Objective**: Measure the charger Linear Regulation to verify Line Linear Regulation meet SPEC or not.
* **Test Procedure**:
  1. Set charger input to be min voltage(such as 90Vac)
  2. Let charger enter pre-charge mode and record the charging current.
  3. Increase the charger input voltage to be max voltage(Such as 264Vac).
  4. Record the charging current. And the △I should less than 1%.
  5. Let charger enter fast-charging/CV charging and repeat this test.
* **Acceptance Criteria**:
  + If no special requirement, Line Regulation needs to <1%.
  1. No load operation
* **Test Objective**: Verify the charger no load input power if within the spec requirement and whether can work normally when attached to the battery.
* **Test Procedure**:
  1. Power on the charger and charging the battery normally.
  2. Remove the battery, record the input power.
  3. Re connect the battery, checking whether the charging can recover.
* **Acceptance Criteria**:
  1. The no load input power should meet the spec requirement (such as 100mW).
  2. The charging should recover normally.
  3. Pre charge, CC charge current test
* **Test Objective**: Verify the charger charging current whether can meet spec requirement.
* **Test Procedure**:
  1. Set the charger at Pre charge, CC charge mode.
  2. Use oscilloscope to catch the charging current at Pre charge mode and CC charge mode
* **Acceptance Criteria**:
  1. The ripple current of pre-charging current <= +/-20%;
  2. The ripple current of fast-charging current <= +/-5%
  3. CV charge voltage test
* **Test Objective**: Verify the charger charging voltage whether can meet spec requirement.
* **Test Procedure**:
  1. Set the charger at CC charging mode.
  2. Increase the charge voltage 0.01V/s
  3. When the charge current start to drop, record the charger output voltage.
* **Acceptance Criteria**:
  1. CV voltage tolerance <=20mv/cell.
  2. Limit CCV charge voltage test
* **Test Objective**: Verify the charger limit CCV whether can meet spec requirement.
* **Test Procedure**:
  1. Set the charger at CC charging mode.
  2. Set the current limit of E-load to be 0.1A(<CC current)
  3. Record the max output voltage of the charger.
* **Acceptance Criteria**:
  1. CCV voltage tolerance <= +/-2%.
  2. Switch MOSFET deadtime, rise time and fall time
* **Test Objective**: Verify the DC-DC main MOSFET dead time, rise time and fall time.
* **Test Procedure**:
  1. Set the charger at Pre charge, CC charge, CV charge mode
  2. Adjust the input voltage from min to max voltage based on SPEC.
  3. Use the oscilloscope to catch the DC-DC main MOSFET dead time, rise time and fall time
* **Acceptance Criteria**:
  1. The rise time (Vgs) needs to <200ns Maximum to avoid too much thermal rise.
  2. The fall time (Vgs) needs to <200ns Maximum to avoid too much thermal rise.
  3. The deadtime for Half-bridge MOSFET application needs to 50ns< Tdead<200ns to avoid too much thermal rise.
  4. Reverse current test (when input off, battery pack reverse to charger current)
* **Test Objective**: Verify the charger output reverse current when input off and with battery connected.
* **Test Procedure**:
  1. Set the charger in CC charge mode.
  2. Let the charger work normally.
  3. Turn off the input voltage.
  4. Measure the output reverse current.
* **Acceptance Criteria**:
  1. reverse current<=500uA.
  2. Audio Noise test.
* **Test Objective**: Evaluate the Power Supply produce audio noise or not and verify the result can meet the SPEC requirement or not.
* **Test Procedure**:
  1. The audio Noise Test needs to follow the IEC61672-1 standard and test in semi-anechoic room.
  2. Set AC Power Supply in 115Vac/230Vac (use 115Vac or 230Vac if only support 110Vac/220Vac).
  3. Set E-load or Bi-direction DC-DC to make Power Supply under 0%/10%/50%/100% load.
  4. Use the decibelmeter to test the Power Supply Hearable Noise, and the distance between the decibelmeter and Power Supply is 50cm(typical) by following IEC61672-1 standard.
  5. Test six directions of the Power Supply and record the Maximum Noise Level as test result.
  6. Do the hearable noise test under 0%/10%/50%/100% load in 115V/230V AC conditions.
* **Acceptance Criteria**:
  + The Hearable Noise Test needs to meet the Spec requirement.
  + If no special requirements, need to follow below test result criteria as IEC61672-1 Grade1 standard. And should not hear any noise in the meeting room for ptoto-A sample testing.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **The Noise Level of EUT (Active Cooling)** | | | | | | |
| **Load** | **Sound Pressure Level(dB)** | | | | | |
| **Grade 1** | | **Grade 2** | | **Grade 3** | |
| **Power < 500W** | **Power ≥ 500W** | **Power < 500W** | **Power ≥ 500W** | **Power < 500W** | **Power ≥ 500W** |
| **20% Rated Load** | 30 | 35 | 35 | 40 | 40 | 45 |
| **50% Rated Load** | 35 | 40 | 40 | 45 | 45 | 50 |
| **Rated Load** | 40 | 45 | 45 | 50 | 50 | 55 |
| Note 1: The sound pressure level corresponds to a reference sound pressure of 20 μPa.  Note 2: The distance between the microphone and the tested product is 50 cm.  Note 3: The audible noise of power supply products without temperature control circuits should meet the requirements of the rated load. | | | | | | |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **The Noise Level of EUT (Passive Cooling)** | | | | | | |
| **Load** | **Sound Pressure Level(dB)** | | | | | |
| **Grade 1** | | **Grade 2** | | **Grade 3** | |
| **Suggest** | **Criteria** | **Suggest** | **Criteria** | **Suggest** | **Criteria** |
| **External Switching Power Supply** | 19 | 22 | 22 | 25 | 25 | 27 |
| **Internal Switching Power Supply** | 25 | 27 | 27 | 30 | 30 | 33 |
| Note 1: The sound pressure level corresponds to a reference sound pressure of 20 μPa.  Note 2: The distance between the microphone and the tested product is 50 cm.  Note 3: The audible noise of power supply products without temperature control circuits should meet the requirements of the rated load. | | | | | | |

