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Lithium ion capacitors for use in electric and electronic equipment — Test methods for electrical characteristics

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Lithium ion capacitors for use in electric and electronic equipment - Test methods for electrical characteristics (IEC 62813:2015)

Condensateurs au lithium-ion destinés à être utilisés dans les équipements électriques et electroniques - Méthodes d'essai relatives aux caractéristiques électriques (IEC 62813:2015)

Lithium-Ionen-Kondensatoren zur Verwendung in elektrischen und elektronischen Geräten - Prüfverfahren für die elektrischen Kennwerte (IEC 62813:2015)

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Foreword

The text of document 40/2322/FDIS, future edition 1 of IEC 62813, prepared by IEC TC 40, "Capacitors and resistors for electronic equipment" was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 62813:2015.

The following dates are fixed:

• latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2015-11-12
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The text of the International Standard IEC 62813:2015 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 62391-1:2006	NOTE	Harmonised as EN 62391-1:2006.
IEC 62576:2009	NOTE	Harmonised as EN 62576:2010.

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

NOTE 1 When an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu.

Publication	Year	Title	EN/HD	Year
IEC 60068-1	2013	Environmental testing -- Part 1: General and guidance	EN 60068-1	2014

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LITHIUM ION CAPACITORS FOR USE IN ELECTRIC AND ELECTRONIC EQUIPMENT – TEST METHODS FOR ELECTRICAL CHARACTERISTICS

1 Scope

This International Standard specifies the electrical characteristics (capacitance, internal resistance, discharge accumulated electric energy, and voltage maintenance rate) test methods of lithium ion capacitors (LIC) for use in electric and electronic equipment.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60068-1:2013, *Environmental testing – Part 1: General and guidance*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

NOTE The terms printed in italics are those which are defined in this Clause 3.

3.1
upper category temperature
highest ambient temperature that a LIC is designed to operate continuously

[SOURCE: IEC 62576:2009, 3.3, modified]

3.2
rated voltage
U_{R}
maximum direct current (d.c.) voltage that may be applied continuously for a certain time under the *upper category temperature* (3.1) to a LIC so that it can exhibit specified demand characteristics

Note 1 to entry: This voltage is the setting voltage in LIC design.

Note 2 to entry: The endurance test using the rated voltage is described in Annex A.

[SOURCE: IEC 62576:2009, 3.6, modified]

3.3
rated lower limit voltage
U_{L}
minimum d.c. voltage such that a LIC can exhibit specified demand characteristics

Note 1 to entry: The rated lower limit voltage is designated by manufacturer.

3.4
charging current
current required to charge a LIC

3.5
discharging current
current required to discharge a LIC

3.6
discharge accumulated electric energy
amount of discharged energy of a LIC accumulated from the *discharge start time* (3.7) to the *time to reach rated lower limit voltage* (3.10)

3.7
discharge start time
T_0
time when discharge of a LIC starts

Note 1 to entry: It is the basis time for the *calculation start time* (3.8) and the *time to reach rated lower limit voltage* (3.10).

3.8
calculation start time
T_1
time at a selected start point used to calculate the *capacitance* (3.12) and the *internal resistance* (3.14) during discharge of a LIC

Note 1 to entry: The calculation start time is expressed as elapsed time since the *discharge start time* (3.7).

3.9
calculation end time
T_2
time at a selected end point used to calculate the *capacitance* (3.12) and the *internal resistance* (3.14) during discharge of a LIC

Note 1 to entry: The calculation end time is expressed as elapsed time since the *discharge start time* (3.7).

3.10
time to reach rated lower limit voltage
T_L
time when the voltage reaches the *rated lower limit voltage* (3.3) during discharge of a LIC

Note 1 to entry: The time to reach rated lower limit voltage is expressed as elapsed time since the *discharge start time* (3.7).

