Electronic Components KEMET CHARGED.

Overview

The KEMET ESS single-ended aluminum electrolytic capacitors are designed for applications requiring a low TVS¼PI QMRMEXYVI WSPYXMSR

%TTPMGEXMSRW

Typical applications include portable micro computers, disk drives, calculators and audio equipment.

&IRI¼XW

- 1,000 hour operating life
- Operating temperature of up to 105°C
- 7 – 9 mm case height
- Safety vent on the capacitor base

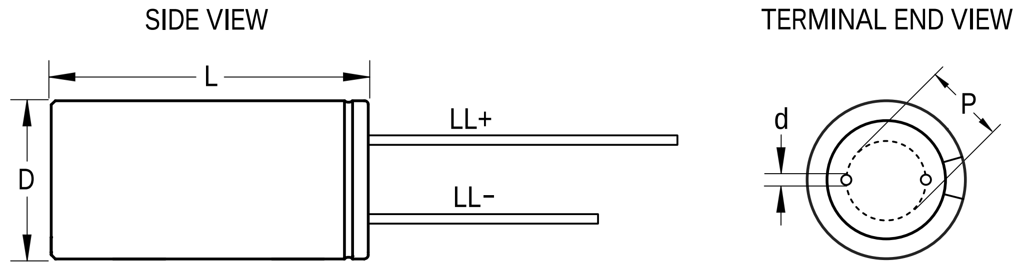
4EVX 2YQFIV 7]WXIQ

ESS	336	M	004		A	B2	AA
Series	Capacitance Code (pF)	Tolerance	Rated Voltage (VDC)		Electrical Parameters	Size Code	Packaging
Single-Ended Aluminum Electrolytic	First two digits represent WMKRM¼GERX ¼KYVIW JSV capacitance values. Last HMKMX WTIGM¼IW the number of zeros to be added.	M = ±20%	004 = 4 6R3 = 6.3 010 = 10 016 = 16	025 = 25 035 = 35 050 = 50 063 = 63	A = Standard	See Dimension Table	See Ordering Options Table

3VHIVMRK 3TXMSRW 8EFPI

(MEQIXIV	4EGOEKMRK 8]TI	0IEH 8]TI	0IEH 0IRKXL QQ	Lead and 4EGOEKMRK 'SHI
Standard Bulk Packaging Options				
4 – 22	Bulk (bag)			

(MQIRWMSRW • 1MPPMQIXIVW



7M^I 'SHI	D		L		p		d		00 00‾	
	Nominal	Tolerance	Nominal	Tolerance	Nominal	Tolerance	Nominal	Tolerance	Nominal	Tolerance
B2	4	±0.5	7	‾	1.5	±0.5	0.45	Nominal	20/15	Minimum
C2	5	±0.5	7	‾	2	±0.5	0.45	Nominal	20/15	Minimum
E2	6.3	±0.5	7	‾	2.5	±0.5	0.45	Nominal	20/15	Minimum
G1	8	±0.5	7	‾	3.5	±0.5	0.5	Nominal	20/15	Minimum
G2	8	±0.5	9	‾	3.5	±0.5	0.5	Nominal	20/15	Minimum

4IVJSVQERGI 'LEVEGXIVMWXMGW

-XIQ	4IVJSVQERGI 'LEVEGXIVMWXMGW
Capacitance Range	1 – 470 µF
Capacitance Tolerance	±20% at 120 Hz/20°C
Rated Voltage	4 – 63 VDC
Life Test	1,000 hours (see conditions in Test Method & Performance)
Operating Temperature	‾ q' XS q'
Leakage Current	- µ ': SV v% [LMGLIZIV MW KVIEXIV
	C = rated capacitance (µF), V = rated voltage (VDC). Voltage applied for 2 minutes at 20°C.

-QTIHERGI > 'LEVEGXIVMWXMGW EX ,^

Rated Voltage (VDC)	4	6	10	16	25	35	50	63
> ‾ q' >	q'6	4	3	2	2	2	2	2
> ‾ q' >	q'12	8	6	4	4	3	3	3

