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# Ruggedized Electrical Double Layer Energy Storage Capacitors Up to 3 V Operating Voltage

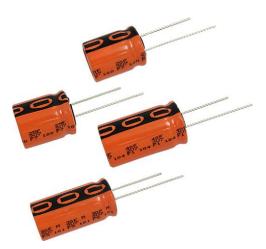


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QUICK REFERENCE DATA						
DESCRIPTION	VALUE					
	10 x 20; 10 x 25; 10 x 30;					
Nominal case sizes	12.5 x 20; 12.5 x 25; 12.5 x 30;					
(Ø D x L in mm)	12.5 x 40; 16 x 20; 18 x 20;					
(S B X E III IIIII)	16 x 25, 18 x 25; 16 x 31;					
	<b>18 x 31</b> , 18 x 35, 18 x 40					
Rated capacitance range, C <sub>R</sub>	5 F to 60 F					
Rated voltage, U <sub>R</sub> (65 °C / 85 °C)	3.0 V / 2.6 V					
Category temperature range	-40 °C to +85 °C					
Endurance test at 85 °C	Up to 1500 h					
Useful life at 85 °C	Up to 2000 h					
Useful life at 20 °C	> 10 years					
Shelf life at 20 °C	2 years					
Cycle life	> 500 000 cycles					

#### **FEATURES**

 Polarized energy storage capacitor with high capacity and energy density



F

- Rated voltage: 3.0 V
- Available in through-hole (radial) version
- Useful life: up to 2000 h at 85 °C
- Ruggedized for high humidity operation
- Rapid charge and discharge
- Maintenance-free, no service necessary
- AEC-Q200 qualified
- Material categorization: for definitions of compliance please see <a href="https://www.vishav.com/doc?99912"><u>www.vishav.com/doc?99912</u></a>

#### **APPLICATIONS**

- Power backup
- Burst power support
- Storage device for energy harvesting
- Micro UPS power source
- Energy recovery

#### **MARKING**

The capacitors are marked (where possible) with the following information:

- Rated capacitance (in F)
- Rated voltage (in V)
- Date code, in accordance with IEC 60062
- · Code indicating factory of origin
- · Logo of manufacturer
- Negative terminal identification
- Series number (235)

#### **PACKAGING**

Supplied loose in box, taped ammo, or in ESD trays.

SELECTION CHART FOR C <sub>R</sub> AND RELEVANT NOMINAL CASE SIZES				
C <sub>R</sub> (F)	U <sub>R</sub> (V) = 3.0 V			
5	10 x 20			
7	10 x 25			
8	12.5 x 20			
10	10 x 30			
12	12.5 x 25			
15	12.5 x 30			
20	16 x 20			
22	12.5 x 40			
25	16 x 25; 18 x 20			
30	18 x 25			
35	16 x 31			
40	18 x 31 <sup>(1)</sup>			
50	18 x 35			
60	18 x 40			

#### Note

(1) Preferred case size



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#### **DIMENSIONS** in millimeters **AND AVAILABLE FORMS**

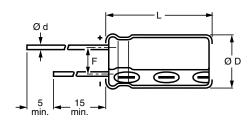


Fig. 1 - Form CA / TRAY: Long leads

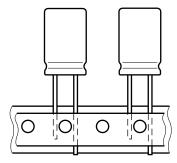


Fig. 2 - Form TFA: Taped in box (ammopack)

#### Table 1

DIMENSIONS in millimeters, MASS, AND PACKAGING QUANTITIES											
NOMINAL CASE SIZE	CASE CODE	Ød	a D		F	MASS	PACKAGING QUANTITIES				
ØDxL	CASE CODE	øа	Ø D <sub>max.</sub>	L <sub>max.</sub>		(g)	FORM CA	FORM TFA	FORM TRAY		
10 x 20	16	0.6	10.5	22	$5.0 \pm 0.5$	≈ 2.2	500	800	-		
10 x 25	16L	0.6	10.5	27	$5.0 \pm 0.5$	≈ 3.0	500	800	-		
10 x 30	16LL	0.8	10.5	32	$5.0 \pm 0.5$	≈ 3.5	500	800	-		
12.5 x 20	17	0.6	13.0	22	$5.0 \pm 0.5$	≈ 4.0	500	500	-		
12.5 x 25	18	0.6	13.0	27	$5.0 \pm 0.5$	≈ 5.0	250	500	-		
12.5 x 30	18L	0.8	13.0	33.5	$5.0 \pm 0.5$	≈ 5.5	250	500	-		
12.5 x 40	18LL	0.8	13.0	42.5	$5.0 \pm 0.5$	≈ 7.0	250	-	-		
16 x 20	19a	0.8	16.5	22	$7.5 \pm 0.5$	≈ 6.0	250	250	200		
16 x 25	19	0.8	16.5	27	$7.5 \pm 0.5$	≈ 8.0	250	250	200		
18 x 20	1820	0.8	18.5	22	$7.5 \pm 0.5$	≈ 7.0	100	250	200		
18 x 25	1825	0.8	18.5	27	$7.5 \pm 0.5$	≈ 10.0	100	250	200		
16 x 31	20	0.8	16.5	33.5	$7.5 \pm 0.5$	≈ 9.0	100	250	200		
18 x 31	1831	0.8	18.5	33.5	$7.5 \pm 0.5$	≈ 12.5	100	250	200		
18 x 35	22	0.8	18.5	37.5	7.5 ± 0.5	≈ 14.5	100	250	200		
18 x 40	1840	0.8	18.5	42.5	$7.5 \pm 0.5$	≈ 16.5	100	-	150		