* 1. Communicated waveform test (SMBus, CANbus or other optional)
* **Test Objective**: Verify the charger communication waveform.
* **Test Procedure**:
  1. Set the charger in CC charge mode.
  2. Use the oscilloscope to catch waveform of communication
* **Acceptance Criteria**:
  1. Rise time, fall time can meet the communication protocol requirement.
* I2C standard:

Standard mode：Trise≤1us，Tfall≤300ns.

Fast mode：Trise≤300ns，Tfall≤300ns

Logic level: VH≥0.7VDD, VL≤0.3VDD.

* CAN standard:

|  |  |  |
| --- | --- | --- |
|  |  | **spec** |
| **Descent time** | **CANH to CANL** | **20~400ns** |
| **Rise time** | **CANH to CANL** | **20~200ns** |
| **Dominant** | **CANH to CANL** | **1.5~3V** |
| **Recessive** | **CANH to CANL** | **-0.5~0.05V** |
|  |  |  |
| **Dominant** | **CANH To GND** | **2.75~4.5V** |  |
| **CANL To GND** | **0.5~2.25V** |  |
| **Recessive** | **CANH To GND** | **2~3V** |  |
| **CANL To GND** | **2~3V** |  |

* 1. IC VCC Voltage test(auxiliary supply)
* **Test Objective**: Verify the main IC VCC circuit whether it can work normally, VCC voltage regulation, LDO ripple voltage.
* **Test Procedure**:
  1. Power on the charger and charging at Pre charge or max CC/CV mode.
  2. Use the oscilloscope to catch the IC VCC voltage waveform at startup and steady state.
* **Acceptance Criteria**:

Ripple & Noise <2% pk-pk

\* Ripple and noise measured with 20MHz bandwidth; 10μF tantalum capacitor in parallel with a 0.1μF ceramic capacitor

* 1. LED display test
* **Test Objective**: Verify the charger LED can display correctly as spec define.
* **Test Procedure**:
  1. Set the charger at Pre charge, CC charge, CV charge mode, or other fault mode
  2. Record the LED states.
* **Acceptance Criteria**:
  1. Meet spec requirement.
  2. Check the LED brightness should not below 50lux.
  3. Input voltage OVP/UVP test
* **Test Objective**: Verify the charger can protect normally at input over voltage or under voltage condition.
* **Test Procedure**:
  1. Set the charger at Pre charge, CC charge, CV charge mode
  2. Adjust the input voltage from minimum to max voltage based on SPEC.
  3. Record the charger output state when input OVP/UVP.
* **Acceptance Criteria**:
  1. Meeting spec requirement.
  2. If no spec requirement from customer, UVP protection needs to control 70%-80%\*Vmin and the OVP protection needs to control 120%-130%\*Vmax.
  3. Output over current, over voltage protection
* **Test Objective**: Verify the charger can protect normally at output over voltage or over current condition.
* **Test Procedure**:
  1. Set the charger at CC charge.
  2. Connect an e-load at the charger output, increase the current at step 0.01A/s.
  3. Record the charger output current when output stops.
  4. Short the VRA voltage of TL431.
  5. Use the oscilloscope to catch the output voltage waveform when output protection.
* **Acceptance Criteria**:
  1. OVP: <110% Voutput in full AC range.
  2. OCP:120 - 150% Ioutput in full AC range
  3. Output short circuit protection
* **Test Objective**: Verify the charger can protect normally at output short circuit condition.
* **Test Procedure**:
  1. Set the charger at CC charge, CV charge mode
  2. Connect a switch at the output, and then short the output.
  3. Use the oscilloscope to catch the output current when short circuit.
* **Acceptance Criteria**:
  1. OCP:>130% Ioutput in full AC range
  2. Input power less than 2W after output short circuit.
  3. Over temperature protection
* **Test Objective**: Verify the charger can protect normally at over temperature condition.
* **Test Procedure**:
  1. Set the charger at CC charge mode
  2. Adjust the NTC value till the charger protection.
  3. Record the NTC value when charging stop.
* **Acceptance Criteria**:
  1. Transformer temperature is less than 110°C, Main MOSFET temperature less than 120°C and tolerance is ±3℃.
  2. Loop stability Test
* **Test Objective**: Evaluate AC-DC,DC-DC switching circuit loop stability performance.
* **Test Procedure**:

Refer to attached instruction PSM2200 operation manual.