8EFPI • 6EXMRKW 4EVX 2YQFIV 6IJIVIRGI

VDC	:(' 7YVKI :SPXEKI	6EXIH 'ETEGMXERGI ,^ q'	'EWI 7M^I (\ 0 v* QQ	(* ,^ 20°C XER ¾	6' ,^ 105°C Q%	LC 20°C QMRYXIW v%	4EVX 2YQFIV
4	5	33	4 x 7	35	30	3.0	ESS336M004AB2(1)
4	5	47	4 x 7	35	35	3.0	ESS476M004AB2(1)
4	5	100	5 x 7	35	55	4.0	ESS107M004AC2(1)
4	5	220	6.3 x 7	35	95	8.8	ESS227M004AE2(1)
6.3	8	22	4 x 7	24	37	3.0	ESS226M6R3AB2(1)
6.3	8	33	5 x 7	24	42	3.0	ESS336M6R3AC2(1)
6.3	8	47	4 x 7	24	46	3.0	ESS476M6R3AB2(1)
6.3	8	47	5 x 7	24	55	3.0	ESS476M6R3AC2(1)
6.3	8	100	5 x 7	24	75	6.3	ESS107M6R3AC2(1)
6.3	8	100	6.3 x 7	24	90	6.3	ESS107M6R3AE2(1)
6.3	8	220	6.3 x 7	24	130	13.9	ESS227M6R3AE2(1)
6.3	8	330	8 x 7	24	140	20.8	ESS337M6R3AG1(1)
10	13	22	4 x 7	20	31	3.0	ESS226M010AB2(1)
10	13	22	5 x 7	20	38	3.0	ESS226M010AC2(1)
10	13	33	4 x 7	20	39	3.3	ESS336M010AB2(1)
10	13	33	5 x 7	20	47	3.3	ESS336M010AC2(1)
10	13	47	4 x 7	20	50	4.7	ESS476M010AB2(1)
10	13	47	5 x 7	20	60	4.7	ESS476M010AC2(1)
10	13	47	6.3 x 7	20	60	4.7	ESS476M010AE2(1)
10	13	100	5 x 7	20	85	10.0	ESS107M010AC2(1)
10	13	100	6.3 x 7	20	100	10.0	ESS107M010AE2(1)
10	13	220	6.3 x 7	20	135	22.0	ESS227M010AE2(1)
10	13	470	8 x 9	20	165	47.0	ESS477M010AG2(1)
16	20	2.2	4 x 7	17	7	3.0	ESS225M016AB2(1)
16	20	3.3	4 x 7	17	13	3.0	ESS335M016AB2(1)
16	20	4.7	4 x 7	17	19	3.0	ESS475M016AB2(1)
16	20	10	4 x 7	17	29	3.0	ESS106M016AB2(1)
16	20	22	4 x 7	17	36	3.5	ESS226M016AB2(1)
16	20	22	5 x 7	17	44	3.5	ESS226M016AC2(1)
16	20	33	4 x 7	17	50	5.3	ESS336M016AB2(1)
16	20	33	5 x 7	17	57	5.3	ESS336M016AC2(1)
16	20	47	5 x 7	17	75	7.5	ESS476M016AC2(1)
16	20	47	6.3 x 7	17	77	7.5	ESS476M016AE2(1)
16	20	68	5 x 7	17	84	10.9	ESS686M016AC2(1)
16	20	100	5 x 7	17	94	16.0	ESS107M016AC2(1)
16	20	100	6.3 x 7	17	110	16.0	ESS107M016AE2(1)
16	20	150	6.3 x 7	17	120	24.0	ESS157M016AE2(1)
16	20	220	8 x 7	17	140	35.2	ESS227M016AG1(1)
16	20	220	8 x 9	17	140	35.2	ESS227M016AG2(1)
16	20	330	8 x 9	17	155	52.8	ESS337M016AG2(1)
16	20	470	8 x 9	17	165	75.2	ESS477M016AG2(1)
25	30	4.7	4 x 7	15	24	3.0	ESS475M025AB2(1)
25	30	10	4 x 7	15	33	3.0	ESS106M025AB2(1)
25	30	10	5 x 7	15	35	3.0	ESS106M025AC2(1)
25	30	10	6.3 x 7	15	35	3.0	ESS106M025AE2(1)
25	30	22	4 x 7	15	43	5.5	ESS226M025AB2(1)
25	30	22	5 x 7	15	51	5.5	ESS226M025AC2(1)
25	30	22	6.3 x 7	15	53	5.5	ESS226M025AE2(1)
25	30	33	5 x 7	15	55	8.3	ESS336M025AC2(1)
25	30	33	6.3 x 7	15	65	8.3	ESS336M025AE2(1)
25	30	47	5 x 7	15	67	11.8	ESS476M025AC2(1)
25	30	47	6.3 x 7	15	79	11.8	ESS476M025AE2(1)
25	30	100	6.3 x 7	15	120	25.0	ESS107M025AE2(1)
25	30	100	8 x 7	15	120	25.0	ESS107M025AG1(1)
35	44	4.7	4 x 7	12	24	3.0	ESS475M035AB2(1)
35	44	4.7	5 x 7	12	24	3.0	ESS475M035AC2(1)
35	44	10	4 x 7	12	34	3.5	ESS106M035AB2(1)
35	44	10	5 x 7	12	36	3.5	ESS106M035AC2(1)
VDC	:(' 7YVKI	6EXIH 'ETEGMXERGI	'EWI 7M^I	(*	6'	LC	4EVX 2YQFIV

(1) Insert packaging code. See Ordering Options Table for available options.