3.11
instant drop voltage at discharge
U_0
voltage at the *discharge start time* (3.7) of a least-squares regression line over the time period from the *calculation start time* (3.8) to the *calculation end time* (3.9) for the voltage drop characteristic of a LIC during discharge

3.12
capacitance
ability of a LIC to store electrical charge

[SOURCE: IEC 62576:2009, 3.14, modified]

3.13
nominal capacitance
C_N
capacitance value designated by manufacturer, usually indicated on a LIC

[SOURCE: IEC 62576:2009, 3.15, modified]

3.14
internal resistance
resistance component expressed in the equivalent series circuit of capacitance and resistance of a LIC

[SOURCE: IEC 62391-1:2006, 2.2.20, modified]

3.15
nominal internal resistance
R_N
internal resistance value designated by manufacturer, usually indicated on a LIC

[SOURCE: IEC 62576:2009, 3.17, modified]

3.16
constant voltage charging
method of charging a LIC at specified constant voltage

[SOURCE: IEC 62576:2009, 3.18, modified]

3.17
constant current charging
method of charging a LIC with specified constant current

3.18
constant current discharging
method of discharging a LIC with specified constant current

3.19
pre-conditioning
charge, discharge, and storage of a LIC under specified atmospheric conditions (temperature, humidity, and air pressure) before tests

Note 1 to entry: Generally, pre-conditioning implies that the LIC is stored until its inner temperature attains thermal equilibrium with the surrounding temperature, before its electrical characteristics are measured.

[SOURCE: IEC 62576:2009, 3.19, modified]

3.20
voltage maintenance rate
A
ratio of the voltage at the open-ended terminals to the charging voltage after a specified time period subsequent to the charging of a LIC

[SOURCE: IEC 62576:2009, 3.26, modified]

4 Test methods

4.1 Test requirements

4.1.1 Standard atmospheric conditions for tests

Unless otherwise specified in the detail specification, all tests shall be made under standard atmospheric conditions for tests as given in IEC 60068-1:2013, 4.3:

– temperature: 15 °C to 35 °C;
– relative humidity: 25% to 75 %;

– air pressure: 86 kPa to 106 kPa.

If any question about determining measurement value arises under the atmospheric conditions or if it is requested, 4.1.2 is applied.

If it is difficult to perform measurements under the standard atmospheric conditions and if no question about determining measurement value arises, tests and measurements may be performed under other conditions than the standard atmospheric conditions.

4.1.2 Standard atmospheric conditions for measurements

Unless otherwise specified in the detail specification, all measurements shall be made under standard atmospheric conditions for measurements as given in IEC 60068-1:2013, 4.2, with the following details:

– temperature: 25 °C ± 2 °C;
– relative humidity: 45 % to 55 %;
– air pressure: 86 kPa to 106 kPa.

4.1.3 Pre-conditioning

Unless otherwise specified in the detail specification, the LIC shall be charged with a constant current and constant voltage power supply, the voltage of which is set to the rated voltage, for 30 min then discharged to the lower limit voltage with a proper discharging device.

4.2 Measurement

4.2.1 Capacitance, discharge accumulated electric energy, and internal resistance

4.2.1.1 Test equipment

The test equipment shall be capable of constant current charging, constant voltage charging, and constant current discharging with current specified in 4.2.1.2, and continuous measurement of current and voltage at specified sampling interval. The basic circuit is shown in Figure 1.

a) D.C. power supply

   The d.c. power supply shall be capable of charging the LIC at specified constant current and specified constant voltage for specified duration.

b) Constant current load

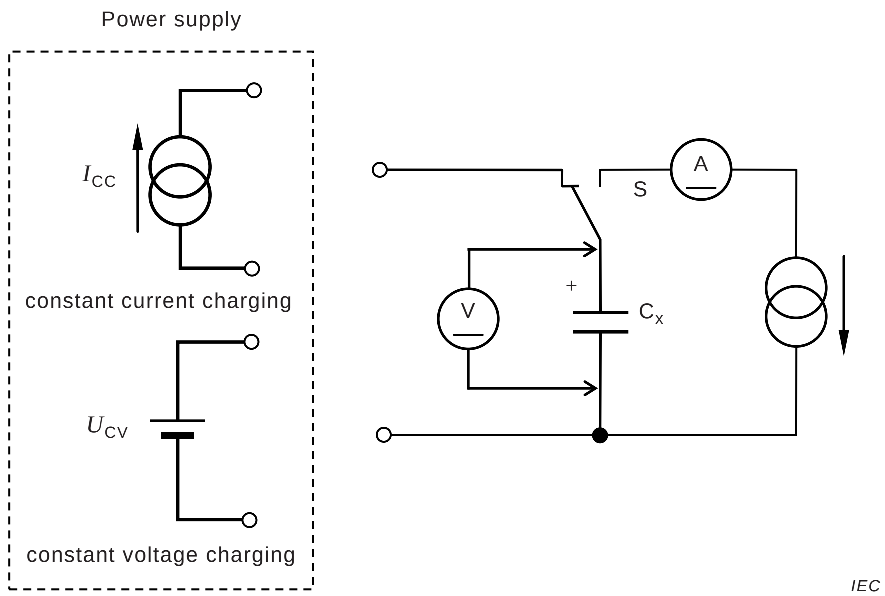
   The constant current load shall be capable of discharging the LIC at specified constant current and its current rise time at discharge start shall be 50 ms or less.

