NOTES ON USING NESSCAP EDLC

[Environmental Considerations]

Electric Double Layer Capacitor(EDLC) products are packaged in rubber-sealed aluminum cases containing an organic electrolyte. Nesscap recommends avoiding use of EDLCs under the following environmental conditions:

- In direct contact with water, salt water/brine or oil,
- Under direct sunlight,
- In high temperature and/or high humidity with the likelihood of water condensation,
- In direct contact with chemically active gas(es),
- Stored or used in acidic or alkaline conditions.

If any of the above conditions are unavoidable, please contact NESSCAP for appropriate recommendations.

[Electrical Considerations]

1. Do not exceed the rated voltage on the device. Prolonged exposure to overvoltage conditions may damage the EDLC and cause premature performance degradation.
2. EDLC devices have specified polarities; do not apply reverse voltage. The polarity of the terminals is indicated on the sleeve of the EDLC products and, in some products, by the physical differences of the terminals.
3. Multiple EDLC devices connected in series may exhibit voltage variations amongst the individual cells. Charging a string of EDLC devices without addressing such variations will lead to one or more device(s) in the string being overcharged. When a device is overcharged (or exposed to overvoltage conditions), rapid performance degradation may result. This further exacerbates the voltage variations and will lead to the failure of the whole string. The following is a list of guidelines for consideration when EDLC devices are used in series as a string:
   - The tolerance range of capacitance of EDLC is –10% (or -0%) to +20% of rated capacitance. This means the capacitance difference could be up to maximum 30% between capacitors. When EDLC products are shipped, they are packaged in groups with a letter designation (e.g. J, K, L, M, etc.) Nesscap refers to these letter designations as grades and these are essentially narrower ranges of capacitances. Nesscap recommends that users only connect in series devices from the same letter grade. If you have devices from different grades, Nesscap recommends that the user test each device to determine their capacitances before connecting them in series. For more information on this topic, please contact a Nesscap sales representative.
   - Due to the above point and for longevity of use, NESSCAP recommends design rules whereby the applied voltage on each device to be lower than the rated voltage of the devices. This is referred to as de-rating and is useful in keeping the voltage of devices in a series string to not exceed the rated voltage despite the variation that will be created due to the capacitance and ESR variations among the devices. Nesscap typically de-rates devices to 2.15V and 2.5V when serially connecting EDLC devices rated at 2.3V and 2.7V, respectively.
   - When preparing EDLC devices for string connections, Nesscap recommends fully discharging the device before soldering or welding. This will ensure that there is no possibility of sparking or other electrical discharge when the devices are connected. Some EDLC devices may show voltage levels up to 0.5V. The devices can be discharged down to near 0V with a resistor or with adequate shorting straps.
   - Voltage of each device in a string should be verified before and after charging to ensure that the devices are being used within the designed voltage range. Proper cell balancing strategies must be implemented in strings with more than 2 devices in series, especially if the application requires numerous and rapid charge and discharge cycles. In application requiring complex duty cycles, contact NESSCAP's technical team for recommendations.
4. Thermal conditions must be considered when designing EDLC devices/systems that will be used for repeated rapid charge and discharge cycles. Ohmic self-heating may cause the EDLC cell to overheat and will lead to rapid degradation of performance.
5. EDLC life is closely correlated with cell temperature. The lifetime of an EDLC device may approximately be doubled if temperature can be lowered by 10°C than what the temperature would be without thermal management. Do not exceed the rated max temperature of the device.