8EFPI • 6EXMRKW 4EVX 2YQFIV 6IJIVIRGI GSRX H

(1) Insert packaging code. See Ordering Options Table for available options.

1SYRXMRK 4SWMXMSRW 7EJIX] :IRX

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

-RWXEPPMRK

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

'EWI (MEQIXIV	7TEGI %VSYRH 7EJIX] :IRX
µ QQ	> 2 mm
" XS µ QQ	> 3 mm
> 40 mm	> 5 mm

It is recommended that capacitors always be mounted with the safety device uppermost or in the upper part of the capa

- -J XLI GETEGMXSVW EVI WXSVIH JSV E PSRK XMQI XLI PIEOEKI GYV value listed in this catalog, the capacitors must be reformed. In this case, they can be reformed by application of the ZSPXEKI XLVSYKL E WIVMIW VIWMWXSV R µ ETTVS\MQEXIP] [illegible] rated voltages.
- In the case of capacitors connected in a series, a suitable voltage sharing must be used. In the case of balancing resistors, the approximate resistance value can be calculated as: R = 60/C.

KEMET recommends, nevertheless, to ensure that the voltage across each capacitor does not exceed its rated voltage

%TTPMGEXMSR ERH 3TIVEXMSR +YMHIPMRIW

)PIGXVMGEP 6EXMRKW

'ETEGMXERGI)7'

Simplified equivalent circuit diagram of an electrolytic capacitor

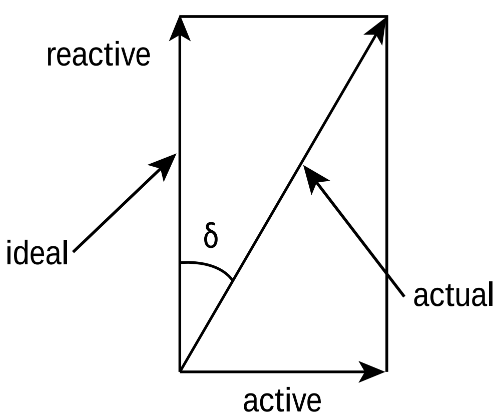
The capacitive component of the equivalent series circuit, (equivalent series capacitance - ESC), is determined by appl
ER EPXIVREXI ZSPXEKI SJ µ : EX E JVIUYIRG] SJ SV ,^ ERH

8IQTIVEXYVI (ITIRHIRGI SJ XLI 'ETEGMXERGI
Capacitance of an electrolytic capacitor depends upon temperature: with decreasing temperature the viscosity of the electrolyte increases, thereby reducing its conductivity.
Capacitance will decrease if 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 evident for electrolytic capacitors than for other types.

*VIUYIRG] (ITIRHIRGI SJ XLI 'ETEGMXERGI
Effective capacitance value is derived from the impedance curve, as long as impedance is still in the range where the capacitance component is dominant.

C = 1 / Æ J
C = capacitance (
f = frequency (Hz
> ! MQTIHE

(MWWMTEXMSR *EGXSV XER ¾ (*
(MWWMTEXMSR *EGXSV XER ¾ MW XLI VEXMS FIX[IIR XLI EGXMZI ERH thought of as a measurement of the gap between an actual and ideal capacitor.

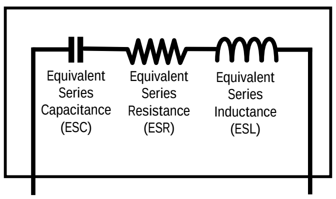


8ER ¾ MW QIEWYVIH [MXL XLI WEQI WIX YT YWIH JSV XLI WIVMIW GETI
8ER ¾ ! Î \ )7' \ )76 [LIVI
ESC = Equivalent series capacitance
ESR = Equivalent series resistance

)UYMZEPIRX 7IVMIW -RHYGXERGI)70

)UYMZEPIRX WIVMIW MRHYGXERGI SV WIPJ MRHYGXERGI VIWYPXW JVS

Capacitor Equivalent Internal Circuit



)UYMZEPIRX 7IVMIW 6IWMWXERGI)76

Equivalent series resistance is the resistive component of the equivalent series circuit. ESR value depends on frequenc
XIQTIVEXYVI ERH MW VIPEXIH XS XLI XER ¾ F] XLI JSPPS[MRK IUYEXM