c) D.C. voltage recorder

   The d.c. voltage recorder shall be capable of conducting measurements and recording with 1 mV resolution and sampling interval of 100 ms.

d) Changeover switch

   The changeover switch shall not cause chattering which may affect the result of voltage-time recording.



Key

I_{CC}	constant-current
U_{CV}	constant-voltage
(A)	D.C. ammeter
(V)	D.C. voltage recorder
S	changeover switch
C_x	LIC under test
	constant current power supply
	constant voltage power supply
	constant current load

Figure 1 – Basic circuit for measuring capacitance, discharge accumulated electric energy, and internal resistance

4.2.1.2 Measurement procedure and conditions

The measurement procedure and conditions shall be as follows. The voltage profile between the LIC terminals in the measurement shall be as shown in Figure 2.

a) Before setting sample

The LIC shall be left in the standard atmospheric condition as defined in 4.1.1 for 2 h to 6 h.

b) Sample setting

Connect the LIC terminals to the circuit.

c) Constant current charging

Charge the LIC to the rated voltage U_R with d.c. power supply specified in 4.2.1.1 and with specified current I calculated by Formula (1).

$$I = \frac{1}{30R_N}\sqrt{1+\frac{27}{5C_NR_N+1}-\frac{26}{10C_NR_N+1}} \qquad (1)$$

where

I is the charging current (A). It is also used to specify the discharging current;

R_N is the nominal internal resistance of the LIC under test (Ω);

C_N is the nominal capacitance of the LIC under test (F).

NOTE The current calculated by Formula (1) is assumed as the current by which the resultant measurement error of the internal resistance is limited within ± 3 % (see Annex B). When the nominal value of internal resistance is uncertain, the current for the measurement can be set according to the advisable procedures described in Annex C.

d) Constant voltage charging

When voltage between the LIC terminals is reached to the rated voltage U_R, switch to constant voltage charging then apply the rated voltage U_R for 30 min.

e) Constant current discharging

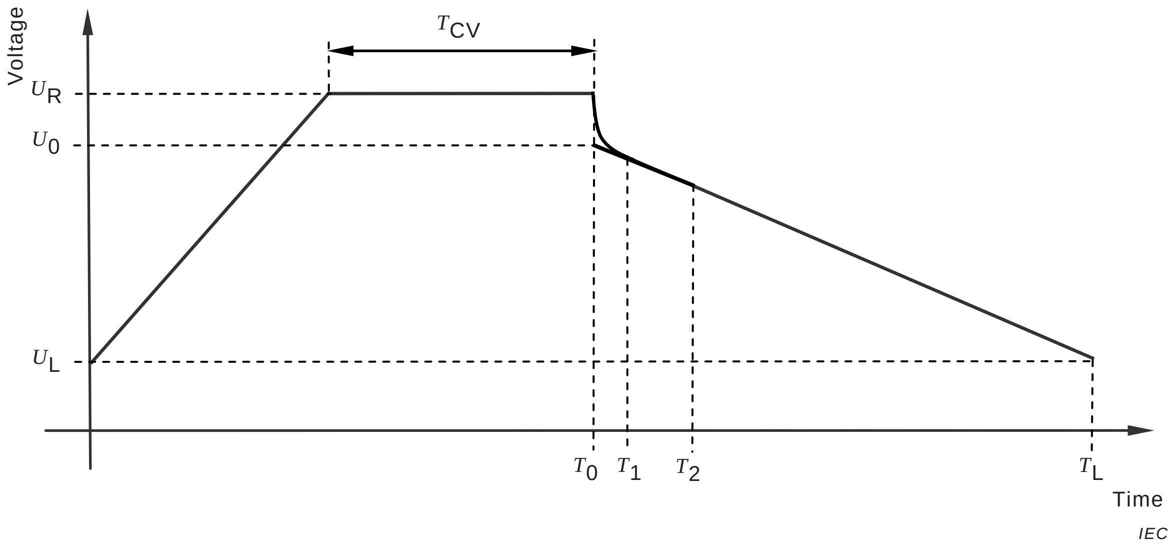
Turn changeover switch from the power supply to the constant current load and discharge with the specified constant current as follows:

