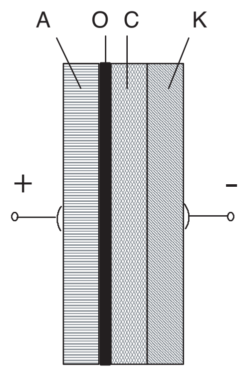
GENERAL INFORMATION

INTRODUCTION

The aluminum electrolytic capacitors are suitable to be used when a great capacitance value is required in a very small size. The volume of an electrolytic capacitor is more than ten times less than a film one considering the same rated capacitance and voltage.
The cost per µF of an electrolytic capacitor is less when compared with all the other capacitor types.

1- BASIC DESIGN

The construction of an aluminum electrolytic capacitor is the following:



Construction scheme
A = ANODE (Al 99.99%)
O = DIELECTRIC Aluminum Oxide
C = ELECTROLYTE + PAPER
K = CATHODE (Al 98%)

The anode (A)
The anode is formed by an aluminum foil of extreme purity. The effective surface area of the foil is greatly enlarged (by a factor of up to 200) by electrochemical etching in order to achieve the maximum possible capacitance values.

The dielectric (O)
The aluminum foil (A) is covered by a very thin oxidized layer of aluminum oxide (O = Al_2O_3). This oxide is obtained by means of an electrochemical process. The thickness is related to the applied voltage (forming voltage): 1.2nm/V.
The oxide withstands a high electric field strength and it has a high relative dielectric constant. Aluminum oxide is therefore well suited as a capacitor dielectric in a polar capacitor.
The Al_2O_3, has a high insulation resistance for voltages lower than the forming voltage.
The oxide layer constitutes a non-linear voltage-dependent resistance: the current increases more steeply as the voltage increases.

GENERAL INFORMATION

The electrolyte-paper-cathode (C,K)

The negative electrode is a liquid electrolyte absorbed in paper. The paper also acts as a spacer between the positive foil carrying the dielectric layer and the opposite Al-foil (the negative foil) acting as a contact medium to the electrolyte. The cathode foil serves as a large contact area for passing current to the operating electrolyte.
The aluminum electrolytic capacitors with a liquid electrolyte are designed as "wet" or "non-solid" capacitors.
Terminations are welded on the foils. The positive foil, the paper and the negative foil are rolled to a winding.
This winding is impregnated with the electrolyte, encapsulated in an Al-case and sealed with a rubber disk.
An aluminum electrolytic capacitor constructed in the way described above, inserted in an electrical circuit, will only operate correctly if the positive pole is connected to the formed Al foil (anode) and the negative one to the cathode.
If the opposite polarity were to be applied, this would cause an electrolytic process resulting in the formation of a dielectric layer an the cathode foil: an internal heat generation and gas emission may destroy the capacitor. In addition, the increase of the thickness of the oxide on the cathode will reduce its capacitance and thus the overall capacitance of the capacitor.
The electrolytic capacitor above described is a polarized capacitor: it is suitable for D.C. operation only.
The D.C. voltage may also be a direct voltage with a superimposed alternating voltage.
Bipolar electrolytic capacitors are also available. In this design the anode and the cathode foils are anodized in the production process and thus have the same capacitance rating.
A direct voltage of either the polarity or an alternating voltage may be applied to a bipolar capacitor.
The size of the bipolar type will be double the polarized one with the same rated capacitance and voltage.

2 - STANDARDS

The international standard for the aluminum electrolytic capacitors is IEC 384-4.

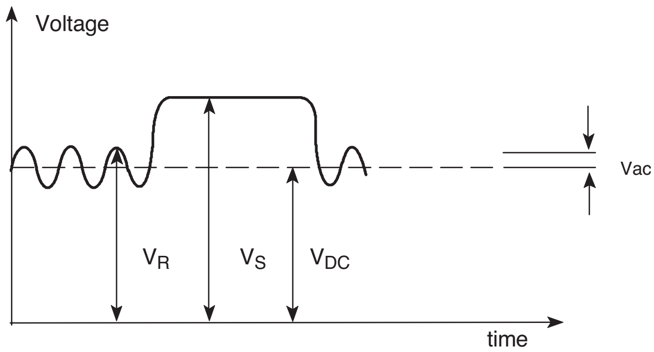
3 - TECHNICAL TERMS EXPLANATION

Rated capacitance
The rated capacitance is the capacitance value for which the capacitor has been designed and which is indicated upon it.
Capacitance tolerance
The capacitance tolerance is the range within which the actual capacitance may deviate from the specific rated capacitance.
Rated voltage V_R
Maximum operating peak voltage of a non-reversing type wave-form for which the capacitor has been designed and which is indicated upon it.
Surge voltage V_S
A peak voltage induced by a switching or any other disturbance of the system which is allowed for a limited number of times (as per IEC 384-4).
Forming voltage V_F
The voltage applied to the anode foil during the forming process.
It is higher than surge voltage V_S.

GENERAL INFORMATION

Superimposed AC, ripple voltage

A superimposed alternating voltage, or ripple voltage, may be applied to aluminum electrolytic capacitors, provided that:
- the sum of the direct voltage and superimposed alternating voltage does not exceed the rated voltage;
- the rated ripple current is not exceeded;
- no polarity reversal will occur.



Ripple current

The ripple current is the rms value of the alternating current that flows through the capacitor as a result of any ripple voltage.

Rated ripple current

The maximum permissible current allowed at a certain temperature and frequency.

Maximum permissible operating temperature (upper category temperature)

The upper category temperature is the maximum permissible temperature at which the capacitor may be operated, measured on the can. It is listed in the data sheets for each series.
If the above limit is trespassed the capacitor may fail prematurely.

Minimum permissible operating temperature (lower category temperature)

The minimum category temperature is the minimum permissible temperature at which the capacitor may be operated, measured on the can.
The conductivity of the electrolyte reduces with decreasing temperature, causing electrolyte resistance, impedance and ESR increasing. For this reason, minimum permissible operating temperature are specified for aluminum electrolytic capacitors.

Storage temperature

Storage at high temperature (e.g. upper category temperature) will reduce leakage current stability, life and reliability of electrolytic capacitors. Store capacitors at a temperature of 5 to 35°C and a humidity 75% maximum.

IEC climatic category

In accordance with the IEC 68-1, the climatic category comprises
1 - Lower category temperature: the test temperature for test A (cold) in accordance with IEC 68-2-1.
2 - Upper category temperature: the test temperature for test B (dry heat) in accordance with IEC 68-2-2
3 - Number of days of the duration of the test Ca (damp heat, steady state) according to IEC 68-2-3.

Safety vent

An overpressure device (safety vent) ensuring that the gas can escape when the pressure reaches a certain value.

GENERAL INFORMATION

4 - ELECTRICAL RATINGS

4.1 - Capacitance (E.S.C.)

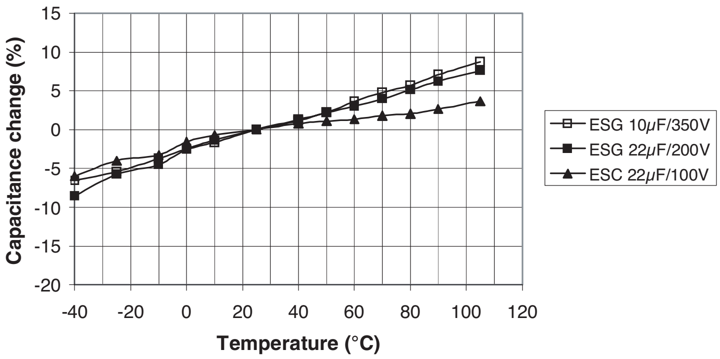
Simplified equivalent circuit diagram of an electrolytic capacitor

The capacitive component of the equivalent series circuit (equivalent series capacitance ESC) is determined by applying an alternate voltage of ⩽ 0,5V at a frequency of 120 or 100Hz and 20°C (IEC 384-1, 384-4).

Temperature dependence of the capacitance

The capacitance of an electrolytic capacitor depends on the temperature: with decreasing temperature, the viscosity of the electrolyte increases reducing its conductivity.
The capacitance will decrease if the temperature decreases.
Furthermore temperature drifts cause armature dilatation and therefore capacitance changes (up to 20%, depending on the series considered, from 0 to 80°C). This phenomenon is more evident for electrolytic capacitors than for other types.