)76 !)UYMZEPIRX WIV

ESR = XER / ÆJ) XER ¾ ! (MWWMTEXMS

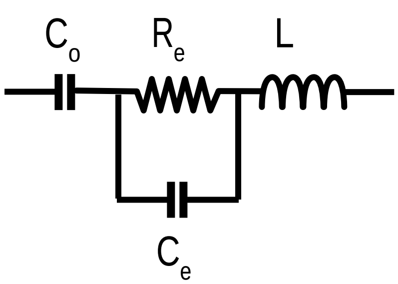
ESC = Equivalent series capacitance

f = Frequency (Hz)

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

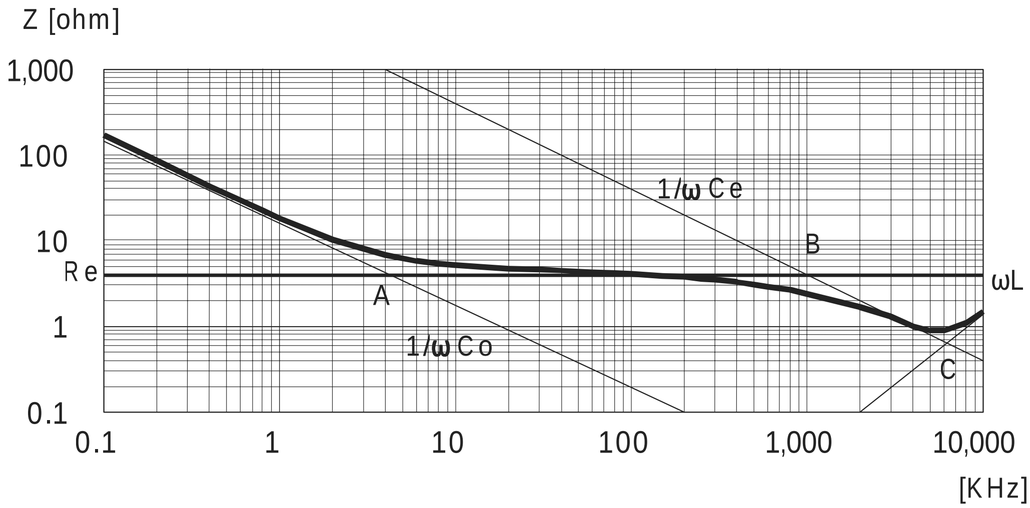
-QTIHERGI >

Impedance of an electrolytic capacitor results from a 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: plates, etc.)
C_e = Electrolyte soaked paper capacitance.
L = Inductive reactance of the capacitor winding and terminals.
Impedance of an electrolytic capacitor is not a constant quantity that retains its value under all conditions; it changes depending on frequency and temperature.
Impedance as a function of frequency (sinusoidal waveform) for a certain temperature can be represented as follows:

-QTIHERGI > GSRX…H



- Capacitive reactance predominates at low frequencies.
- ;MXL MRGVIEWMRK JVIUYIRG] $_o$ decreases until it reaches the order of magnitude of Î' electrolyte resistance $_e$ (A)
- At even higher frequencies, resistance of the electrolyte predominates: $_e$ (A – B)
- ;LIR XLI GETEGMXSV…W VIWS $_0$, capacitive and inductive reactance mutually cancel each other Î'$_e$! Î0$_0$ =Î1/SQR(L$_e$C)
- %FSZI XLMW JVIUYIRG] MRHYGXMZI VIEGXERGI SJ XLI [MRHMRK ERH an increase in impedance

Generally speaking, it can be estimated that C$_e$ ³ C$_o$. '

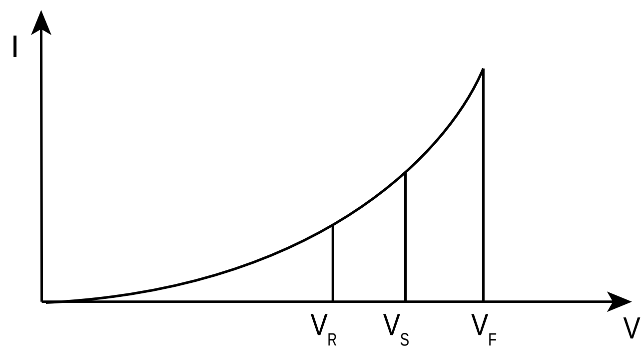
Impedance as a function of frequency (sinusoidal waveform) for different temperature values can be represented as fol (typical values):

0IEOEKI 'YVVIRX 0'
(YI XS XLI EPYQMRYQ S\MHI PE]IV XLEX WIVZIW EW E HMIPIGXVMG E
been applied for long periods. This current is called leakage current.