* **Acceptance Criteria**:
  + If no special requirement, Gain Margin needs to have >6dB margin (Under 180°Phase change), Phase Margin needs to have >45°margin (Under 0dB Gain change), the Zero-Cross Frequency needs to <1/10 design switching Frequency.
  1. Burn in test (Room, high, low temperature)
* **Test Objective**: Verify the charger components temperature rise at normal working condition.
* **Test Procedure**:
  1. Charge the battery from pre charge mode
  2. Set the input voltage to minimum or maximum voltage.
  3. Measure the output Voltage, output Current, input power and Power Component (Magnetic Component（core， wire）/Power MOSFET/LDO/input/output Electrolytic Capacitor/RCD absorb circuit/ output rectifier diodes/FET，PWM IC，NTC，Y capacitor, X capacitor, Photo，heatsink，housing, AC input outlet etc.) at each temperature.
* **Acceptance Criteria**:
  1. Meeting components derating requirement.
  2. Component/Connector Single FMEA Test
* **Test Objective**: Evaluate the charger Component/Connector Single FMEA Test meets the SPEC requirement or not.
* **Test Procedure**:
  1. Set the charger in CC charge mode
  2. Use manual method to do the single FEMA for the component have damaged risk and any connector Pin distance which <3mm.
  3. Turn on the charger to charge
  4. Use oscilloscope/passive probe to measure the output voltage.
  5. Check about the phenomenon of the charger and record the output voltage.
* **Acceptance Criteria**:
  + The Component/Connector Single FMEA Test needs to meet the SPEC requirement.
  + If no special requirements, the Component/Connector Single FMEA Test needs to control < 110%\*Vrate Overshoot and guarantee no component explosion and flammable under Single FMEA condition.
  1. Connector GND wire open test
* **Test Objective**: Evaluate the charger output connector GND wire Single FMEA Test will not cause any components damage.
* **Test Procedure**:
  1. Set the charger in CC charge mode.
  2. Turn on the charger to charge.
  3. Open the output connector GND wire.
  4. Use oscilloscope/passive probe to measure the output voltage, communication signals voltage.
  5. Check the phenomenon of the charger.
* **Acceptance Criteria**:
  + The charger output connector GND wire Single FMEA Test will not cause any components damage.
  + If no special requirements, the GND Single FMEA Test needs to control < 110%\*Vrate Overshoot and guarantee no component damaged under Single FMEA condition.
  1. ON/OFF cycling (no load and Full load, more than 1000cycle)
* **Test Objective**: Verify the charger input on/off operation is safe, will not lose function such as input inrush shock.
* **Test Procedure**:
  1. Set the charger at CC charge mode
  2. Turn on input voltage.
  3. Use the switch to turn off/ turn on the input 1000 times.
* **Acceptance Criteria**:
  1. Charger can work normally after 1000 times.
  2. Output short circuit protection (more 1000time)
* **Test Objective**: Verify the charger output short circuit is safe, short circuit protection is normal, will not loss function after short circuit remove.
* **Test Procedure**:
  1. Set the charger at CC charge mode
  2. Turn on input voltage.
  3. Use the switch(<50 mOHM) to short the output 1000 times.
* **Acceptance Criteria**:
  1. Charger can work normally after 1000 times.
  2. Magnetic Components Stress Verification Test
* **Test Objective**: Evaluate the Magnetic Components stress margin meets the tolerance analysis or not.
* **Test Procedure**:

**Room Temp Test**:

* 1. Set AC Power Supply input in 85Vac/265Vac (use 132Vac or 265Vac if only support 110Vac/220Vac).
  2. Set E-load or Bi-direction DC-DC to make Power Supply under 0%/10%/100% load.
  3. Use oscilloscope/high voltage differential probe/current probe to measure the Magnetic Components Voltage (VL) and Current (IL) (Transformer/Inductor/etc.).
  4. Measure the Magnetic Components Voltage and Current in 0%/10%/100% load in 85V/265V.
  5. Calculate the magnetic induction intensity and electric current density for each Magnetic Components (Transformer/Inductor/etc.) in room temperature.