1) For internal resistance measurement, set the discharge current: I calculated by Formula (1);
2) For discharge accumulated electric energy and capacitance measurement, set the discharge current: tenth of I calculated by Formula (1).

f) Test, measurement and recording

Measure and record the voltage-time characteristics between the LIC terminals

1) Sampling and recording interval shall be set to 100 ms.
2) Sampling and recording shall be conducted continuously from charge start time to the time to reach rated lower limit voltage U_L.



Key

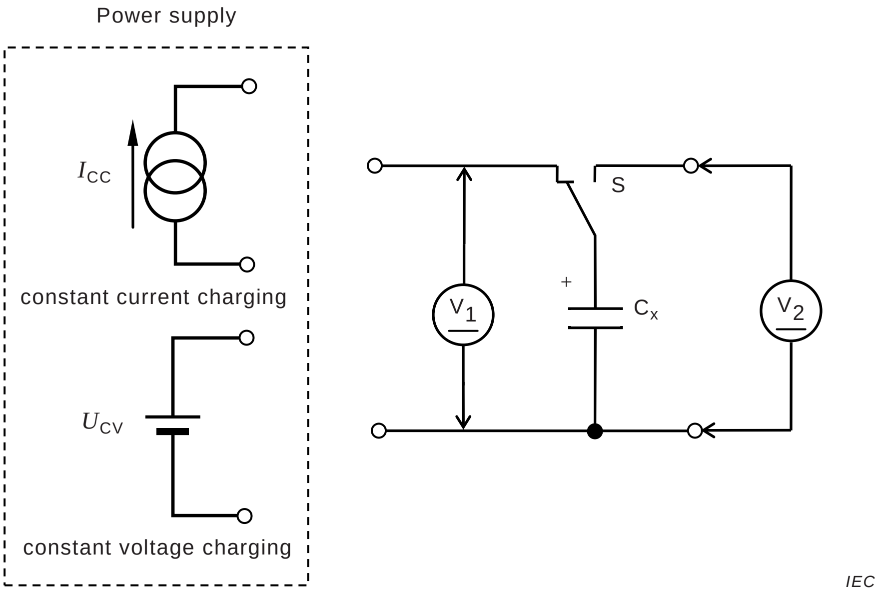
T_0	discharge start time (s)
T_1	calculation start time, which is set to $C_N R_N$ (s)
T_2	calculation end time, which is set to 2 $C_N R_N$ (s)
T_L	time to reach rated lower limit voltage (s)
T_{CV}	duration of constant voltage charging (s)
U_R	rated voltage (V)
U_L	rated lower limit voltage (V)
U_0	instant drop voltage at discharge (V)

Figure 2 – Voltage profile for measuring capacitance, discharge accumulated electric energy, and internal resistance

4.2.2 Measurement for voltage maintenance rate

4.2.2.1 Test equipment

The basic circuit is shown in Figure 3. The d.c. voltmeters V_1 and V_2 shall have a resolution of 5 mV or less for voltage measurement. The input impedance shall be sufficiently high so that measurement errors are negligible.