% LMKL PIEOEKI GYVVIRX ½S[W EJXIV ETTP]MRK ZSPXEKI XS XLI GETE
prolonged storage without any applied voltage. In the course of continuous operation, the leakage current will decrease
reach an almost constant value.

After a voltage-free storage the oxide layer may deteriorate, especially at a high temperature. Since there are no leakag
currents to transport oxygen ions to the anode, the oxide layer is not regenerated. The result is that a higher than norma
PIEOEKI GYVVIRX [MPP ½S[[LIR ZSPXEKI MW ETTPMIH EJXIV TVSPSRK

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 voltage applied at constant temperature can be shown schematically
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
This lies between V_R and V_F. The capacitor can be subjected to V_S for short periods only.

Electrolytic capacitors are subjected to a reforming process before acceptance testing. The purpose of this precondition
is to ensure that the same initial conditions are maintained when comparing different products.

6MTTPI 'YVVIRX 6'
The maximum ripple current value depends on:
- Ambient temperature
- Surface area of the capacitor (heat dissipation area)
- XER ¾ SV)76
- Frequency

The capacitor’s life depends on the thermal stress.

*VIUYIRG] (ITIRHIRGI SJ XLI 6MTTPI 'YVVIRX

)76 ERH XLYW XLI XERY¼RG[ITSRH XLI EXXTPMIH ZSPXEKI 8LMW MRHMGE
a function of the frequency.

8IQTIVEXYVI (ITIRHIRGI SJ XLI 6MTTPI 'YVVIRX

8LI HEXE WLIIX WTIGM¼IW QE\MQYQ VMTTPI GYVVIRX EX XLI YTTIV GE

)\TIGXIH 0MJI 'EPGYPEXMSR

Expected life depends on operating temperature according to the following formula: $L = Lo \times 2^{(To-T)/10}$

Where:

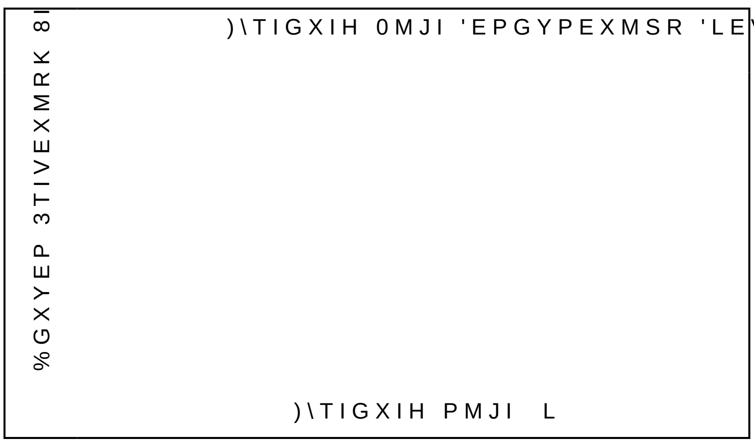
L: Expected life

Lo: Load life at a maximum permissible operating temperature

T: Actual operating temperature

To: Maximum permissible operating temperature

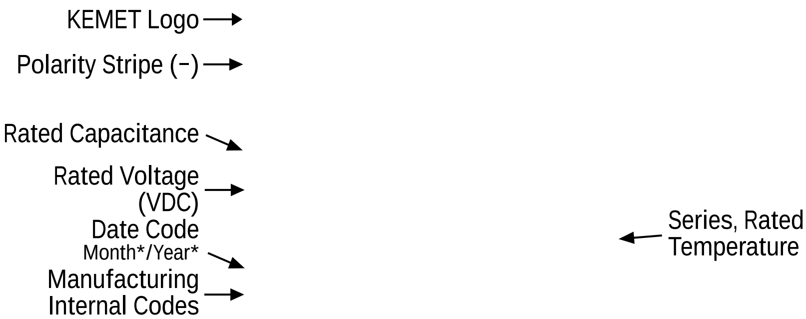
This formula is applicable between 40°C and To.



4EGOEKMRK 5YERXMXMIW

Size 'SHI	(MEQIXIV QQ	0IRKXL QQ	&YPO		%YXS MRWIVXMSR	
			7XERHEVH 0IEHW	'YX 0IEHW	%QQS 8ETI	6IIP
B2	4	7	10,000	15,000	2,500	3,000
C2	5	7	10,000	15,000	2,000	2,600
E2	6.3	7	10,000	15,000	2,000	2,200
+	8	7	6,000	8,000	1,000	1,500
+	8	9	6,000	8,000	1,000	1,500