Capacitance change vs. temperature
(typical value)



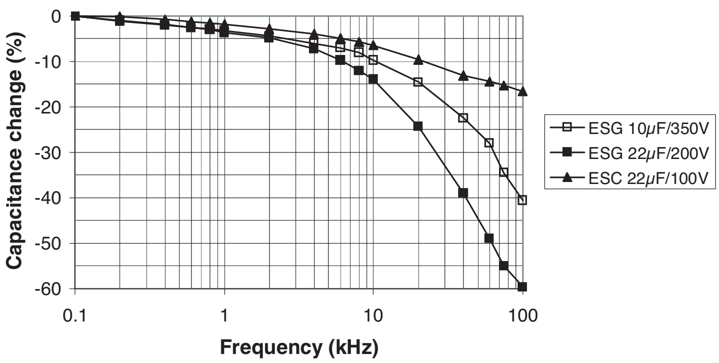
Frequency dependence of the capacitance

The effective capacitance value is derived from the impedance curve, as long as the impedance is still in the range where the capacitance component is dominant.

$$C = \frac{1}{2\pi f Z}$$

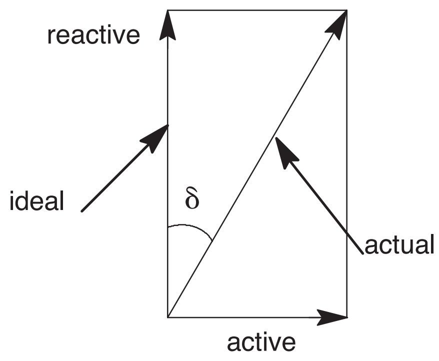
C = Capacitance (F)
f = Frequency (Hz)
Z = Impedance (Ω)

Capacitance change vs. frequency
(typical value)



GENERAL INFORMATION

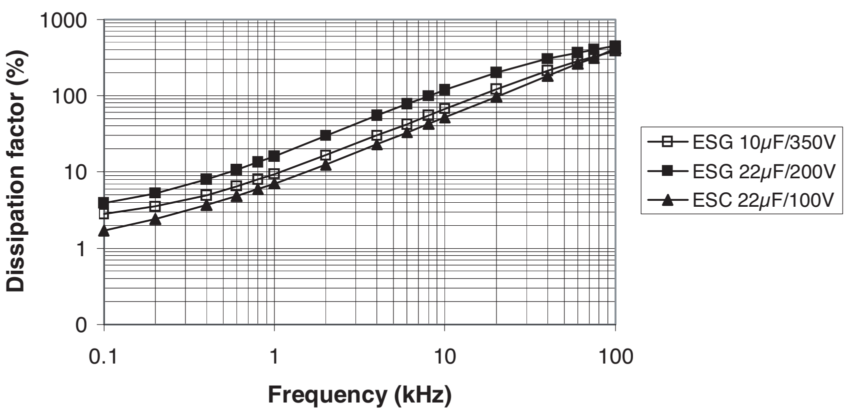
4.2 - Dissipation factor tgδ (D.F.)
The dissipation factor tgδ is the ratio between the active and the reactive power for a sinusoidal waveform voltage. It can be thought as a measurement of the gap between an actual and an ideal capacitor.



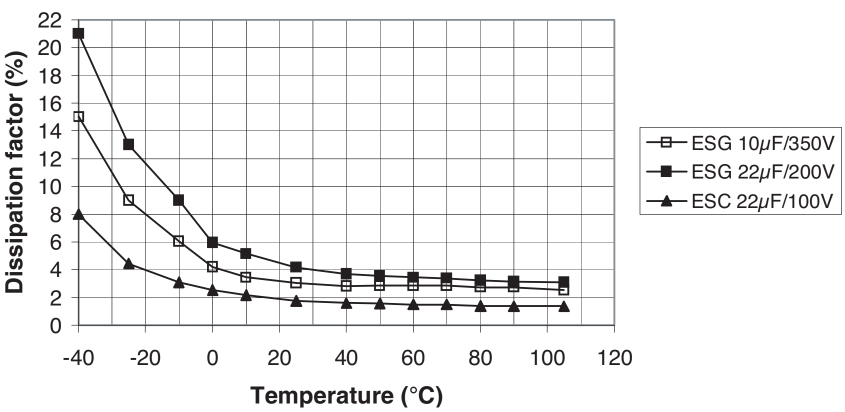
The tgδ is measured with the same set up as for the series capacitance ESC.

tgδ = ω x ESC x ESR where: ESC = Equivalent Series Capacitance
ESR = Equivalent Series Resistance

Dissipation factor vs. frequency
(typical value)



Dissipation factor vs. temperature
(typical value)



GENERAL INFORMATION

4.3 - Self inductance (E.S.L.)

The self inductance or equivalent series inductance results from the terminal configuration and the internal design of the capacitor (see equivalent series circuit page 5).

4.4 - Equivalent series resistance (E.S.R.)

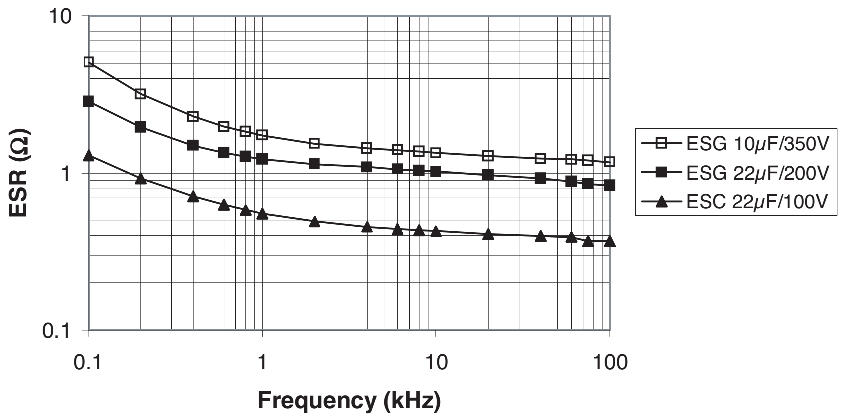
The equivalent series resistance is the resistive component of the equivalent series circuit. The ESR value depends on frequency and temperature and is related to the tgδ by the following equation:

$$ESR = \frac{tg\delta}{2\pi f \, ESC}$$

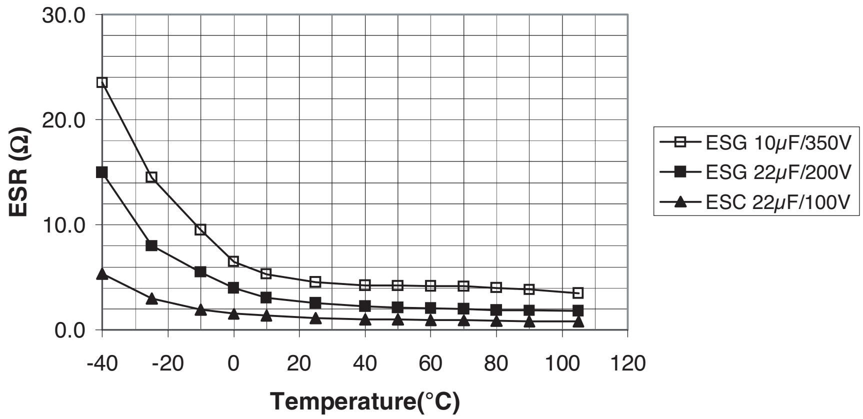
ESR = Equivalent Series Resistance (Ω)
tgδ = Dissipation Factor
ESC = Equivalent Series Capacitance (F)
f = Frequency (Hz)

The tolerance limits of the rated capacitance must be taken into account when calculating this value.

ESR change vs. frequency
(typical value)



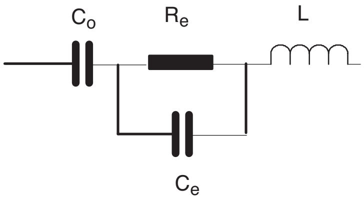
ESR change vs. temperature
(typical value)



The resistance of the electrolyte decreases strongly with increasing temperature.

GENERAL INFORMATION

4.5 - Impedance (Z)
The impedance of an electrolytic capacitor results from here below circuit formed by the following individual equivalent series components:



C_o = Aluminum oxide capacitance (surface and thickness of the dielectric)

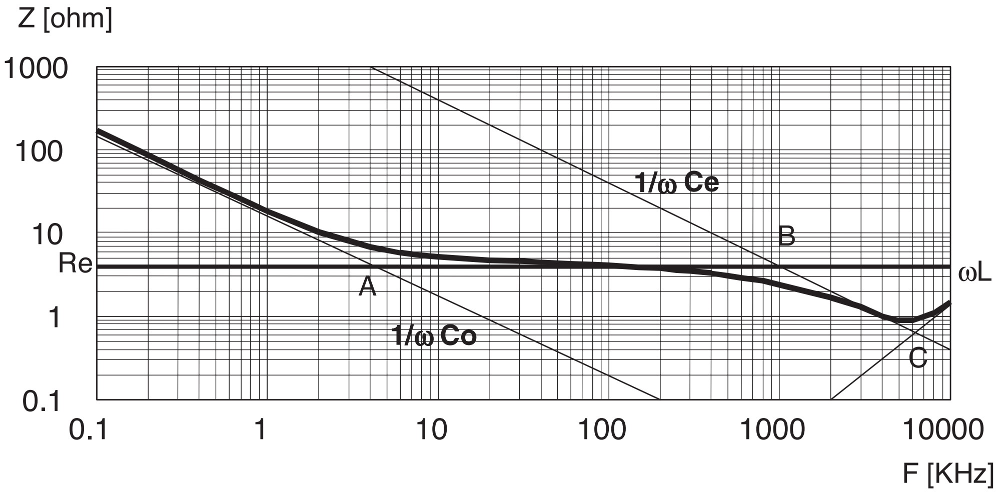
R_e = Resistance of electrolyte and paper mixture (other resistances not depending on the frequency are not considered: tabs, plates, and so on)

C_e = Electrolyte soaked paper capacitance

L = Inductive reactance of the capacitor winding and terminals.