[Mounting]

1. Do not scratch or file the lead or snap-in terminals. The terminals are plated to ensure good wetting of solder. Physically or chemically altering the surface will affect the solderability of the lead and the snap-in terminal devices.
2. Do not overheat when soldering. Solder temperature lower than 260°C and solder time of under 5 seconds are recommended.
3. Avoid mechanical impacts, such as dropping on the floor, and avoid damages to the sleeve and the lead wire.
4. Do not exceed the vibration and shock ratings of EDLC devices.
5. **(Radial type only) IMPORTANT! DO NOT deform** (Pictureⓐ), **pull** (Pictureⓑ) **or twist** (Pictureⓒ) **the terminals or lead wires.** The terminals or lead wires are attached to the electrodes in the interior of the aluminum casing and provide an electrolyte-containing seal with the rubber. Repeated or forceful bending, pulling or twisting of the lead wire may break such a seal and allow electrolyte to leak out. Electrolyte leakage will shorten the useful life of the EDLC and may also cause corrosion and/or short-circuits in PCB components nearby. If deforming of the lead wire is unavoidable or essential to the assembly process, the leads can be bent away from the base of the lead at the rubber. (Pictureⓓ) The minimum recommended distance away from the base of the lead is the radius of the device. In all lead manipulations, ensure that no stress is applied to the base of the leads.

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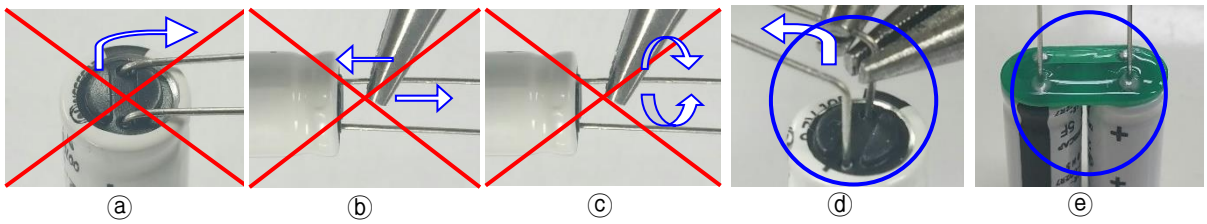
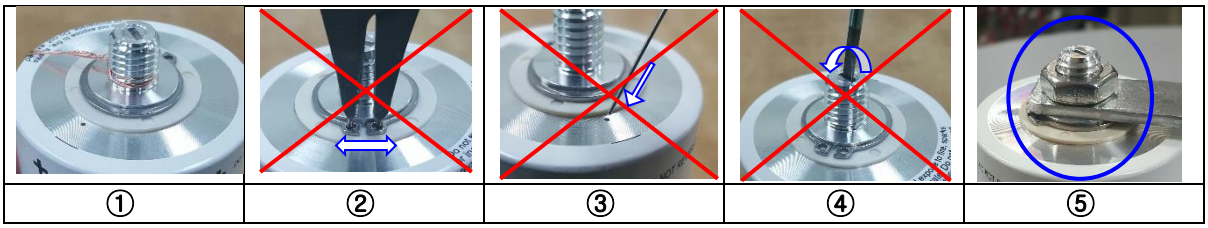


6. **(Radial type only)** NESSCAP recommends utilizing PCB when connecting EDLC to the circuit or electric devices. For best practice, avoid connecting wires directly to the EDLC devices and avoid locations near heat generating components.
7. **(Radial type only)** Please maintain minimum stand-off distance of 5 mm between the rupture vents on the EDLC devices and the module housing.
8. **(Large Cylindrical type only)** Large cylindrical type EDLC cells are supplied with terminals short-circuited by a wire (as shown in Picture① below). This is to discharge any residual charge and to ensure the cells are ready for assembly in a uniform discharged state. Please remove and dispose of the shorting wire.
9. **(Large Cylindrical type only)** Factory-installed snap-rings are not intended to be removed by users of EDLC (Picture②); Avoid physical damage (ex. physical impact) on the terminals; avoid damages the hole on the top plate where the rupture vent is located (Picture③); do not loosen the electrolyte-filling bolt at the terminal (Picture④); failure to comply with these precautions may shorten the life of the product and cause electrolyte leakage. Use standard nuts to install busbars in order to connect the large cylindrical cells (Picture⑤). Use washers as necessary to prevent loosening of bolts due to vibration. Refer to product datasheet for correct torque for fastening a nut on the terminals.