**High Temp Test:**

* 1. Keep the same procedure as room temp and set the product in maximum usage temperature + 5’C degree environment.
  2. Measure the Magnetic Components Voltage and Current in 0%/10%/100% load in 85V/265V.
  3. Calculate the magnetic induction intensity and electric current density for each Magnetic Components (Transformer/Inductor/etc.) in high temperature.
* **Acceptance Criteria**:
  + All those Magnetic Component stress tests need to meet the SPEC requirement.
  + If no special requirements, All Magnetic Component stress need to satisfy below requirement.
    - * 1. The Ferrite Core (Such as PC40/PC44/PC47/PC95), need to control magnetic induction intensity B Value Under 0.3T.
        2. The Sendust Core (Such as FeSiAl/FeNi), needs to control magnetic induction intensity B Value Under 0.6-0.8T (depend on the core material selection).
        3. The High ui Value core for common mode choke (Such as R7K/R10K/R12K) control magnetic induction intensity B Value Under 0.3T(calculate the B value by the leakage inductor of CM Choke).
        4. The Active Cooling, the current density needs to be controlled in <8A/mm^2 for application.
        5. The Passive Cooling, the current density needs to be controlled in <4.5A/mm^2 for application.
  1. Power Component (MOSFET/SiCFET/GaNFET) Stress Verification Test
* **Test Objective**: Evaluate the Power Component stress meets the tolerance analysis or not.
* **Test Procedure**:
  1. Set AC Power Supply input in 85Vac/265Vac (use 132Vac or 265Vac if only support 110Vac/220Vac).
  2. Set E-load or Bi-direction DC-DC to make Power Supply under 0%/10%/100% load.
  3. Use oscilloscope/high voltage differential probe/current probe to measure the Power Voltage (Vds) and Current (Ids).
  4. Measure the Power Voltage (Vds) and Current (Ids) Waveform in 0%/10%/100% load in 85V/265V.
  5. Calculate the Peak Current/RMS Current/Peak Voltage/Power Consumption for each Power Components.
* **Acceptance Criteria**:
  + All those Power Component stress need to meet the SPEC requirement.
  + If no special requirements, All Power Component stress need to satisfy below requirement.
    - * 1. The Peak Current/The RMS Current needs to have >20% margin compared to datasheet illustrated.
        2. The Peak Voltage needs to have >20% margin compared to datasheet illustrated.
        3. The Power Consumption needs to meet the tolerance analysis and component temperature needs to control in 120’C.
  1. Power Component (MOSFET/SiCFET/GaNFET) Gate Driving Capacity (Rise-time/Fall-time/Deadtime) Test
* **Test Objective**: Evaluate Power Component (MOSFET/SiCFET/GaNFET) Gate Driving Capacity (Rise-time/Fall-time/Deadtime) meets the tolerance analysis or not.
* **Test Procedure**:
  1. Set AC Power Supply Input in 85Vac/115Vac/230Vac/265Vac (use 85Vac -132Vac or 185Vac -265Vac if only support 110Vac/220Vac).
  2. Set E-load or Bi-direction DC-DC to make Power Supply under 0%/10%/100% load.
  3. Use oscilloscope/Passive probe/High Voltage Differential Probe to measure the Power Component Driver Waveform.
  4. Measure the Power Components Gate Driving Voltage (Vgs) and Power Voltage (Vds) in 0%/10%/100% load in 85V/265V.
* **Acceptance Criteria**:
  + All those Power Component (MOSFET/SiCFET/GaNFET) Gate Driving Capacity (Rise-time/Fall-time/Deadtime) need to meet the SPEC requirement.
  + If no special requirements, All Power Component Gate Driving Capacity need to satisfy below requirement.
    - * 1. The Rise Time (Vgs) needs to <500ns Maximum to avoid too much thermal rise.
        2. The Fall Time (Vgs) needs to <200ns Maximum to avoid too much thermal rise.
        3. The Deadtime for Half-bridge MOSFET application needs to <500ns Maximum to avoid too much thermal rise.
  1. Protection Component (eFuse/Fuse/PTC) Stress Verification Test
* **Test Objective**: Evaluate Protection Component (eFuse/Fuse/PTC) stress meets the tolerance analysis or not.
* **Test Procedure**:
  1. Set AC Power Supply Input in 85Vac/265Vac (use 132Vac or 265Vac if only support 110Vac/220Vac).
  2. Set E-load or Bi-direction DC-DC to make Power Supply under 0%/10%/100% load.
  3. Use oscilloscope/Passive probe/High Voltage Differential Probe to measure Protection Component Waveform.
  4. Measure the Protection Component(eFuse/Fuse/PTC) Voltage (Vprotection) and Current (Iprotection) in 0%/10%/100% load in 85V/265V.
* **Acceptance Criteria**:
  + All those Protection Component (eFuse/Fuse/PTC) stress need to meet the SPEC requirement.
  + If no special requirements, All Protection Component (eFuse/Fuse/PTC) need to satisfy below requirement.
    - * 1. The Protection Component I2T Value needs to have >50% margin.
        2. The Protection Component Peak Voltage and RMS Current need to have >20% margin for rated voltage and current.
  1. Auxiliary Power Circuit (Flyback Auxiliary Winding/DC-DC circuit) Tolerance Verification Test
* **Test Objective**: Evaluate Auxiliary Power Circuit (Flyback Auxiliary Winding/DC-DC circuit) Output Voltage/Current meets the tolerance analysis or not.
* **Test Procedure**:
  1. Set AC Power Supply Input in 85Vac/115Vac/230Vac/265Vac (use 85Vac -132Vac or 185Vac -265Vac if only support 110Vac/220Vac).
  2. Set E-load or Bi-direction DC-DC to make Power Supply under 0%/10%/100% load.
  3. Use Oscilloscope/Passive Probe/High Voltage Differential Probe to measure Auxiliary Power Circuit Waveform.
  4. Measure the Auxiliary Power Circuit Output Voltage and Current in 0%/10%/100% load in 85V/115V/230V/265V.
* **Acceptance Criteria**:
  + Auxiliary Power Circuit Output Voltage and Current need to meet the SPEC requirement.
  + If no special requirements, Auxiliary Power Circuit Output Voltage and Current need to satisfy below requirement.
    - * 1. Output Voltage needs to > Vpwm\_min + 3V and < Vpwm\_min - 3V to cover PWM IC VCC Support Range.
        2. Output Current Rate current needs to > 120% \* PWM IC maximum current consumption.
        3. Output Current Voltage Ripple needs < 1%\*Vauxiliary as general.
  1. Passive Thermal Circuit (Absorb RC/RCD/etc.) Stress Verification Test
* **Test Objective**: Evaluate the Stress of Passive Thermal Circuit meet the tolerance analysis or not.
* **Test Procedure**:
  1. Set AC Power Supply Input in 85Vac/115Vac/230Vac/265Vac (use 85Vac -132Vac or 185Vac -265Vac if only support 110Vac/220Vac).
  2. Set E-load or Bi-direction DC-DC to make Power Supply under 0%/10%/100% load.
  3. Use Oscilloscope/Passive Probe/High Voltage Differential Probe to measure Passive Thermal Circuit Waveform.
  4. Measure the Passive Thermal Circuit Voltage and Current in 0%/10%/100% load in 85Vac/115Vac/230Vac/265Vac.
* **Acceptance Criteria**:
  + Passive Thermal Circuit Voltage and Current need to meet the SPEC requirement.
  + If no special requirements, Passive Thermal Circuit Voltage Output Voltage and Current need to satisfy below requirement.
    - * 1. Passive Thermal Circuit stress voltage and current need to have >20% margin of the Maximum voltage and current shown in the datasheet.
        2. Passive Thermal Circuit durative power consumption needs < 1W limit for each component if using passive cooling
        3. If using active cooling, Passive Thermal Circuit durative power consumption needs to have >20% thermal rise margin for component limitation.
        4. For Pulse power consumption, need to have >20% thermal rise margin for component limitation shown in datasheet.
  1. The Air-distance/Creepage Distance Verification Test.
* **Test Objective**: Verify the Air-distance/Creepage Distance of the Power supply meet the Agency Standard or not (IEC62368/IEC60335/IEC60601/UL1012/UL1310/etc.).
* **Test Procedure**:
  1. Check the L/N distance before Fuse and L/N to Protection Earth distance meet Agency Standard or not.
  2. Check the Primary to Secondly Component (Transformer/Inductor/Opto-Coupler/Isolation Driver/etc.) meet Agency Standard or not.