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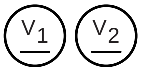


D.C. voltmeter

Figure 3 – Basic circuit for measuring the voltage maintenance rate

4.2.2.2 Measurement procedure and conditions

The measurement procedure and conditions shall be as follows. The voltage profile between the LIC terminals in the measurement shall be as shown in Figure 4.

a) Before setting sample

The LIC shall be left in the standard atmospheric condition as defined in 4.1.1 for 2 h to 6 h.

b) Sample setting

Connect the LIC terminals to the circuit.

c) Constant current charging

Charge the LIC to the rated voltage U_R with d.c. power supply specified in 4.2.1.1 and with specified current I calculated by Formula (1).

d) Constant voltage charging

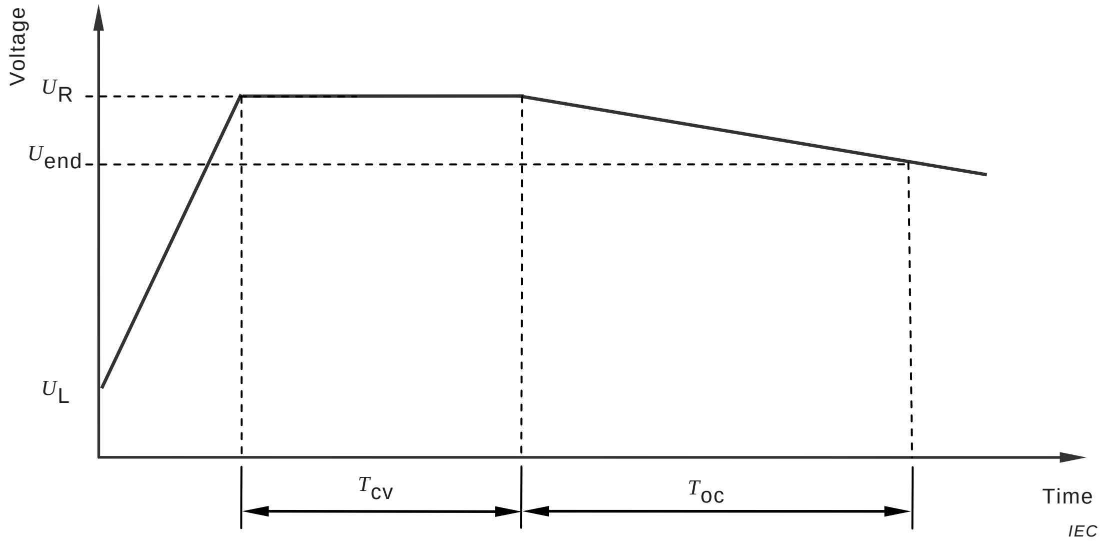
When voltage between the LIC terminals is reached to the rated voltage U_R, switch to the constant voltage charging then apply the rated voltage U_R for 24 h.

e) Terminal opening

Disconnect the LIC terminals from the circuit.

f) Measurement

Measure voltage between the LIC terminals when T_{OC} is 72 h (see Figure 4).



Key

T_{oc} duration of measurement, which is set to 72 h (h)

U_{end} voltage between the LIC terminals at T_{oc} (V)

Figure 4 – Voltage profile for measuring voltage maintenance rate

4.3 Calculation

4.3.1 Calculation of capacitance and discharge accumulated electric energy

The capacitance and the discharge accumulated electric energy are calculated by using the energy conversion method described in a). When agreed between manufacturer and customer, simplified method described in b) can be used instead.

a) Calculation of capacitance and accumulated electric energy by energy conversion method

The capacitance C_x shall be calculated by Formula (2) and the discharge accumulated electric energy W shall be calculated by Formula (3) (see Figure 2).

$$C_x = \frac{2W}{{U_0}^2 - {U_L}^2} \tag{2}$$

$$W = \frac{I}{200} \sum_{k=0}^{n-1} (V_{k+1} + V_k) \tag{3}$$

where

C_x is the capacitance (F) of the LIC;

W is the discharge accumulated electric energy, which is time integral of the electric power on all sampling points from discharge start sampling point (k = 0) to discharge end sampling point (k = n);

V_k is the measured voltage at sampling point k (V).