The impedance of an electrolytic capacitor is not a constant quantity that retains its value under all the conditions: it changes depending on the frequency and the temperature.

The impedance as a function of frequency (sinusoidal waveform) for a certain temperature can be represented as follows:

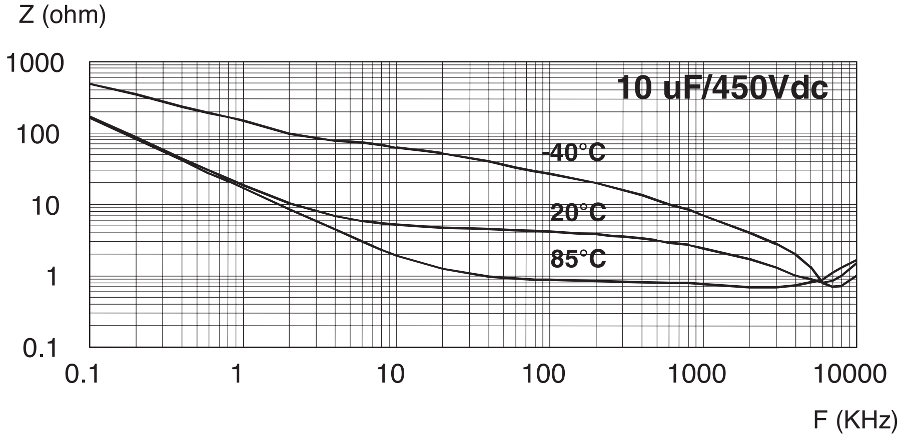


- Capacitive reactance predominates at low frequencies
- With increasing frequency, the capacitive reactance $Xc=1/\omega C_o$ decreases until it reaches the order of magnitude of the electrolyte resistance R_e (A)
- At even higher frequencies, the resistance of the electrolyte predominates: $Z= R_e$ (A - B)
- When the capacitor's resonance frequency is reached (ω_0), capacitive and inductive reactance mutually cancel each other $1/ \omega C_e = \omega L$, ω_0=SQR($1/LC_e$) (C).
- Above this frequency, the inductive reactance of the winding and its terminals ($XL=Z=\omega L$) becomes effective and leads to an increase in impedance.

Generally speaking it can be estimated that $C_e \simeq 0{,}01\ C_o$.

GENERAL INFORMATION

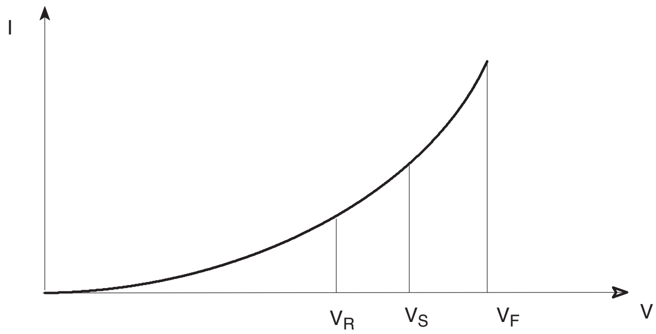
The impedance as a function of frequency (sinusoidal waveform) for different temperature values can be represented as follows (typical values):



R_e is the most temperature dependant component of electrolytic capacitor equivalent circuit. The electrolyte resistivity will decrease if the temperature rises.
In order to obtain a low impedance value all over the temperature range, R_e must be as little as possible, but too low R_e values means a very aggressive electrolyte and then a shorter life of the electrolytic capacitor at the high temperatures. A compromise must be reached.

4.6 - Leakage current (L.C.)

Due to the aluminum oxide layer that serves as a dielectric, a small current will continue to flow even after a DC voltage has been applied for long periods. This current is called leakage current.
A high leakage current flows after applying a voltage to the capacitor and then decreases in few minutes (e.g. after a prolonged storage without any applied voltage). In the course of the continuous operation, the leakage current will decrease and reach an almost constant value.
After a voltage free storage the oxide layer may deteriorate, especially at high temperature. Since there are no leakage current to transport oxygen ions to the anode, the oxide layer is not regenerated. The result is that a higher than normal leakage current will flow when a voltage is applied after prolonged storage.
As the oxide layer is regenerated in use, the leakage current will gradually decrease to its normal level.
The relationship between the leakage current and the voltage applied at constant temperature can be shown schematically as follows:



Where:

V_F = **Forming voltage**
If this level is exceeded a large quantity of heat and gas will be generated and the capacitor could be damaged.

V_R = **Rated Voltage**
This level represents the top of the linear part of the curve.

V_S = **Surge voltage**
It lies between V_R and V_F: the capacitor can be subjected to V_S for short periods only.

In accordance with the IEC 384-4, electrolytic capacitors have to be subjected to a reforming process before acceptance testing. The purpose of this preconditioning is to ensure that the same initial conditions are maintained when comparing different products.

GENERAL INFORMATION

4.7 - Ripple current (R.C.)

The maximum ripple current value depends on:
- ambient temperature
- surface area of the capacitor (heat dissipation area)
- tgδ or ESR
- frequency

The capacitor's life depends on the thermal stress.

Frequency dependence of the ripple current

The ESR and thus the tgδ depend on the frequency of the applied voltage. It means that the allowed ripple current is a function of the frequency too.

Temperature dependence of the ripple current

The data sheet specifies the maximum ripple current at the upper category temperature for each capacitor.

4.8 - Expected Life Calculation Chart

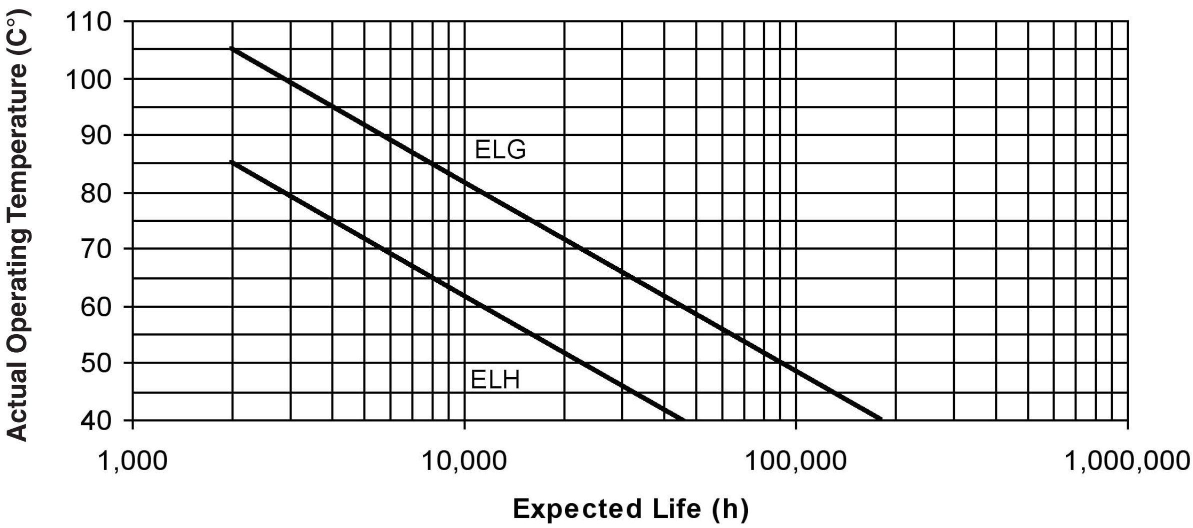
Expected Life depends on Operating Temperature according to the following formula:

$$L = Lo \times 2^{(To-T)/10}$$

Where:
L: Expected Life
Lo: Load Life at Maximum Permissible Operating Temperature
T: Actual Operating Temperature
To: Maximum Permissible Operating Temperature

This formula is applicable between 40°C and To.

Expected Life Calculation Chart



4.9 - Mounting positions (safety vent)

In operation, electrolytic capacitors will always conduct a leakage current which causes electrolysis. The oxygen produced by electrolysis will regenerate the dielectric layer but, at the same time, the hydrogen released may cause the internal pressure of the capacitor to increase.
The overpressure vent (safety vent) ensures that the gas can escape when the pressure reach a certain value. All the mounting position must allow the safety vent to work properly.

GENERAL INFORMATION

5 - GUIDE AND PRECAUTIONS

The aim of this guide is to minimize the risks of failure due to bad applications and provide some important information and precautions on the specific peculiarities of the component.