Remark: Take care of Transformer/Inductor which need to consider the distance between the footprint to the winding meet agency requirement or not.

* 1. Check the Primary and Secondly Component to Protection Earth distance Agency Standard or not.

Remark:

1. All the Y-CAP need to consider as a functional isolation component in mostly agency standard, it can be considered as reinforce isolation component in IEC62368 in special case for Y1-cap.

2. All the Air-distance and Creepage need to have the agency certification (TUV/VDE certification)

* **Acceptance Criteria**:
  + The Air-distance/Creepage Distance need to meet the Spec and Agency requirement.
  + If no special requirements, Air-distance/Creepage Distance need to meet below request:
    - * 1. The Air-distance between primary-secondly needs to >3.5mm
        2. The Creepage between primary-secondly needs to >6.5mm, for transformer needs to >8mm
        3. The Air-distance between primary-earth needs to >2.5mm
        4. The Creepage between primary-earth needs to >3.5mm
  1. Isolation Voltage/Hi-Pot Test
* **Test Objective**: Verify the Isolation Voltage/Hi-Pot meet the Agency Standard or not (IEC62368/IEC60335/IEC60601/UL1012/UL1310/etc.).
* **Test Procedure**:
  1. Check each Component Certificated Isolation Voltage between Primary-Secondly/Primary-Protection Earth/ Secondly-Protection Earth meet the Agency requirement or not (Transformer/Inductor/Opto-Coupler/Isolation Driver/etc.).