The discharge accumulated electric energy represented in watt-hour notation is calculated by dividing W by 3 600.

b) Calculation of capacitance and accumulated electric energy by simplified method

The capacitance C_x shall be calculated by Formula (4) and the discharge accumulated electric energy W shall be calculated by Formula (5) (see Figure 2).

$$C_{\text{x}} = \frac{I(T_{\text{L}} - T_0)}{10(U_0 - U_{\text{L}})} \tag{4}$$

$$W = \frac{C_{\text{x}}(U_0{}^2 - U_{\text{L}}{}^2)}{2} \tag{5}$$

The discharge accumulated electric energy represented in watt-hour notation is calculated by dividing W by 3 600.

4.3.2 Calculation of internal resistance

The internal resistance R_{x} is calculated by Formula (6) (see Figure 2).

$$R_{\text{x}} = \frac{U_{\text{R}} - U_0}{I} \tag{6}$$

where

R_{x} is the internal resistance (Ω) of the LIC.

4.3.3 Calculation of voltage maintenance rate

The voltage maintenance rate A is calculated by Formula (7) (see Figure 4).

$$A = \frac{U_{\text{end}}}{U_{\text{R}}} \times 100 \tag{7}$$

where

A is the voltage maintenance rate (%) of the LIC.

Annex A
(informative)

Endurance test (continuous application of rated voltage at high temperature)

A.1 General

This Annex A describes the endurance test for continuous application of rated voltage at high temperature to determine the rated voltage defined in 3.2.

A.2 Test procedure

A.2.1 Test conditions

Unless otherwise given in the relevant specification, the test conditions should be as follows:

– temperature: upper category temperature;
– voltage: rated voltage;
– duration 1 000 h.

A.2.2 Test procedure

The test procedure should be as follows.

a) Initial measurements

Measure and calculate capacitance and internal resistance by the measurement procedure described in 4.2.1 and the calculation method described in 4.3.1 and 4.3.2.

b) Testing

Place the LIC in a chamber at the upper category temperature and charge it up to the rated voltage with current calculated by Formula (1) then keep the voltage for specified duration.

c) Final measurements

Measure and calculate capacitance and internal resistance as described in a). The rates of change can be obtained in comparison to their initially measured values.

A.2.3 Requirements

Unless otherwise agreed between manufacturer and customer, the capacitance change ΔC and internal resistance change ΔR should meet the following values.

$$\Delta C = \left| \frac{C_f - C_i}{C_i} \right| \times 100\ \% \leq 20\ \%$$

where

C_i is the initial capacitance (F) before the test;

C_f is the capacitance (F) after the test.

$$\Delta R = \left| \frac{R_f - R_i}{R_i} \right| \times 100\ \% \leq 50\ \%$$

where

R_i is the initial internal resistance (Ω) before the test;

R_f is the internal resistance (Ω) after the test.

Annex B
(informative)

Calculation of the measuring currents based on the propagated error

B.1 General

This Annex B describes the calculation of the measuring currents provided in 4.2.1.2, Formula (1).

B.2 Measurement propagated error and measuring currents

The internal resistance R is calculated from Formula (B.1).

$$R = \frac{(U_{\mathrm{R}} - U_0)}{I} \qquad \text{(B.1)}$$

From the formula of propagated error, the relative error of R is expressed as follows.

$$\left(\frac{\delta R}{R}\right)^2 = \frac{\delta U_{\mathrm{R}}{}^2 + \delta U_0{}^2}{(U_{\mathrm{R}} - U_0)^2} + \left(\frac{\delta I}{I}\right)^2 \qquad \text{(B.2)}$$

$\delta I / I$ is small enough to be ignorable. When the measuring voltage corresponding to explanatory variable t_{i} at each sampling point is random variable, U_0 is expressed as follows from the formula of propagated error of least-square method as follows.

$$\delta U_0 = \delta U \sqrt{\frac{\sum t_{\mathrm{i}}{}^2}{N \sum t_{\mathrm{i}}{}^2 - (\sum t_{\mathrm{i}})^2}} \qquad \text{(B.3)}$$

N is a number of sampling points. The voltage measurement errors at each sampling point are assumed to be equal to δU at each sampling point. And δU_{R} is also assumed to be equal to δU .