Marking



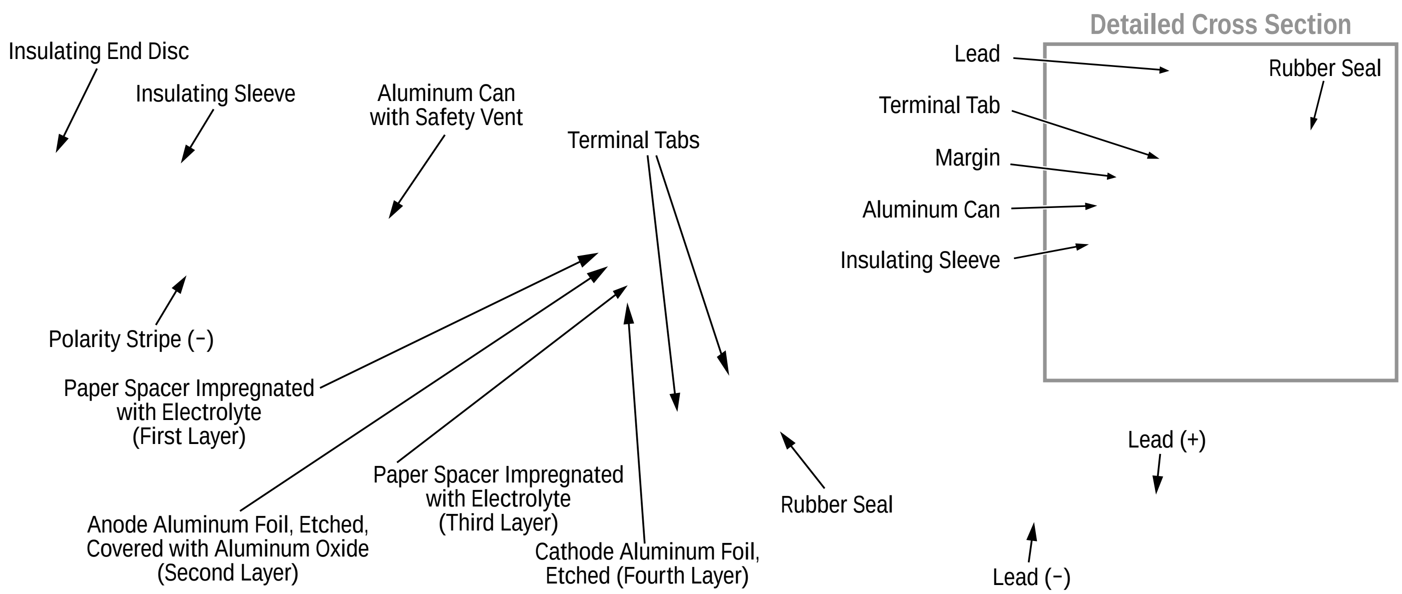
*Y = Year

Code	01	02	03	04	05	06	07	08	09
Year	2011	2012	2013	2014	2015	2016	2017	2018	2019

*M = Month

Code	01	02	03	04	05	06	07	08	09	10	11	12
Month	1	2	3	4	5	6	7	8	9	10	11	12

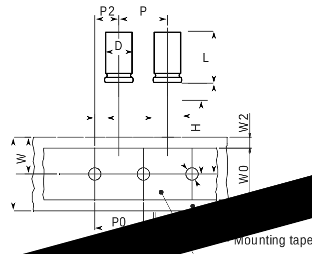
' S R W X V Y G X M S R



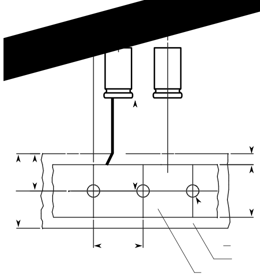
8ETMRK JSV %YXSQEXMG -RWIVXMSR 1EGLMRIW

Formed to 2.5 mm
(Lead and packaging code LA and FA)

Formed to 5 mm
(Lead and packaging code JA and DA)



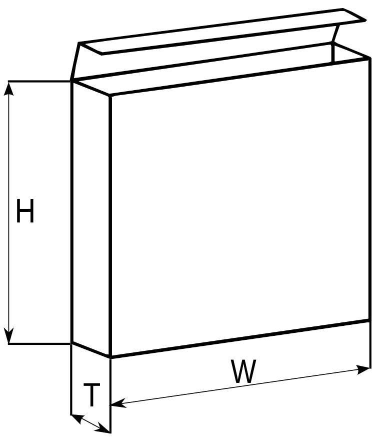
Straight Leads (Diamete [redacted]
Lead and pac [redacted] KA