[Part Failure Indicators]

Any of the following phenomena may be an indication that the EDLC device has failed, disconnect it from electrical supply immediately:

- When surface temperature of the EDLC device(s) exceeds the upper limit of rated temperature within a few minutes of use.
- When there is audible sound of vent rupture or perceivable odor from the EDLC devices. This is usually always accompanied with swelling of the device housing.
- When a EDLC device is visibly swollen.
- When electrical sparks are observed at the terminals under high current conditions.

[Cleaning]

1. Do not wash EDLC devices in cleaning solutions as they may cause contamination, corrosion, degradation of seals, and/or short-circuit paths.
2. Contact NESSCAP if cleaning is necessary after soldering. Certain types of solvents may cause damage to rubber seals on EDLC devices.

[Storage]

1. Do not store in high temperature and high humidity environment. Nesscap recommends store products at temperature between 5°C～30°C and where the relative humidity is less than 60%. Avoid abrupt temperature changes, which may cause water condensation and deterioration of the product. Avoid exposure to direct sunlight for extended period as it may cause deterioration and discoloration of the sleeve.
2. For longer-term storage, Nesscap recommends fully discharging the device and shorting the terminals.
3. Do not store the product in atmosphere containing water-droplets or toxic gases.
4. Avoid exposure to acid or alkaline liquids, vapor and/or toxic gases.
5. The EDLC may have a trace amounts of electrolyte on the surface of the device: use proper personal protection in handling of the product in accordance with applicable regulation and industrial practices.

[Disposal]

Refer to the MSD for material composition of EDLC devices. Comply with all local, regional, federal or national requirements for disposal of EDLC devices. In most jurisdictions, EDLC disposal can be handled by industrial waste handling organizations.

[Distributor's Responsibility]

Distributors of Nesscap products are responsible for the following:

1. Ensuring that **Notes on Using Nesscap EDLC** (this document) is provided to the end user for all sales of Nesscap products and hard copies are included in all shipments to said customers.
2. **Notes on Using Nesscap EDLC** is also available on Nesscap's website www.nesscap.com for download.

NOTES ON USING NESSCAP PSEUDOCAPACITOR

[Environmental Considerations]

Pseudocapacitor (Pseudocap) products are packaged in rubber-sealed aluminum cases containing an organic electrolyte. Nesscap recommends avoiding use of Pseudocaps under the following environmental conditions:

- In direct contact with water, salt water/brine or oil,
- Under direct sunlight,
- In high temperature and/or high humidity with the likelihood of water condensation,
- In direct contact with chemically active gas(es),
- Stored or used in acidic or alkaline conditions.

If any of the above conditions are unavoidable, please contact NESSCAP for appropriate recommendations.

[Electrical Considerations]

3. Do not exceed the rated voltage on the device. Prolonged exposure to overvoltage conditions may damage the Pseudocap and cause premature performance degradation.
4. Do not discharge Pseudocap devices below 0.9V during normal operation. Going below 0.9V may cause irreversible damage to the Pseudocap devices.
5. Pseudocap devices have specified polarities; do not apply reverse voltage. The polarity of the terminals is indicated on the sleeve of the Pseudocap products and, in some products, by the physical differences of the terminals.
6. Multiple Pseudocap devices connected in series may exhibit voltage variations amongst the individual cells. Charging a string of ED Pseudocap devices without addressing such variations will lead to one or more device(s) in the string being overcharged. When a device is overcharged (or exposed to overvoltage conditions), rapid performance degradation may result. This further exacerbates the voltage variations and will lead to the failure of the whole string. The following is a list of guidelines for consideration when Pseudocap devices are used in series as a string:

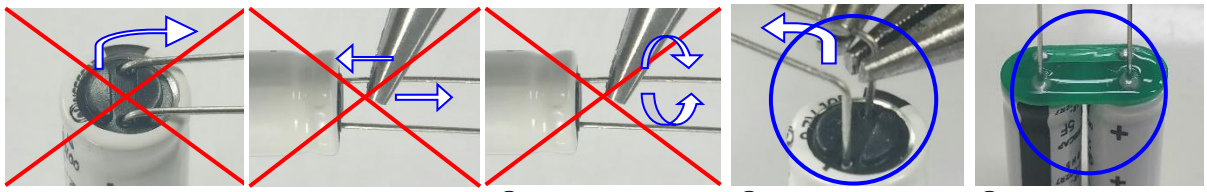
- The tolerance range of capacitance of Pseudocap is –10% to +20% of rated capacitance. This means the capacitance difference could be up to maximum 30% between capacitors. When Pseudocap products are shipped, they are packaged in groups with a letter designation (e.g. J, K, L, M, etc.) Nesscap refers to these letter designations as grades and these are essentially narrower ranges of capacitances. Nesscap recommends that users only connect in series devices from the same letter grade. If you have devices from different grades, Nesscap recommends that the user test each device to determine their capacitances before connecting them in series. For more information on this topic, please contact a Nesscap sales representative.
- Due to the above point and for longevity of use, NESSCAP recommends design rules whereby the applied voltage on each device to be lower than the rated voltage of the devices. This is referred to as de-rating and is useful in keeping the voltage of devices in a series string to not exceed the rated voltage despite the variation that will be created due to the capacitance and ESR variations among the devices. Nesscap typically de-rates Pseudocap devices to 2.15V per device when serially connecting multiple Pseudocap devices.
- When preparing Pseudocap devices for string connections, Nesscap recommends fully discharging the device before soldering. Pseudocap devices out of the box should be at approx. 0.4V. This voltage is due to the inherent material composition and the device should not be discharged any further. Exercise caution when soldering multiple Pseudocap devices in series as the voltages of the Pseudocap string will increase with each cell being connected. While wave-soldering and the electrical shorting condition presented by such process has shown not be an issue, Nesscap does not recommend shorting Pseudocap devices.
- Voltage of each device in a string should be verified before and after charging to ensure that the devices are being used within the designed voltage range. Proper cell balancing strategies must be implemented in strings with more than 2 devices in series, especially if the application requires numerous and rapid charge and discharge cycles. In application requiring complex duty cycles, contact NESSCAP's technical team for recommendations.

7. Thermal conditions must be considered when designing Pseudocap devices/systems that will be used for repeated rapid charge and discharge cycles. Ohmic self-heating may cause the Pseudocap cell to overheat and will lead to rapid degradation of performance.
8. Pseudocap life is closely correlated with cell temperature. The lifetime of a Pseudocap device may approximately be doubled if temperature can be lowered by 10°C than what the temperature would be without thermal management. Do not exceed the rated max temperature of the device.

[Mounting]

9. Do not scratch or file the lead or snap-in terminals. The terminals are plated to ensure good wetting of solder. Physically or chemically altering the surface will affect the solderability of the lead and the snap-in terminal devices.
10. Do not overheat when soldering. Solder temperature lower than 260°C and solder time of under 5 seconds are recommended.
11. Avoid mechanical impacts, such as dropping on the floor, and avoid damages to the sleeve and the lead wire.
12. Do not exceed the vibration and shock ratings of Pseudocap devices.

13. **(Radial type only) IMPORTANT! DO NOT deform** (Picture ⓐ), **pull** (Picture ⓑ) **or twist** (Picture ⓒ) **the terminals or lead wires.** The terminals or lead wires are attached to the electrodes in the interior of the aluminum casing and provide an electrolyte-containing seal with the rubber. Repeated or forceful bending, pulling or twisting of the lead wire may break such a seal and allow electrolyte to leak out. Electrolyte leakage will shorten the useful life of the Pseudocap and may also cause corrosion and/or short-circuits in PCB components nearby. If deforming of the lead wire is unavoidable or essential to the assembly process, the leads can be bent away from the base of the lead at the rubber. (Picture ⓓ) The minimum recommended distance away from the base of the lead is the radius of the device. In all lead manipulations, ensure that no stress is applied to the base of the leads.