5.1 - Polarity

Electrolytic capacitors for D.C. applications require polarization. Polarity is clearly indicated on the capacitors and it's better checked both in circuit design and in mounting. For very short period a limited reverse voltage less than 1 V is permitted. Exceeding the specified reverse voltage can induce damage, overheating, over pressure, open or short circuit conditions and the destruction of the capacitor. For this reason the electrolytic capacitors are equipped (see detailed specifications in any series) with a specific pressure device "safety vent" which opens at a given pressure and limits the risk of explosions due to overpressure.
For special purposes, no polarized capacitors, so-called bipolar capacitors, may be provided. This type of capacitor is used for a circuit where the polarity is occasionally reversed but must not be used for AC voltage applications.

5.2 - Voltage

Do not apply a DC voltage exceeding the rated voltage (V_R). It's possible to apply the surge voltage (V_S) only for little time. Exceeding the capacitors specified voltage limits may cause premature damage and even destruction of the capacitor may be the consequence.

5.3 - Temperature range

The capacitors must be used within specified temperature range. In any case the general principle is: the lower the ambient temperature, the longer the life. According to Arrhenius' rule, the life time is approximately halved with each 10°C of the ambient temperature increasing.

5.4 - Ripple current

The sum of D.C. voltage and the maximum amplitude of ripple voltage shall remain within rated voltage (V_R) and 0 V.
The useful life of the capacitors is a function of the r.m.s. ripple current because ripple current induces over-heating and over pressure and therefore reduces the life.
For different ripple frequencies, the ripple current must be calculated by correction factors shown for each product and each frequency. In case of many frequencies, the following calculation shall be done:

$$I_R = \sqrt{\left[\sum_{i}^{N} \left(\frac{Irms_i}{F_i} \right)^2 \right]}$$

Where:
I_R = ripple current according to the frequency of the rated ripple current.
N = number of significant harmonics.
Irmsi = rms current of the i^{th} harmonic.
F_i = correction factor of the i^{th} harmonic.

5.5 - Charge and discharge

Do not use polarized capacitors in circuit where heavy charge and discharge cycles are frequently repeated. If you use the capacitors in this situation, capacitance could decrease and capacitors could be damaged due to generated heating and internal pressure.
Specified capacitors are designed to meet the requirements of charging and discharging cycles.

5.6 - Storage

Capacitors should be stored at room temperature, normal atmospheric pressure, low humidity, and in manufacturers packaging. We recommended to store the capacitors indoors at a temperature of 5 to 35°C and humidity less than 75% RH in places free from salt water, toxic gases, ultraviolet rays radiation, etc. If the capacitors are stored for a long time, oxide layer may deteriorate. As a result, the leakage current could be higher than the value listed in this catalogue. In this case capacitors must be reformed (see Installing paragraph page 12). Capacitors stored at the above storing conditions, for max 18 months starting from the production date, don't need to be reformed.

5.7 - Self-recharge phenomenon

Even if the aluminium electrolytic capacitors are totally discharged, these components may afterwards develop some voltage without external influence. This phenomenon depending on the capacitor type and its designed voltage, such self-recharge may result in values (sometimes around 10-15 volt) which could represent some risk: damage semiconductor devices, sparking by-pass terminal and so on.
It is recommended, for instance, to keep the terminal shorter or repeat the discharge before mounting them.

GENERAL INFORMATION

5.8 - Electrolytes

Ethylene Glycol is used for main solvent and Organic Acids for main solute.
Quaternary ammonium salts are not used.
Nevertheless the following rules should be observed when handling electrolytic capacitors:

- Any escaping electrolyte should not come into contact with eyes or skin.
- If electrolyte comes into contact with the skin, wash the affected part immediately with running water.
  If the eyes are affected, rinse them for 10 minutes with plenty of water.
  If symptoms persist, seek medical treatment.
- Avoid breathing in electrolyte vapor or mists. Workplace and other affected areas should be well ventilated.
- Clothing that has been contaminated by electrolyte must be changed or rinsed in water.

5.9 - Installing

- A general principle is that lower use temperatures result in a longer useful life of the capacitor. For this reason it should be ensured that electrolytic capacitors are placed away from heat emitting components. Adequate space should be allowed between components for cooling air circulate, particularly when high ripple current loads are applied. In any case the max category temperature must not be exceeded.
- Do not deform the case of capacitors or use capacitors with deformed case.
- Verify that the connections of the capacitors are able to insert on the board without excessive mechanical force.
- For capacitors with screw terminals apply the correct permissible torque.
- If the capacitors have to be mounted with additional means, the mounting accessories recommended shall be used.
- Verify the correct polarization of the capacitor on the board.
- Verify that the space around pressure relief device is according to the following guideline:

Case diameter	Space around safety vent
$\leqslant$ 16 mm	$>$ 2 mm
$>$ 16 to $\leqslant$ 40 mm	$>$ 3 mm
$>$ 40 mm	$>$ 5 mm

  It is recommended that capacitors are always mounted with the safety device uppermost or in the upper part of the capacitors.
- If the capacitors are stored for long time, the leakage current must be verified and, if the leakage current is superior to the value listed in this catalogue, capacitors must be reformed.
  In this case, they can be reformed by application of the rated voltage through a series resistor approximately 1 kΩ for capacitors with $V_R \leqslant$160 V (5W resistor) and 10 kΩ for the other rated voltages.
- In case of capacitors connected in series, a suitable voltage sharing must be used.
  In case of balacing resistors, the approximate resistance value can be calculated as:
  R=60/C
  We recommend anyway to make sure that the voltage across each capacitor does not exceed its rated voltage.

5.10 - Soldering

In case of small sized of electrolytic capacitors nothing abnormal will occur if dipping is performed at less than 260°C for less than 10 seconds (for SMD type refer to “SMD reflow soldering conditions”).

5.11 - Cleaning agents

Halogen hydrocarbons may cause serious damage if allowed to come into contact with aluminum electrolytic capacitors. These solvents may dissolve or decompose the insulating film and reduce the insulating properties. The capacitor seals may be affected and swell, and the solvents may penetrate them. This will lead to premature component failure.

GENERAL INFORMATION

5.12 - Warning and cautions

The electronic components shown in this catalogue are designed and produced mainly for such general purpose electronic equipments as industrial, audio, visual, home appliances, office equipment, and information processing and communication.
If you wish to use these components in medical or transportation equipment (automotive, train, ships, aircraft, spacecraft, security systems) or other equipment that requires high safety application, you are required to confirm application through your own testing.
Regardless of a component's intended use, if high safety application are required, it is recommended that you establish a protective or redundant circuit and conduct safety tests.
Regardless of a component's intended use, it is recommended thar you obtain from Arcotronics the component's technical specifications to ensure that the component is suitable for the equipment in wich it will be installed.

6 - PART NUMBERING SYSTEM

6.1 Part number digits

1 2 3 . 4 5 6 . 7 . 8 9 10 . 11 . 12 13 . 14 . 15

- Series (1 2 3)
- Rated Capacitance (4 5 6)
- Capacitance tolerance (7)
- Rated Voltage (8 9 10)
- Electrical parameters (11)
- Size D x L (12 13)
- Packaging specification (14)
- Internal use (15)

6.2 Digits explanation

6.2.1 1st, 2nd, 3rd Digit – (Series)

EDK	=	General purpose	2000 h - 85 °C	SMD
EDL	=	Long life	3000-5000 h - 85 °C	SMD
EDE	=	General purpose	1000 h - 105 °C	SMD
EDH	=	Long life	2000 h - 105 °C	SMD
EDC	=	Low impedance	1000 h - 105 °C	SMD
EDY	=	Low impedance and long life	2000 h - 105 °C	SMD
EDN	=	General purpose bi-polar	1000 h - 85 °C	SMD
ES5	=	Super miniature L= 5 mm	1000 h - 105 °C	Single - Ended Leaded
ESS	=	Miniature L= 7 mm	1000 h - 105 °C	Single - Ended Leaded
ESK	=	General purpose	2000 h - 85 °C	Single - Ended Leaded
ESE	=	General purpose	1000 h - 105 °C	Single - Ended Leaded
ESH	=	General purpose	2000 h - 105 °C	Single - Ended Leaded
ESC	=	Low impedance	2000-3000 h - 105 °C	Single - Ended Leaded
ESX	=	Low impedance	2000-5000 h - 105 °C	Single - Ended Leaded
ESY	=	Low impedance	1000-5000 h - 105 °C	Single - Ended Leaded
ESG	=	Low impedance and long life	5000 h - 105 °C	Single - Ended Leaded
ESW	=	Low impedance and long life	3000-6000 h 105°C	Single - Ended Leaded
ESF	=	Low impedance and long life	3000-10000 h 105°C	Single - Ended Leaded
ESZ	=	Low impedance and long life	8000-10000 h 105°C	Single - Ended Leaded
ESB	=	Low leakage current	1000 h - 105 °C	Single - Ended Leaded
ESN	=	General purpose bi-polar	1000 h - 105 °C	Single - Ended Leaded

GENERAL INFORMATION

ELH	=	General purpose	2000 h - 85 °C	Snap-in
ELS	=	Self estinguishing	2000 h - 85°C	Snap-in
ELG	=	General purpose	2000 h - 105 °C	Snap-in
ELD	=	Long life	3000 h - 105°C	Snap-in
ELX	=	Long life	5000 h - 105°C	Snap-in
EHD	=	General purpose	2000 h - 85 °C	Snap-in (4 pins)
EGG	=	General purpose	2000 h -105 °C	Snap-in (4 pins)
EGD	=	Long life	3000 h -105 °C	Snap-in (4 pins)
EGX	=	Long life	5000 h -105 °C	Snap-in (4 pins)
EPH	=	Long life 10000 h/85°C	2000 h - 85 °C	Screw Terminal

6.2.2 4th, 5th, 6th Digit – (Rated capacitance)

Rated capacitance is expressed by an exponential code, where the digits 4 and 5 represent the first two numbers of the rated capacitance value. Digit 6 is the exponent to apply at base 10 for obtain the capacitance in pF.