When Δt is the sampling interval, the following formula applies:

$$t_{\mathrm{i}} = (T_1 - \Delta t) + i\Delta t \qquad \text{(B.4)}$$

Assigning this to Formula (B.3) gives:

$$\delta U_0 = \delta U \sqrt{\frac{1}{N} + \frac{3}{N(N^2 - 1)}\left(\frac{2T_1}{\Delta t} + N - 1\right)^2} \qquad \text{(B.5)}$$

By assigning Formula (B.5) to Formula (B.2) and by the condition that the relative error $\delta R / R$ of internal resistance is limited within ±3 %, Formula (B.6) is given.

Formula (1) is obtained by Formulas (B.6). and (B.7), using Δt to 0,1 s and δU = 1 mV.

$$I = \frac{\delta U}{0{,}03R}\sqrt{1 + \frac{1}{N} + \frac{3}{N(N^2 - 1)}\left(\frac{2T_1}{\Delta t} + N - 1\right)^2} \tag{B.6}$$

$$N = \frac{(T_2 - T_1)}{\Delta t} + 1 \tag{B.7}$$

Annex C
(informative)

Procedures for defining the measuring current of LIC with uncertain nominal internal resistance

C.1 General

This Annex C describes the defining procedures of measuring current provided in Annex B for the LIC which has uncertain nominal internal resistance.

C.2 Defining procedures of measuring current for LIC

When the nominal value of internal resistance of the LIC is uncertain, the current for the measurement of the LIC can be set according to the following procedures (see Figure C.1):

a) Using an estimated value of internal resistance (R_{est}), measure and calculate internal resistance by the measurement procedure described in 4.2.1 and the calculation method described in 4.3.2.

b) Using the resultant internal resistance (R_{res}) calculated in a) as a new estimated value, repeat the process described in a).

c) Repeat b) until the difference between R_{est} and R_{res} becomes less than 10 % of R_{est}. However, when the instant drop voltage at discharge U_0 becomes less or equal to the rated lower limit voltage U_L, try procedures from a) to c) again with smaller current. When R_{res} indicates a negative value, try from a) to c) again with larger current.

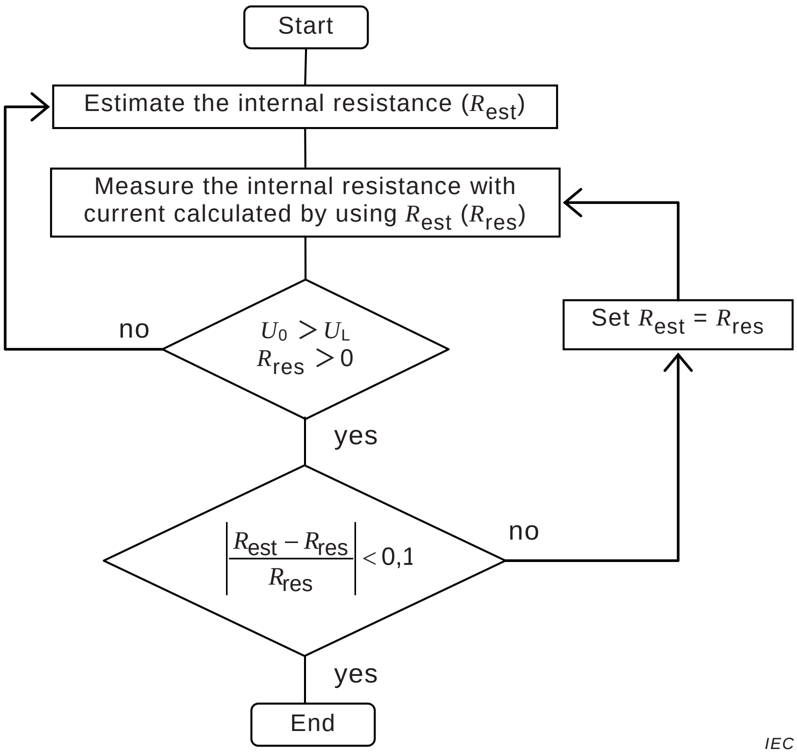


Figure C.1 – Flowchart of current setting procedures

Bibliography

IEC 62391-1:2006, *Fixed electric double-layer capacitors for use in electronic equipment – Part 1: Generic specification*

IEC 62576:2009, *Electric double-layer capacitors for use in hybrid electric vehicles – Test methods for electrical characteristics*

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