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14. **(Radial type only)** NESSCAP recommends utilizing PCB when connecting Pseudocap to the circuit or electric devices. For best practice, avoid connecting wires directly to the Pseudocap devices and avoid locations near heat generating components.
15. **(Radial type only)** Please maintain minimum stand-off distance of 5 mm between the rupture vents on the Pseudocap devices and the module housing.

[Part Failure Indicators]

Any of the following phenomena may be an indication that the Pseudocap device has failed, disconnect it from electrical supply:

- When surface temperature of the Pseudocap device(s) exceeds the upper limit of rated temperature within a few minutes of use.
- When there is audible sound of vent rupture or perceivable odor from the Pseudocap devices. This is usually always accompanied with swelling of the device housing.
- When a Pseudocap device is visibly swollen.
- When electrical sparks are observed at the terminals under high current conditions.

[Cleaning]

16. Do not wash Pseudocap devices in cleaning solutions as they may cause contamination, corrosion, degradation of seals, and/or create short-circuit paths.
17. Contact NESSCAP if cleaning is necessary after soldering. Certain types of solvents may cause damage to rubber seals on Pseudocap devices.

[Storage]

18. Do not store in high temperature and high humidity environment. Nesscap recommends store products at temperature between 5°C~30°C and where the relative humidity is less than 60%. Avoid abrupt temperature changes, which may cause water condensation and deterioration of the product. Avoid exposure to direct sunlight for extended period as it may cause deterioration and discoloration of the sleeve.
19. Recommend protecting the terminals from shorts.
20. Do not store the product in atmosphere containing water-droplets or toxic gases.
21. Avoid exposure to acid or alkaline liquids, vapor and/or toxic gases.
22. The Pseudocap may have a trace amounts of electrolyte on the surface of the device: use proper personal protection in handling of the product in accordance with applicable regulation and industrial practices.

[Disposal]

Refer to the MSD for material composition of Pseudocap devices. Comply with all local, regional, federal or national requirements for disposal of Pseudocap devices. In most jurisdictions, Pseudocap disposal can be handled by industrial waste handling organizations.

[Distributor's Responsibility]

Distributors of Nesscap products are responsible for the following:

23. Ensuring that **Notes on Using Nesscap Pseudocapacitor** (this document) is provided to the end used for all sales of Nesscap products and hard copies are included in all shipments to said customers.
24. **Notes on Using Nesscap Pseudocapacitor** is also available on Nesscap's website www.nesscap.com for download.

NOTES ON USING NESSCAP ULTRACAPACITOR MODULES

[Operating Environment]

For safe operation of Nesscap ultracapacitor module(s), usage or storage in the conditions/environments listed below must be avoided at all times:

1. Exposed to direct sunlight
2. Operating temperature above the specified temperature in the product datasheet
3. Vibration that is more severe than the specified vibration standard in the product datasheet
4. In contact with water, brine, or oil
5. In contact with chemically active gas(es)
6. Acidic or alkaline environment
7. Humid environment which can lead to moisture condensation

[Installation and Operation]