0,47 µF	= 470.000 pF	47 x 10.000	**474**
1 µF	= 1.000.000 pF	10 x 100.000	**105**
47 µF	= 47.000.000 pF	47 x 1.000.000	**476**
470 µF	= 470.000.000 pF	47 x 10.000.000	**477**
470.000 µF	= 470.000.000.000 pF	47 x 10.000.000.000	**47K**
1.000.000 µF	= 1.000.000.000.000 pF	10 x 100.000.000.000	**10L**

Special rated capacitance values will managed in accordance with the procedures of *"Arcotronics' Times and Methods Office"*.

For instance: 1360 mF = **1Z1**

For instance: 1380 mF = **1Z2**

6.2.3 7th Digit – (Capacitance tolerance)

J = ±5% **K** = ±10% **M** = ±20% **I** = -5% +10% **X** = -10% +30% **Q** = -10% +20%
Z = Special capacitance tolerance. When this digit has been chosen, it must be clearly defined.

6.2.4 8th, 9th, 10th Digit – (Rated voltage)

6R3 = 6,3 Vdc **063** = 63 Vdc **100** = 100 Vdc **450** = 450 Vdc

6.2.5 11th Digit – (Electrical parameters)

This digit outlines the special electric parameter of a special capacitor version.

A = STANDARD
B = Low D.F. (tanδ)
C = Low E.S.R. (Equivalent Series Resistance)
D = Low Z (Impedance)
E = High ripple current
F = Low leakage current
G = Formed cathode
N = Extended cathode

GENERAL INFORMATION

6.2.6 12th, 13th Digit - (Size D x L mm)

SMD

Size	3 x 5.4	4 x 5.4	5 x 5.4	6.3 x 5.4	6.3 x 7.7	8 x 6.2	8 x 10.2	10 x 10.2
Code	**9A**	**9B**	**9D**	**9G**	**9H**	**9L**	**9M**	**9P**

Size	12.5 x 13.5	12.5 x 16	16 x 16,5					
Code	**9R**	**9S**	**9T**					

Single ended, snap-in and screw terminal

Size	3 x 5	4 x 5	4 x 7	5 x 5	5 x 7	5 x 11	6 x 5	6 x 7
Code	**A1**	**B1**	**B2**	**C1**	**C2**	**C3**	**E1**	**E2**
Size	6 x 11	6 x 15	8 x 5	8 x 7	8 x 9	8 x 11	8 x 14	8 x 15
Code	**E3**	**E4**	**G5**	**G1**	**G2**	**G3**	**G7**	**G4**
Size	8 x 16	8 x 20	10 x 12	10 x 15	10 x 17	10 x 19	10 x 25	10 x 30
Code	**G8**	**G6**	**H1**	**H2**	**H3**	**H4**	**H5**	**H6**
Size	12 x 20	12 x 25	12 x 30	12 x 35	12 x 40	13 x 13	13 x 16	13 x 20
Code	**K5**	**K1**	**K2**	**K3**	**K4**	**L1**	**L2**	**L3**
Size	13 x 25	13 x 30	13 x 32	13 x 36	13 x 40	16 x 15	16 x 20	16 x 25
Code	**L4**	**L8**	**L5**	**L6**	**L7**	**M6**	**M5**	**M7**
Size	16 x 26	16 x 32	16 x 36	16 x 40	18 x 16	18 x 20	18 x 25	18 x 32
Code	**M1**	**M2**	**M3**	**M4**	**N6**	**N4**	**N5**	**N1**
Size	18 x 36	18 x 40	18 x 45	20 x 40	22 x 20	22 x 25	22 x 30	22 x 35
Code	**N2**	**N3**	**N7**	**P4**	**Q7**	**Q1**	**Q2**	**Q3**
Size	22 x 40	22 x 45	22 x 50	25 x 20	25 x 25	25 x 30	25 x 35	25 x 40
Code	**Q4**	**Q5**	**Q6**	**R7**	**R1**	**R2**	**R3**	**R4**
Size	25 x 45	25 x 50	25 x 60	30 x 20	30 x 25	30 x 30	30 x 35	30 x 40
Code	**R5**	**R6**	**R9**	**S7**	**S1**	**S2**	**S3**	**S4**
Size	30 x 45	30 x 50	35 x 25	35 x 30	35 x 35	35 x 40	35 x 45	35 x 50
Code	**S5**	**S6**	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**
Size	35 x 51	35 x 60	35 x 79	35 x 105	40 x 40	40 x 51	40 x 60	40 x 81
Code	**T7**	**T8**	**T9**	**TA**	**V9**	**V7**	**V8**	**V1**
Size	40 x 96	45 x 100	51 x 60	51 x 79	51 x 105	51 x 118	51 x 143	63 x 79
Code	**V2**	**J5**	**W1**	**W2**	**W3**	**W4**	**W5**	**X5**
Size	63 x 105	63 x 115	63 x 130	63 x 143	66 x 105	66 x 140	76 x 105	76 x 130
Code	**X1**	**X4**	**X2**	**X3**	**U3**	**U4**	**Y1**	**Y2**
Size	76 x 143	76 x 150	76 x 155	76 x 222	90 x 98	90 x 143	90 x 150	90 x 170
Code	**Y3**	**Y4**	**Y6**	**Y5**	**Z1**	**Z3**	**Z4**	**Z5**
Size	90 x 196	90 x 222	90 x 230					
Code	**Z8**	**Z6**	**Z7**					

GENERAL INFORMATION

6.2.7 14th Digit – (Packaging)

A	= SMD	= Reel	
	Single ended	= Loose (standard leads)	
	Snap-in	= Loose	
	Screw terminal	= Loose (screw housing d=8mm)	
X	= Screw terminal	= Loose (screw housing d=13mm)	
B	= Screw terminal	= Loose (screw housing d=17mm)	
C	= Screw terminal	= Loose (screw housing d=15mm)	
Y	= Screw terminal	= Loose with hexagonal case	
D	= Ammopack - pitch 5 mm for diameters < 10mm		
E	= Ammopack - straight leads for diameters 4~18mm		
F	= Ammopack - formed leads with pitch 2.5mm for diameters 4~5mm		
J	= Reel - pitch 5mm for diameters < 10mm		
K	= Reel - straight leads for diameters 4 ~ 16mm		
L	= Reel - formed leads with pitch 2.5mm for diameters 4 ~ 5mm		
P	= Straight cut leads		Shape A (see page 22) Special packaging – loose with bee hive cells for diameter ⩾ 10mm
Q	= Straight cut and crimped leads		Shape D (see page 22) Special packaging – loose with bee hive cells for diameter ⩾ 10mm
R	= Straight cut leads		Shape A (see page 22)
S	= Cut and formed leads		Shape B (see page 22)
T	= Crimped cut and formed leads		Shape C (see page 22)
U	= Straight cut and crimped leads		Shape D (see page 22)

The leads length must be fixed by the 15th Digit when **P** or **R** or **S** or **T** or **U** has been chosen.

6.2.8 15th Digit – (INTERNAL USE)

A = Standard leads length for loose version or flat case for screw terminal type.
S = Case with stud system mounting without accessory, for screw terminals only.
T = Case with stud system mounting and with accessory 39522111000, for screw terminals only.
U = Case with stud system mounting and with accessory 39522111200, for screw terminals only.
V = Leads length 4.0 ±0.2mm, for snap-in only.
W = Case with stud system mounting and with accessory 39522112500, for screw terminals only.
X = Case with stud system mounting and with accessory 39522111500, for screw terminals only.
Y = Case with stud system mounting and with accessory 39522112000, for screw terminals only.
Z = Flat case and ring clip, for screw terminals only.

when **P** or **R** or **S** or **T** or **U** has been chosen as digit 14th, the digit 15th get the following meanings:

1 = Leads length 3.1 ±0.2mm (Shape A, B, C, D)
2 = Leads length 3.3 ±0,2mm (Shape A, B, C, D)
3 = Leads length 3.7 ±0.2mm (Shape A, B, C, D)
4 = Leads length 4.2 ±0.2mm (Shape A, B, C, D)
5 = Leads length 2.6 ±0.2mm (Shape A, B)
9 = Leads length 5.0 ±0.5mm (Shape A, B, C, D)