Remark: Take care of Transformer/Inductor which need to consider the winding material using Triple isolation wire meet the agency or not.

* 1. The Hi-pot test environment should be in a dark room without obvious light, it’s better to also use mobile phone camera to check if any purple light found during the test, because human eye can’t see that light.
  2. Short circuit all primary connector port as primary input, Short circuit all Secondly connector port as secondly input.
  3. Apply the Hi-Pot Voltage between Primary-Secondly as Spec requested and do the Hi-Pot Test.
  4. If exist Protection Earth Input port, Short Circuit all the Protection Earth Input port as Earth.
  5. Apply the Hi-Pot Voltage between Primary-Earth as Spec requested and do the Hi-Pot Test.
* **Acceptance Criteria**:
  + The Isolation Voltage/Hi-Pot test need to meet the Spec and Agency requirement.
  + If no special requirements, he Isolation Voltage/Hi-Pot test need to meet below request:
    - * 1. All the Isolation component isolation voltage need to >3000V
        2. The Hi-Pot test needs to apply >3000V/60sec for primary-secondly, 1500V/60sec for primary to earth.
        3. The Test Unit cannot have any electric arc during the Hi-Pot test (the Hi-pot test environment should be in a dark room without obvious light)
  1. AC Leakage Current Test
* **Test Objective**: Verify the AC Leakage Current meet the Agency Standard or not (IEC62368/IEC60335/IEC60601/UL1012/UL1310/etc.).
* **Test Procedure**:
  1. Set AC Power Supply Input in 265Vac (use 132Vac if only support 110Vac).
  2. Use Dummy Load to make Power Supply under 100% load.
  3. Use AC Leakage Current tester to measure AC Leakage Current.
  4. Measure the normal AC leakage current and the FEMA AC leakage current between Primary-Secondly and Primary-Earth. (if the protection earth is existed)
* **Acceptance Criteria**:
  + The AC Leakage Current needs to meet the SPEC and Agency requirement.
  + If no special requirements, the AC Leakage Current needs to satisfy below requirement.
    - * 1. The normal AC leakage current needs <100uA for Primary-Secondly (Touch Current).
        2. The FEMA AC leakage current needs <500uA for Primary-Secondly (Touch Current).
        3. The normal AC leakage current needs <500uA for Primary-Earth (Earth Leakage Current).
        4. The FEMA AC leakage current needs <1mA for Primary-Earth (Earth Leakage Current).
  1. Surge Test
* **Test Objective**: Verify the Surge Test meet the Agency Standard or not (IEC61000).
* **Test Procedure**:
  1. Set AC Power Supply Input in 265Vac (use 132Vac if only support 110Vac).
  2. Use Dummy Load to make Power Supply under 100% load.
  3. Use the Surge tester to do the Surge Test (needs to do 0'/90'/180'/270' Phase with 8us/20us Standard).
  4. After finishing the test, verify if the Power Supply function is compiled or not.
* **Acceptance Criteria**:
  + The Surge Test needs to meet the SPEC and Agency requirements.
  + If no special requirements, The Surge Test needs to satisfy below requirement.
    - * 1. The Surge Voltage between L/N to Earth is 2kV/8us/20us (Common Mode).
        2. The Surge Voltage between L to N is 1kV/8us/20us (Different Mode).
  1. ESD Test
* **Test Objective**: Verify the ESD Test meet the Agency Standard or not (IEC61000).
* **Test Procedure**:
  1. Set AC Power Supply Input in 230Vac (use 115Vac if only support 110Vac).
  2. Use Dummy Load to make Power Supply under 100% load.
  3. Use the ESD tester to do the Contact/Air ESD Discharge for Power Supply.

Remark: For the connector or housing which is metal and can be contacted by human hand, need to apply Contact ESD discharge standard. For the other place which cannot be touched, needs to apply Air ESD discharge standard.

* 1. After finishing the test, verify if the Power Supply function is compiled or not.
* **Acceptance Criteria**:
  + The ESD Test needs to meet the SPEC and Agency requirements.
  + If no special requirements, The ESD test needs to satisfy below requirement.
    - * 1. For Contact ESD discharge, needs to apply 9.6kV/10 times for Positive and Negative for each test position.
        2. For Air ESD discharge, needs to apply 18kV/10 times for Positive and Negative for each test position.
  1. Conducted/Radiated Emission Test
* **Test Objective**: Verify the Conducted/Radiated Emissions Test meet the Agency Standard or not (IEC61000).
* **Test Procedure**:
  1. Set AC Power Supply Input in 115Vac/230Vac (use 115Vac or 230Vac if only support 110Vac/220Vac).
  2. Use Dummy Load to make Power Supply under 0%/10%/100% load.
  3. Do the Conduct Emission Test in Conduct EMC Test Field by following IEC61000 standard.
  4. Do the Radiated Emission Test in Radiated EMC Test Field by following IEC61000 standard.