1. The module should be stored shorted by connecting a shorting wire between the positive (+) and negative (-) terminals of the module.
2. When connecting a module to a system, shorting wire placed on the terminals of the module must be removed. Operation of the system with the shorting wire still connected to the terminals of the module can lead to failure of the system and system components.
3. The module must not be operated at voltage higher than the rated voltage. Exposure to over-voltage conditions can result in accelerated leakage current increase, capacitance loss, ESR rise, and heating of the module, which will decrease the effective lifetime of the module significantly.
4. The electrical current that is larger than the value allowed by the module must not be used at any times as it can lead to malfunctioning of the module and create potentially dangerous situations.
5. When the multiple modules are connected in series, capacitance variation in the modules can create voltage imbalance amongst the modules. Nesscap recommends minimizing the capacitance variation of modules used in one system and the implementation of robust cell balancing strategies depending on the application requirements.
6. Ensure that the modules are securely mounted for the application. Every module has multiple mounting holes which can be used to secure the module to a base structure or frame.
7. When connecting multiple modules together, thermal aspects of module use must be considered. Heat accumulation in modules can cause accelerated performance degradation.
8. Provide adequate cooling of the modules as necessary for the application.
9. Lifetime of ultracapacitor modules is highly dependent on the ambient temperature. For best experience and lifetime performance, the temperature of the module must be maintained well below the maximum operating temperature stated in the product datasheet.
10. Shut off the system electrical mains when connecting power lines to module(s). The low resistance of the module products may cause large currents if the charging currents are uncontrolled. Implement good electrical safety practices.
11. The voltage of the module must be checked before connecting the power lines. Fully discharge modules before connecting. When the shorting wire is removed from the module, the module voltage may recover up to a certain point depending on the number of cells connected in series inside the module. Connecting modules with live voltages may cause malfunctions on the connecting system and potentially jeopardize the safety of the operator. The shorting wire placed on the module should ideally be removed right before the connecting the modules to form the final system configuration. Nesscap highly recommends that the module voltage is always checked prior to any electrical connection being made.
12. Applying reverse voltage on ultracapacitor module(s) may result in malfunctioning, rapid performance degradation, or catastrophic failure of the module. The polarity of the module terminals must be checked in advance for the correct connection of the power lines.
13. Conducive wire in the power line must not come in contact with the case of the module. If the conductive wire is exposed due to damage to the insulation sheath and touches the case, it can cause malfunctioning of the module and/or the system.
14. During assembly or mounting of the module, the terminal bolt must be tightened to the specified torque value. Excessive torque may damage the module terminal(s).
15. When connecting the power, clear off any metallic materials (such as tools or measurement devices) from the vicinity of the modules to prevent any arcing or shorts.

16. Properly discharge a module using proper equipment and/or resistors. Shorting wire should only be installed when the module voltage is lower than 1V. Even at under 1V, expect the wire to heat up. Wear proper hand protection to avoid burns.
17. Do not disassembled or otherwise compromise the integrity of the module package.

[Module Troubleshooting]

If any of the following phenomena are observed, verify the items listed below each phenomenon. If the problem persists, please disconnect the power line and contact Nesscap.

1. The module is not charging:
   A. Ensure that the connection between the module and the charging equipment is OK.
   B. Ensure that the charging equipment is properly working.
   C. Some chargers may detect ultracapacitor modules as a short due to the low impedance of the modules. Develop a workaround to let the charger recognize ultracapacitor modules without sacrificing safety.
2. There is a noticeable odor generated from the module during charging or during normal operation.
   A. Stop charging and stop using the module/system. Discharge module to a low voltage, disconnect the module from the system, and contact Nesscap.
3. There is an electric spark generated from the module during charging or during normal operation.
   A. Stop charging and stop using the module/system. Discharge module to a low voltage, disconnect the module from the system, and contact Nesscap.

[Storage]

1. Do not store in high temperature and high humidity environment. Nesscap recommends store products at temperature between 5℃~30℃ and where the relative humidity is less than 60%. Avoid abrupt temperature changes, which may cause water condensation and deterioration of the product. Avoid exposure to direct sunlight for extended period as it may cause deterioration and discoloration of the sleeve.
2. For longer-term storage, Nesscap recommends fully discharging the device and shorting the terminals.
3. Do not store the product in atmosphere containing water-droplets or toxic gases.
4. Avoid exposure to acid or alkaline liquids, vapor and/or toxic gases.

[Disposal]

For disposal of the module, comply with all local, regional, federal or national requirements for disposal of ultracapacitor modules. In most jurisdictions, ultracapacitor disposal can be handled by industrial waste handling organizations.

[Distributor's Responsibility]

Distributors of Nesscap products are responsible for the following:

1. Ensuring that **Notes on Using Nesscap Ultracapacitor Modules** (this document) is provided to the end user for all sales of Nesscap products and hard copies are included in all shipments to said customers.
2. **Notes on Using Nesscap Ultracapacitor Modules** is also available on Nesscap's website **www.nesscap.com** for download.