GENERAL INFORMATION

6.2.9 Part number example

ELG 157 M 450 A S2 A A

Code	Meaning
ELG	Series (ELG)
157	Rated Capacitance (150 µF)
M	Capacitance tolerance (± 20%)
450	Rated Voltage (450 Vdc)
A	Electrical parameters (STANDARD)
S2	Size D x L (30x30 mm)
A	Packaging specification (LOOSE)
A	Internal use

Packing quantity

SINGLE ENDED

P/N digits	D (mm)	L (mm)	BULK Inner box pcs	TAPED ammopack pcs	TAPED reel pcs	LEAD CUTTING Inner box pcs
B1	4	5	10000	2500	1500	15000
C1	5	5	10000	2000	1300	15000
E1	6	5	10000	2000	1100	15000
B2	4	7	10000	2500	1500	15000
C2	5	7	10000	2000	1300	15000
E2	6	7	10000	2000	1100	15000
C3	5	11	10000	2000	1300	15000
E3	6	11	10000	2000	1100	15000
G1	8	7	6000	1000	750	8000
G3	8	11	6000	1000	750	8000
G4	8	15	5000	1000	750	5000
G6	8	20	4000	1000	750	4000
H1	10	12	4000	700	600	4000
H2	10	15	3000	700	600	4000
H4	10	19	2400	700	600	3000
H5	10	25	2400	500		2400
H6	10	30	2000	500		2000
K5	12	20	2000	500		2000
K1	12	25	2000	500		2000
K2	12	30	1600	500		1600
K3	12	35	1000	500		500
K4	12	40	1000	500		500
L3	13	20	2000	500		2000
L4	13	25	1600	500		1600
L8	13	30	1200			2400
L7	13	40	1000	500		500
M5	16	20	1000	300		500
M7	16	25	1000	300		500
M2	16	32	800			500
M3	16	36	600			500
M4	16	40	600			500
N4	18	20	800			1000
N5	18	25	800			500
N1	18	32	500			500
N2	18	36	500			500
N3	18	40	500			500
Q4	22	40	300			400

SMD

P/N digits	D (mm)	L (mm)	Qty/reel pcs	Qty/inner pcs
9B	4.0	5.4	2000	20000
9D	5.0	5.4	1000	10000
9G	6.3	5.4	1000	10000
9H	6.3	7.7	1000	10000
9L	8.0	6.2	1000	10000
9M	8.0	10.2	500	4000
9P	10.0	10.2	500	4000
9R	12.5	13.5	200	800
9S	12.5	16.0	150	600
9T	16	16.5	125	500

SCREW TERMINALS

P/N digits	D (mm)	L (mm)	Qty/box pcs
T7	35	51	75
T8	35	60	75
T9	35	79	75
TA	35	105	75
W1	51	60	36
W2	51	79	36
W3	51	105	36
W4	51	118	36
W5	51	143	36
X5	63	79	25
X1	63	105	25
X2	63	130	25
X3	63	143	25
Y1	76	105	16
Y2	76	130	16
Y3	76	143	16
Y5	76	222	16
Z1	90	98	8
Z3	90	143	8
Z6	90	222	8
Z7	90	230	8

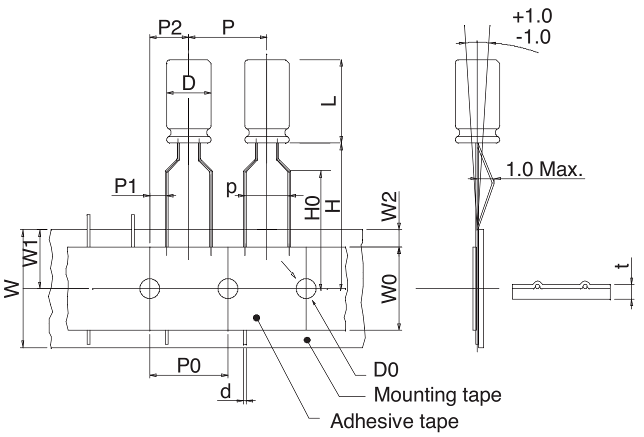
SNAP-IN

P/N digits	D (mm)	L (mm)	Qty / box pcs
Q1	22	25	400
Q2	22	30	400
Q3	22	35	400
Q4	22	40	400
Q5	22	45	400
R1	25	25	200
R2	25	30	200
R3	25	35	200
R4	25	40	200
R5	25	45	200
R6	25	50	200
S1	30	25	200
S2	30	30	200
S3	30	35	200
S4	30	40	200
S5	30	45	200
S6	30	50	200
T2	35	30	200
T3	35	35	200
T4	35	40	200
T5	35	45	200
T6	35	50	200

Lead taping for automatic insertion machines

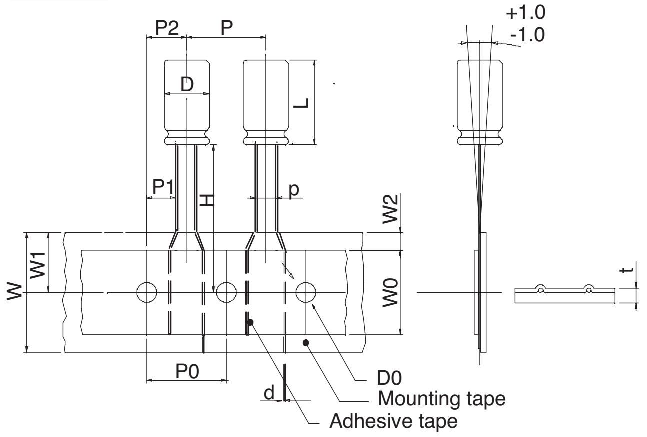
SINGLE-ENDED LEAD

Fig.1



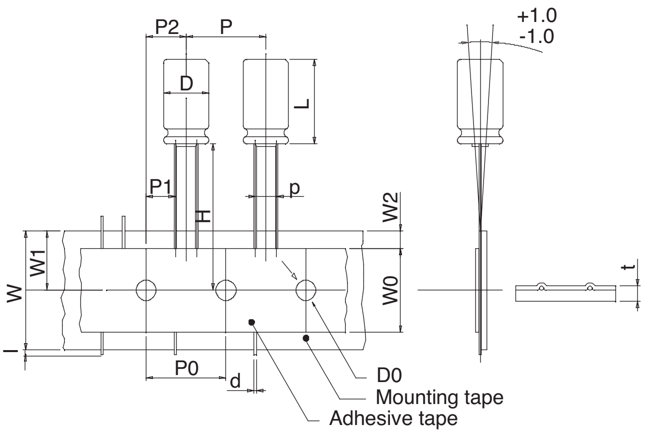
Taping pitch 5 mm formed leads
14 th digit of P/N = **D**

Fig.2



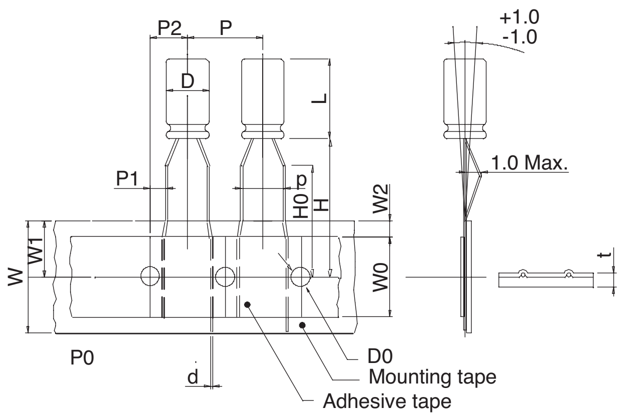
Taping straight leads Ø D 4 to Ø D8 mm
14 th digit of P/N = **E**

Fig.3



Taping straight leads Ø D >8 mm
14 th digit of P/N = **E**

Fig.4



Taping pitch 2.5 mm
14 th digit of P/N = **F**

For dimensions see following page.