Remark: All Conducted/Radiated Emission test needs to confirm agency standard applied, such as EN55032/EN60601/FCC 15/CISPR.

* **Acceptance Criteria**:
  + The Conducted/Radiated Emission Test needs to meet the SPEC and Agency requirements.
  + If no special requirements, the Conducted/Radiated Emission Test needs to satisfy below requirement.
    - * 1. Conducted Emission Test needs to meet the Emission limitation of EN55032 and FCC 15 Class B standard.
        2. Radiated Emission Test needs to meet the Emission limitation of EN55032 and FCC 15 Class B standard.
  1. Conducted/Radiated Immunity Test
* **Test Objective**: Verify the Conducted/Radiated Immunity Test meet the Agency Standard or not (IEC61000).
* **Test Procedure**:
  1. Set AC Power Supply Input in 115Vac/230Vac (use 115Vac or 230Vac if only support 110Vac/220Vac).
  2. Use Dummy Load to make Power Supply under 0%/10%/100% load.
  3. Do the Conduct Immunity Test in Conduct EMC Test Field by following IEC61000 standard.
  4. Do the Radiated Immunity Test in Radiated EMC Test Field by following IEC61000 standard.

Remark: All Conducted/Radiated Immunity test needs to confirm agency standard applied, such as EN55032/EN60601/FCC 15/CISPR.

* **Acceptance Criteria**:
  + The Conducted/Radiated Immunity Test needs to meet the SPEC and Agency requirements.
  + If no special requirements, the Conducted/Radiated Immunity Test needs to satisfy below requirement.
    - * 1. For the Conducted Immunity Test, apply 3V standard for 150KHz-80MHz by following the IEC61000 standard.
        2. For the Radiated Immunity Test, apply 10V/m standard for 80MHz-1GHz by following the IEC61000 standard.
  1. Harmonic Current Emissions Test
* **Test Objective**: Verify the Harmonic Current Emissions Test meet the Agency Standard or not (IEC61000).
* **Test Procedure**:
  1. Set AC Power Supply Input in 115Vac/230Vac (use 115Vac or 230Vac if only support 110Vac/220Vac).
  2. Use Dummy Load to make Power Supply under 100% load.
  3. Use the Oscilloscope/High Voltage Differential Probe/Current Probe to measure AC input voltage/current.
  4. Do the Harmonic Current Emissions Test by following IEC61000 standard.
* **Acceptance Criteria**:
  + The Harmonic Current Emissions test needs to meet the SPEC and Agency requirements.
  + If no special requirements, the Harmonic Current Emission needs to satisfy below requirement.
    - * 1. The Harmonic Current Emission needs to meet Class A limitation described in IEC61000 standard.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Class A | Odd | Harmonic Current Limit(A) | Even | Harmonic Current Limit(A) |
| 3 | 2.300 | 2 | 1.080 |
| 5 | 1.140 | 4 | 0.430 |
| 7 | 0.770 | 6 | 0.300 |
| 9 | 0.400 | 8 | 0.230 |
| 11 | 0.330 | 10 | 0.184 |
| 13 | 0.210 | 12 | 0.153 |
| 15 | 0.150 | 14 | 0.131 |
| 17 | 0.132 | 16 | 0.115 |
| 19 | 0.118 | 18 | 0.102 |
| 21 | 0.107 | 20 | 0.092 |
| 23 | 0.098 | 22 | 0.084 |
| 25 | 0.090 | 24 | 0.077 |
| 27 | 0.083 | 26 | 0.071 |
| 29 | 0.078 | 28 | 0.066 |
| 31 | 0.073 | 30 | 0.061 |
| 33 | 0.068 | 32 | 0.058 |
| 35 | 0.064 | 34 | 0.054 |
| 37 | 0.061 | 36 | 0.051 |
| 39 | 0.058 | 38 | 0.048 |
|  |  | 40 | 0.046 |

* 1. Voltage Dip/Short Interruption Test
* **Test Objective**: Verify the Voltage Dip/Short Interruption Test meets the Agency Standard or not (IEC61000).
* **Test Procedure**:
  1. Set AC Power Supply Input in 115Vac/230Vac (use 115Vac or 230Vac if only support 110Vac/220Vac).
  2. Use Dummy Load to make Power Supply under 100% load.
  3. Use the Oscilloscope/Passive Probe/High Voltage Differential Probe to measure AC Input Voltage/Output Voltage.
  4. Do the Voltage Dip/Short Interruption Test by following IEC61000 standard.
* **Acceptance Criteria**:
  + The Voltage Dip/Short Interruption test result needs to meet the SPEC and Agency requirement.
  + If no special requirements, The Voltage Dip/Short Interruption test result needs to satisfy below requirement.
    - * 1. Voltage Drop Test needs to control <20%\*Voutput change under the test below:

|  |  |
| --- | --- |
| **Voltage Dip Level** | **Duration** |
| 0% Vac | 0.5 Period |
| 0% Vac | 1 Period |
| 40% Vac | 10 Period(50Hz) 12 Period(60Hz) |
| 70% Vac | 25 Period(50Hz) 30 Period(60Hz) |
| 80% Vac | 250 Period(50Hz) 300 Period(60Hz) |

* + - * 1. Short Interruption Test needs to guarantee the Power Supply functional comply under the test below:

|  |  |
| --- | --- |
| **Voltage Dip Level** | **Duration** |
| 0% Vac | 250-300 Period |

A diagram of a waveform

AI-generated content may be incorrect.