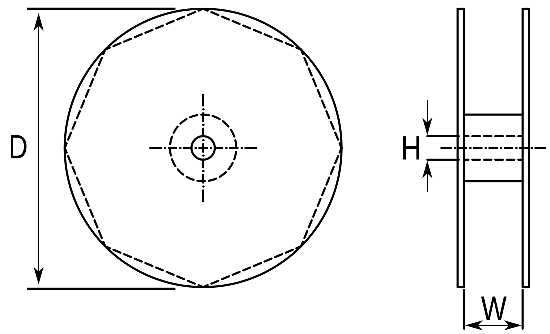
(MQIRWMSR QQ	D	L	p	d	P	P0	P1	P2	W	W0	W1	W2	,	,	I	D0	X
Tolerance	+0.5		–	±0.05	±1.0	±0.3	±0.7	±1.3	–	±0.5	Maximum	Maximum	±0.75	±0.5	Maximum	±0.2	±0.2
Formed to 2.5 mm	4	5–7	2.5	0.45	12.7	12.7	5.1	6.35	18	12	11	3	16	18.5		4	0.7
	5	µ	2.5	0.45	12.7	12.7	5.1	6.35	18	12	11	3	16	18.5		4	0.7
		>7	2.5	0.5	12.7	12.7	5.1	6.35	18	12	11	3	16	18.5		4	0.7
Formed to 5 mm	4	5–7	5	0.45	12.7	12.7	3.85	6.35	18	12	11	3	16	18.5		4	0.7
	5	µ	5	0.45	12.7	12.7	3.85	6.35	18	12	11	3	16	18.5		4	0.7
		>7	5	0.5	12.7	12.7	3.85	6.35	18	12	11	3	16	18.5		4	0.7
	6	µ	5	0.5	12.7	12.7	3.85	6.35	18	12	11	3	16	18.5		4	0.7
		>7	5	0.5	12.7	12.7	3.85	6.35	18	12	11	3	16	18.5		4	0.7
	8	µ	5	0.5	12.7	12.7	3.85	6.35	18	12	11	3	16	18.5		4	0.7
		>7	5	0.5	12.7	12.7	3.85	6.35	18	12	11	3	16	18.5		4	0.7
Straight leads	4	5–7	1.5	0.45	12.7	12.7	5.6	6.35	18	12	11	3	18.5			4	0.7
	5	µ	2	0.45	12.7	12.7	5.35	6.35	18	12	11	3	18.5			4	0.7
		>7	2	0.5	12.7	12.7	5.35	6.35	18	12	11	3	18.5			4	0.7
	6	µ	2.5	0.5	12.7	12.7	5.1	6.35	18	12	11	3	18.5			4	0.7
		>7	2.5	0.5	12.7	12.7	5.1	6.35	18	12	11	3	18.5			4	0.7
	8	µ	3.5	0.5	12.7	12.7	4.6	6.35	18	12	11	3	18.5			4	0.7
		>7	3.5	0.5	12.7	12.7	4.6	6.35	18	12	11	3	18.5			4	0.7
	10	12–25	5	0.6	12.7	12.7	3.85	6.35	18	12	11	3	18.5		1	4	1
	12	15–25	5	0.6	15	15	3.85	7.5	18	12	11	3	18.5		1	4	1
	13		5	0.6	15	15	3.85	7.5	18	12	11	3	18.5		1	4	1
			5	0.6	15	15	3.85	7.5	18	12	11	3	18.5		1	4	1
	16		7.5	0.8	30	30	3.75	7.5	18	12	11	3	18.5		1	4	1
	18		7.5	0.8	30	30	3.75	7.5	18	12	11	3	18.5		1	4	1