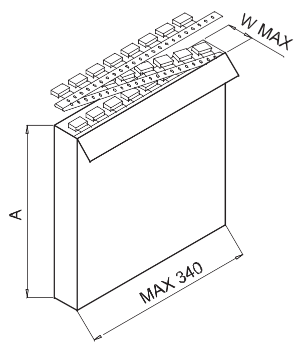
Lead taping for automatic insertion machines

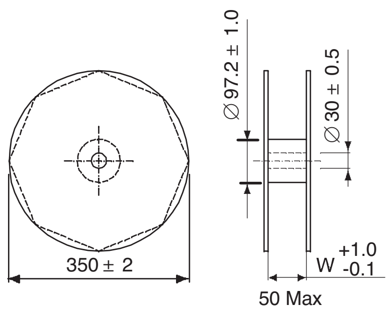
Diagram of dimensions for lead taping (Unit = mm)

Dimensions		Ø D	L	p	d	P	P0	P1	P2	W	W0	W1	W2	H	H0	I	D0	t
Tolerance		+0.5 -0		+0.8 -0.2	±0.05	±1.0	±0.3	±0.7	±1.3	+1.0 -0.5	±0.5	Max	Max	±0.75	±0.5	Max	±0.2	±0.2
Figures	4	4	5-7	2.5	0.45	12.7	12.7	5.1	6.35	18.0	12.0	11.0	3.0	18.5	16.0	-	4.0	0.7
		5	≤7	2.5	0.45	12.7	12.7	5.1	6.35	18.0	12.0	11.0	3.0	18.5	16.0	-	4.0	0.7
			>7	2.5	0.5	12.7	12.7	5.1	6.35	18.0	12.0	11.0	3.0	18.5	16.0	-	4.0	0.7
	1	4	5-7	5.0	0.45	12.7	12.7	3.85	6.35	18.0	12.0	11.0	3.0	18.5	16.0	-	4.0	0.7
		5	≤7	5.0	0.45	12.7	12.7	3.85	6.35	18.0	12.0	11.0	3.0	18.5	16.0	-	4.0	0.7
			>7	5.0	0.5	12.7	12.7	3.85	6.35	18.0	12.0	11.0	3.0	18.5	16.0	-	4.0	0.7
		6	≤7	5.0	0.5	12.7	12.7	3.85	6.35	18.0	12.0	11.0	3.0	18.5	16.0	-	4.0	0.7
			>7	5.0	0.5	12.7	12.7	3.85	6.35	18.0	12.0	11.0	3.0	18.5	16.0	-	4.0	0.7
		8	≤7	5.0	0.5	12.7	12.7	3.85	6.35	18.0	12.0	11.0	3.0	18.5	16.0	-	4.0	0.7
			>7	5.0	0.5	12.7	12.7	3.85	6.35	18.0	12.0	11.0	3.0	18.5	16.0	-	4.0	0.7
	2	4	5-7	1.5	0.45	12.7	12.7	5.6	6.35	18.0	12.0	11.0	3.0	18.5	-	-	4.0	0.7
		5	≤7	2.0	0.45	12.7	12.7	5.35	6.35	18.0	12.0	11.0	3.0	18.5	-	-	4.0	0.7
			>7	2.0	0.5	12.7	12.7	5.35	6.35	18.0	12.0	11.0	3.0	18.5	-	-	4.0	0.7
		6	≤7	2.5	0.5	12.7	12.7	5.1	6.35	18.0	12.0	11.0	3.0	18.5	-	-	4.0	0.7
			>7	2.5	0.5	12.7	12.7	5.1	6.35	18.0	12.0	11.0	3.0	18.5	-	-	4.0	0.7
		8	≤7	3.5	0.5	12.7	12.7	4.6	6.35	18.0	12.0	11.0	3.0	18.5	-	-	4.0	0.7
			>7	3.5	0.5	12.7	12.7	4.6	6.35	18.0	12.0	11.0	3.0	18.5	-	-	4.0	0.7
	3	10	12-25	5.0	0.6	12.7	12.7	3.85	6.35	18.0	12.0	11.0	3.0	18.5	-	1.0	4.0	1
		12	15-25	5.0	0.6	15.0	15.0	3.85	7.5	18.0	12.0	11.0	3.0	18.5	-	1.0	4.0	1
		13	15-25	5.0	0.6	15.0	15.0	3.85	7.5	18.0	12.0	11.0	3.0	18.5	-	1.0	4.0	1
			15-25	5.0	0.6	15.0	15.0	3.85	7.5	18.0	12.0	11.0	3.0	18.5	-	1.0	4.0	1
		16	15-25	7.5	0.8	30.0	30.0	3.75	7.5	18.0	12.0	11.0	3.0	18.5	-	1.0	4.0	1
		18	15-25	7.5	0.8	30.0	30.0	3.75	7.5	18.0	12.0	11.0	3.0	18.5	-	1.0	4.0	1

Ammopack and reel dimensions (Unit = mm)

Size ∅ DxL (mm)	Ammopack	
	A	W
∅4	230	42
∅5 x 5~7	230	42
∅6 x 5~7	275	42
∅8 x 5~9	235	45
∅5 x 11	230	48
∅6 x 11	270	48
∅8 x 11	235	48
∅8 x 14~20	240	57
∅10 x 12	250	52
∅10 x 15~19	256	57
∅10 x 22~25	250	60
∅12	270	57
∅13	285	62
∅16	265	62



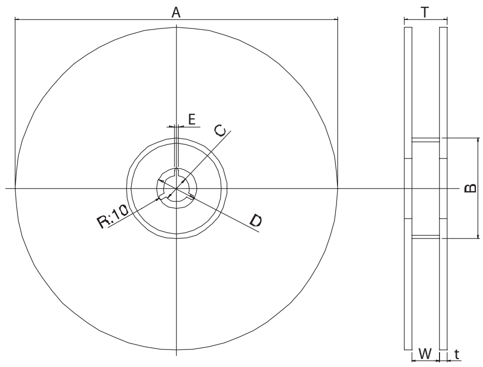


Lead taping for automatic insertion machines

SMD

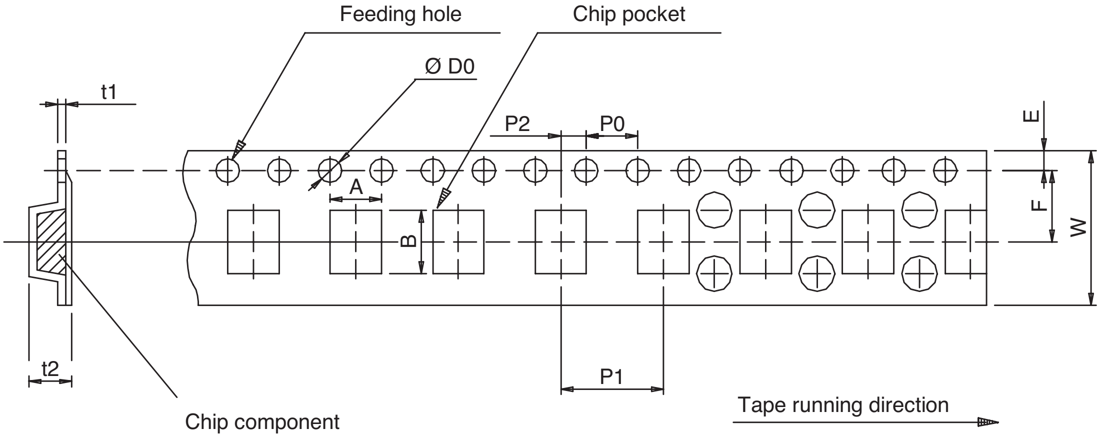
Reel dimensions (Units = mm)

Size ØDxL	A ±0,2	B MIN.	C ±0,5	D ±0,8	E ±0,5	W ±1,0	T ±1,0	t
4,0 x 5,4	380	50	13	21	2,0	14	20	3
5,0 x 5,4	380	50	13	21	2,0	14	20	3
6,3 x 5,4	380	50	13	21	2,0	18	24	3
6,3 x 7,7	380	50	13	21	2,0	18	24	3
8,0 x 6,2	380	50	13	21	2,0	18	24	3
8,0 x 10,2	380	50	13	21	2,0	26	32	3
10,0 x 10,2	380	50	13	21	2,0	26	32	3
12,5 x 13,5	380	80	13	23	2,5	34	40	3
12,5 x 16,0	380	80	13	23	2,5	34	40	3
16,0 x 16,5	380	80	13	23	2,5	46	52	3



Taping dimensions (Units = mm)

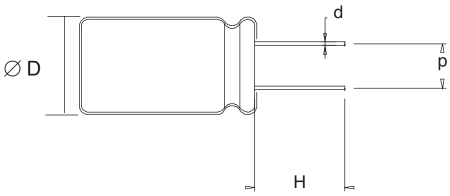
Size ØDxL	W	A	B	P0 ±0,1	P1 ±0,1	P2 ±0,1	F	D0 +0,1	E	t1	t2
4,0 x 5,4	12	4,7	4,7	4,0	8,0	2,0	5,5	1,5	1,75	0,4	5,8
5,0 x 5,4	12	5,7	5,7	4,0	12,0	2,0	5,5	1,5	1,75	0,4	5,8
6,3 x 5,4	16	7,0	7,0	4,0	12,0	2,0	7,5	1,5	1,75	0,4	5,8
6,3 x 7,7	16	7,0	7,0	4,0	12,0	2,0	7,5	1,5	1,75	0,4	5,8
8,0 x 6,2	16	8,7	8,7	4,0	12,0	2,0	7,5	1,5	1,75	0,4	6,8
8,0 x 10,2	24	8,7	8,7	4,0	16,0	2,0	11,5	1,5	1,75	0,4	11,0
10,0 x 10,2	24	10,7	10,7	4,0	16,0	2,0	11,5	1,5	1,75	0,4	11,0
12,5 x 13,5	32	13,4	13,4	4,0	24,0	2,0	14,2	1,5	1,75	0,5	14,0
12,5 x 16,0	32	13,4	13,4	4,0	24,0	2,0	14,2	1,5	1,75	0,5	17,5
16,0 x 16,5	44	17,5	17,5	4,0	28,0	2,0	20,2	1,5	1,75	0,5	17,5