* 1. AC Electrical Fast Transient Test
* **Test Objective**: Verify the AC Electrical Fast Transient Test meets the Agency Standard or not (IEC61000).
* **Test Procedure**:
  1. Set AC Power Supply Input in 115Vac/230Vac (use 115Vac or 230Vac if only support 110Vac/220Vac).
  2. Use Dummy Load to make Power Supply under 100% load.
  3. Use the Oscilloscope/Passive Probe to measure Output Voltage.
  4. Do the AC Electrical Fast Transient Test by following IEC61000 standard.
* **Acceptance Criteria**:
  + The AC Electrical Fast Transient Test needs to meet the SPEC requirement.
  + If no special requirements, the AC Electrical Fast Transient Test needs to satisfy below requirement.
    - * 1. The AC Electrical Fast Transient Test needs to control <20%\*Voutput change under the test below:

|  |  |  |  |
| --- | --- | --- | --- |
| **AC/DC Input Port and Earth Port** | | **Signal Port and Control Port** | |
| **Voltage(kV)** | **Repeatable Frequency(Khz)** | **Voltage(kV)** | **Repeatable Frequency(Khz)** |
|  |
| 2 | 5kHz/100kHz | 1 | 5kHz/100kHz |  |
|  |  |  |  |  |

A diagram of a pulse test

AI-generated content may be incorrect.

* 1. Isolation Magnetic Component (Transformer) Normal and FMEA Overstress Test
* **Test Objective**: Evaluate the Power Supply Isolation Magnetic Component (Transformer) Normal and FMEA Overstress test meets the Agency Requirement or not.
* **Test Procedure**:

**Normal Mode Test**:

* 1. Set AC Power Supply in 85Vac/265Vac (use 85Vac or 265Vac if only support 110Vac/220Vac).
  2. Set E-load or Bi-direction DC-DC to make Power Supply under Maximum Output Current (before trigger OCP current).
  3. Set the Power Supply in Maximum environment temperature + 5’C degree to do this test.
  4. Use Logger to monitor the Isolation Magnetic Component temperature (transformer core and wires temperature).
  5. Do the thermal burn in test and monitor the thermal rise of Isolation Magnetic Component.

**FMEA Mode Test:**

* 1. Keep the same procedure as normal test to monitor the Magnetic Component temperature.
  2. Use manual method to do the single FEMA for the key component. (such as MOSFET/transformer winding/current shunt resistor/NTC or etc.)
  3. Do the thermal burn in test and monitor the thermal rise of Isolation Magnetic Component.
* **Acceptance Criteria**:
  + The Isolation Magnetic Component (Transformer) Normal and FMEA Overstress Test needs to meet the SPEC requirement.
  + If no special requirements, the Isolation Magnetic Component (Transformer) Normal and FMEA Overstress Test needs to meet below requirement.

|  |  |  |
| --- | --- | --- |
| Isolation Magnetic Component (Transformer) Normal and FMEA Overstress Test | Agency Requirement (IEC60601/IEC60335/IEC62368) | |
| Winding Wire Class | Maximum  Thermal('C) |
| Class A | 140 |
| Class E | 155 |
| Class B | 165 |
| Class F | 180 |
| Class H | 200 |

* 1. Shut down battery charge up test
* **Test Objective**: Evaluate the charger whether can normally charge up the battery at shutdown mode or not.
* **Test Procedure**:

**Charge the shutdown Battery at cell voltage under CUV threshold test**:

* 1. Shutdown the battery at cell voltage under CUV threshold.
  2. Check the charger if can normally charge up the battery.

**Charge the shutdown Battery at cell voltage higher CUV threshold test:**

* 1. Shutdown the battery at cell voltage higher than CUV threshold.
  2. Check the charger if can normally charge up the battery.
* **Acceptance Criteria**:
  + The charger can normally charge up the shutdown battery at any condition, cannot trigger any protection.

Revision History

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Revision** | **Description of Change** | **Changed by** | **Approved by** | **Date** |
| X1 | New release | Evan | Kylin/Kyle/CYW/XJJ | Mar.-11-2025 |
| X2 | Add Connector GND wire open test item | Evan | Kylin/Kyle/CYW/XJJ | Jul.-1-2025 |
| X3 | 1.Update the Hi-pot test condition  2.Add 3.43 shut down battery charge up test | Evan | Kylin/Kyle/CYW/XJJ | Aug.-1-2025 |
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