0IEH 8ETMRK 4EGOEKMRK

Ammo Box

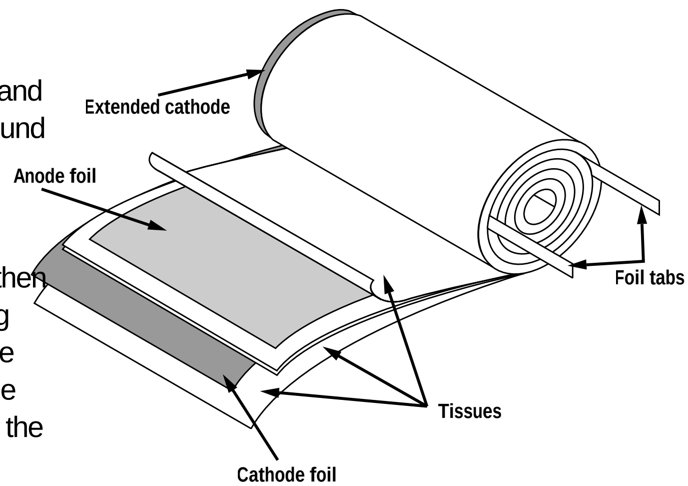


Reel



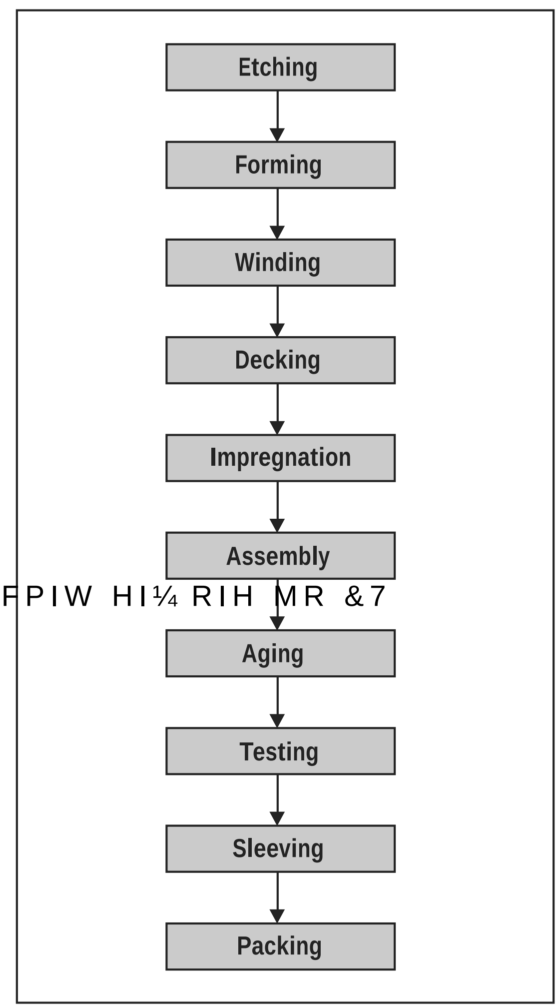
'EWI 7M^	%QQS			6IIP		
	,	W	8	D	,	W
		Maximum	Maximum	±2	±0.5	–
4	230	340	42	350	30	50
5 x 5 – 7	230	340	42			

'SRWXVYGXMSR (EXE



The manufacturing process begins with the anode foil being electrochemically etched to increase the surface area and then “formed” to produce the aluminum oxide layer. Both the anode and cathode foils are then interleaved with absorbent paper and wound into a cylinder. During the winding process, aluminum tabs are attached to each foil to provide the electrical contact.

The deck, complete with terminals, is attached to the tabs and then folded down to rest on top of the winding. The complete winding is impregnated with electrolyte before being housed in a suitable container, usually an aluminum can, and sealed. Throughout the process, all materials inside the housing must be maintained at the highest purity and be compatible with the electrolyte.



Each capacitor is aged and tested before being sleeved and packed. The purpose of aging is to repair any damage in the oxide layer and thus reduce the leakage current to a very low level. Aging is normally carried out at the rated temperature of the capacitor and is accomplished by applying voltage to the device while carefully controlling the supply current. The process may take several hours to complete.

Damage to the oxide layer can occur due to variety of reasons:

- Slitting of the anode foil after forming
- Attaching the tabs to the anode foil
- Minor mechanical damage caused during winding

A sample from each batch is taken by the quality department after completion of the production process. This sample size is controlled F] XLI YWI SJ VIGSKRM^IH WEQTPMRK XEFPIW HI¼RIH MR &7

The following tests are applied and may be varied at the request of the customer. In this case the batch, or special procedure, will determine the course of action.

Electrical:

- Leakage current
- Capacitance
- ESR
- Impedance
- Tc1(n)-8. ( )]TJ T*225 Cnncn

- TlhD7nl1A00140014e

/)1)8)PIGXVSRMGW 'SVTSVEXMSR 7EPIW 3¾ GIW

*SV E GSQTPIXI PMWX SJ SYV KPSFEP WEPIW S¾ GIW TPIEWI ZMWMX

(MWGPEMQIV

%PP TVSHYGX WTIGM¼ GEXMSRW WXEXIQIRXW MRJSVQEXMSR ERH HEXE GSPPIGXMZIP] XLI ˆ
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ETTPMGEXMSRW FYX EVI RSX MRXIRHIH XS GSRWXMXYXI • ERH /)1)8 WTIGM¼ GEPP] HMWGPEM
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failures may still occur. Accordingly, customer applications which require a high degree of reliability or safety should employ suitable designs or other safeguard
(such as installation of protective circuitry or redundancies) in order to ensure that the failure of an electrical component does not result in a risk of personal inju
property damage.

Although all product–related warnings, cautions and notes must be observed, the customer should not assume that all safety measures are indicted or that othe
measures may not be required.