Radial leads cutting, forming and crimping

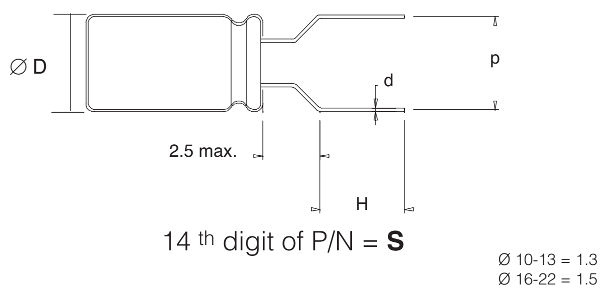
Cutting forming and crimping methods

Shape (A)



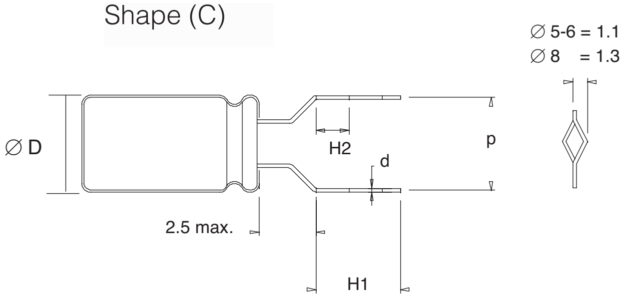
14 th digit of P/N = **R**

Shape (B)



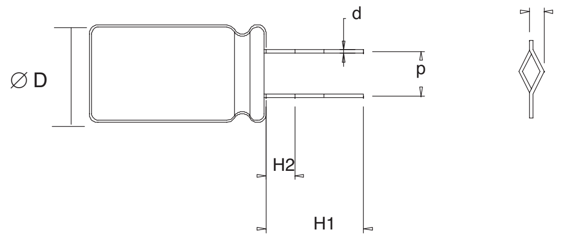
14 th digit of P/N = **S**

Shape (C)



14 th digit of P/N = **T**

Shape (D)



14 th digit of P/N = **U**

Stand off rubber available upon request for loose and taped versions

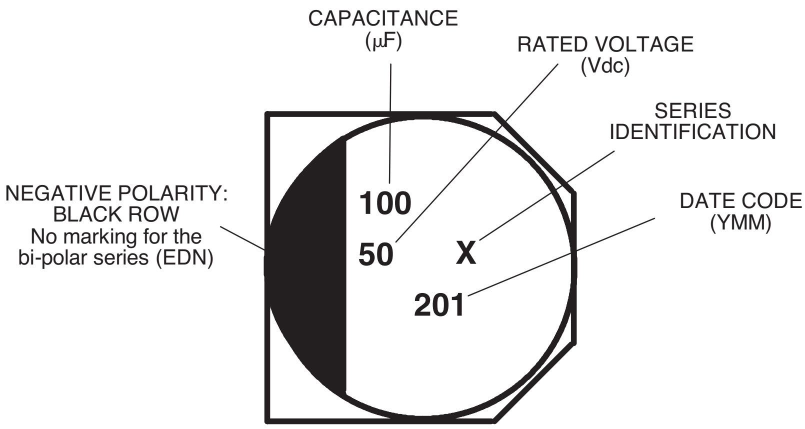
(Unit=mm)

Shape	Cutting forming and crimping methods	**Ø D**	**Ø 5**	**Ø 6.3**	**Ø 8**	**Ø 10**	**Ø 12, 13**	**Ø 16**	**Ø 18**	**Ø 22**
A	Leads cut only	p ±0.5	2.0	2.5	3.5	5.0	5.0	7.5	7.5	10.0
		H ±0.5	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
		d ±0.05	0.5	0.5	0.5	0.6	0.6	0.8	0.8	0.8
B	Leads cut and formed	p ±0.5	5.0	5.0	5.0					
		H ±0.5	5.0	5.0	5.0					
		d ±0.05	0.5	0.5	0.5					
C	Leads cut, crimped and formed	p ±0.5	5.0	5.0	5.0					
		H1 ±0.5	5.0	5.0	5.0					
		H2 ±0.1	2.5	2.5	2.5					
		d ±0.05	0.5	0.5	0.5					
D	Leads cut and crimped	p ±0.5				5.0	5.0	7.5	7.5	10.0
		H1 ±0.5				5.0	5.0	5.0	5.0	5.0
		H2 ±0.1				2.5	2.5	2.5	2.5	2.5
		d ±0.05				0.6	0.6	0.8	0.8	0.8

SMD - Designed for surface mount technology

Marking

Note that 6.3V rated voltage shall be marked as 6V, but 6.3V shall be assured.



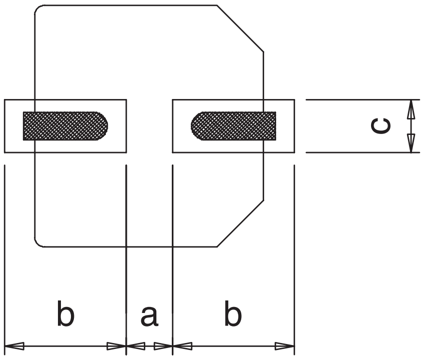
Test method and performance

Load life test		Shelf life test	
Test conditions		**Test conditions**	
Voltage:	max rated voltage	Voltage:	no voltage applied
Temperature:	max operating temperature	Temperature:	max operating temperature
Test duration:	hours specified in Endurance test	Test duration:	1000 hours.
Performance			
The following specifications will be satisfied when the capacitors are restored at 20°C			
Capacitance change:	within 20% of initial value		
Dissipation Factor:	not exceed 200% of the initial requirement		
Leakage Current:	not exceed initial requirement		

Reflow soldering	
Test conditions	
Temperature:	as in Reflow soldering conditions
Test duration:	as in Reflow soldering conditions
Performance	
The following specifications will be satisfied when the capacitors are restored at 20°C	
Capacitance change:	within 10% of initial value
Dissipation Factor:	not exceed initial requirement
Leakage Current:	not exceed initial requirement

SMD - Designed for surface mount technology

Recommended land size



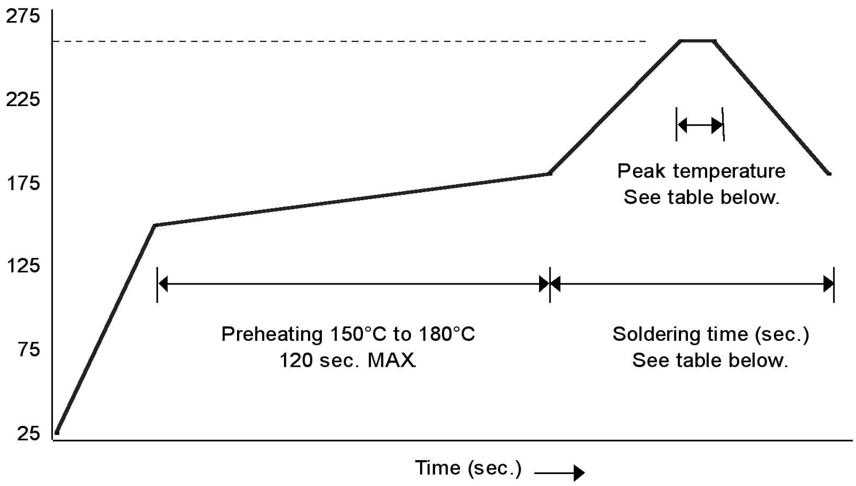
Size ØDxL	A	B	C
4,0 x 5,4	1,0	2,5	1,6
5,0 x 5,4	1,5	2,8	1,6
6,3 x 5,4	1,8	3,2	1,6
6,3 x 7,7	1,8	3,2	1,6
8,0 x 6,2	2,2	4,0	1,6
8,0 x 10,2	3,1	4,0	2,0
10,0 x 10,2	4,6	4,1	2,0
12,5 x 13,5	7,0	7,5	4,0
12,5 x 16,0	7,0	7,5	4,0
16,0 x 16,5	9,5	8,5	6,0

Reflow soldering condition

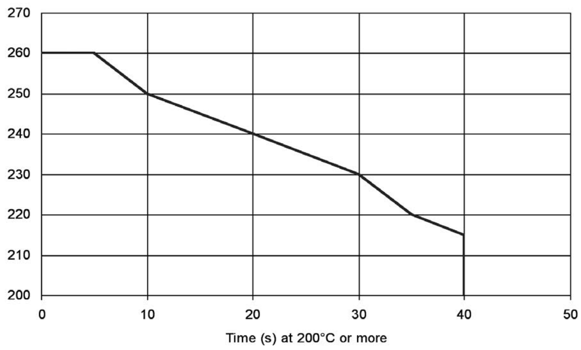
For reflow use a thermal conduction system such as infrared radiation or hot blast. Vapor heat transfer systems are not recommended. Reflow should be performed once and not exceed the following limits (temperature, time, etc . . .)

LEAD FREE TYPE REFLOW SOLDERING CONDITION

Reflow soldering profile



Reflow soldering condition for Ø 4 to 6.3 up 50V



Reflow soldering condition
for Ø 4 to 6.3 from 63 to 100 V and Ø 8 to 16 from 4 to 450V