ELECTRICAL DATA						
SYMBOL	DESCRIPTION					
C <sub>R</sub>	Rated capacitance, tolerance -20 % / +50 %					
Ι <sub>P</sub>	Max. peak current					
IL	Max. leakage current after 0.5 h / 72 h at U <sub>R</sub>					

#### Note

 Unless otherwise specified, all electrical values in Table 2 apply at T<sub>amb</sub> = 20 °C, P = 86 kPa to 106 kPa and RH = 45 % to 75 %

#### **ORDERING EXAMPLE**

Capacitor series 235 EDLC-HVR 40 F / 3.0 V

Nominal case size: Ø 18 mm x 31 mm; Form TRAY

Ordering code: MAL223591001E3



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#### Table 2

EL	ELECTRICAL DATA AND ORDERING INFORMATION																	
U <sub>R</sub> (V)	U <sub>MT</sub> <sup>(1)</sup> (V)	(V)	U <sub>S</sub> (V) (< 1 s)	C <sub>R</sub> <sup>(3)</sup> 100 Hz (F)	NOMINAL CASE SIZE Ø D x L (mm)	MAX. ESR <sub>DC</sub> <sup>(3)</sup> INITIAL (mΩ)	MAX. ESR <sub>AC</sub> INITIAL, 1 kHz (mΩ)	MA PE CURI	P AX. AK RENT A)	I <sub>I</sub> MA LEAK CURF AFT (mA)	XX. AGE RENT ER	STO ENE E A	RGY 「U <sub>R</sub>	ENE Ed A	CIFIC RGY T U <sub>R</sub> /kg)		ERING C AL2235	
65 °C	75 °C	85 °C					()	65 °C	85 °C	0.5 h	72 h	65 °C	85 °C	65 °C	85 °C	FORM CA	FORM TFA	FORM TRAY
3.0	2.8	2.6	3.15	5	10 x 20	39	32	12	10	2	25	0.006	0.005	2.8	2.1	51011E3	31011E3	-
3.0	2.8	2.6	3.15	7	10 x 25	35	28	12	10	3	35	0.009	0.007	2.9	2.2	51012E3	31012E3	-
3.0	2.8	2.6	3.15	8	12.5 x 20	32	25	15	12	4	40	0.010	0.008	2.5	1.9	51014E3	31014E3	-
3.0	2.8	2.6	3.15	10	10 x 30	31	24	15	12	4	45	0.013	0.009	3.6	2.7	51013E3	31013E3	-
3.0	2.8	2.6	3.15	12	12.5 x 25	30	23	17	14	5	55	0.015	0.011	3.0	2.3	51015E3	31015E3	-
3.0	2.8	2.6	3.15	15	12.5 x 30	27	20	20	17	6	70	0.019	0.014	3.4	2.6	51016E3	31016E3	-
3.0	2.8	2.6	3.15	20	16 x 20	28	22	25	20	8	75	0.025	0.019	4.2	3.1	51003E3	31003E3	91003E3
3.0	2.8	2.6	3.15	22	12.5 x 40	22	15	25	20	9	75	0.028	0.021	3.9	3.0	51017E3	-	-
3.0	2.8	2.6	3.15	25	16 x 25	26	20	25	20	8	75	0.031	0.023	3.9	2.9	51006E3	31006E3	91006E3
3.0	2.8	2.6	3.15	25	18 x 20	24	19	25	20	8	75	0.031	0.023	4.5	3.4	51004E3	31004E3	91004E3
3.0	2.8	2.6	3.15	30	18 x 25	23	17	30	25	12	140	0.038	0.028	3.8	2.8	51007E3	31007E3	91007E3
3.0	2.8	2.6	3.15	35	16 x 31	24	18	30	25	15	200	0.044	0.033	4.9	3.7	51002E3	31002E3	91002E3
3.0	2.8	2.6	3.15	40	18 x 31	22	16	35	30	20	200	0.050	0.038	4.0	3.0	51001E3	31001E3	91001E3
3.0	2.8	2.6	3.15	50	18 x 35	19	14	35	30	25	250	0.063	0.047	4.3	3.2	51008E3	31008E3	91008E3
3.0	2.8	2.6	3.15	60	18 x 40	17	13	35	30	30	300	0.075	0.056	4.5	3.4	51009E3	-	91009E3

#### Notes

- $^{(2)}$  U<sub>MT</sub> = rated voltage at 75 °C
- $^{(3)}$   $U_{CT}$  = rated voltage at upper category temperature
- (4) Rated capacitance C<sub>R</sub> and ESR<sub>DC</sub>

#### Table 3

DURANCE TEST DURATION AND USEFUL LIFE						
NOMINAL CASE SIZE Ø D x L	CASE CODE	ENDURANCE AT 85 °C (h)	USEFUL LIFE AT 85 °C (h)			
10 x 20	16	750	1000			
10 x 25	16L	750	1000			
10 x 30	16LL	750	1000			
12.5 x 20	17	1000	1500			
12.5 x 25	18	1000	1500			
12.5 x 30	18L	1000	1500			
12.5 x 40	18LL	1000	1500			
16 x 20	19a	1000	2000			
16 x 25	19	1000	2000			
18 x 20	1820	1000	2000			
18 x 25	1825	1000	2000			
16 x 31	20	1000	2000			
18 x 31	1831	1000	2000			
18 x 35	22	1000	2000			
18 x 40	1840	1000	2000			



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#### Table 4

RUGGEDIZED FOR HIGH HUMIDITY - BIASED HUMIDITY TESTING						
PARAMETER	PROCEDURE (AT RATED VOLTAGE)	REQUIREMENTS				
Humidity (relative)	85 %	After loading the capacitor for the specified time at maximum category temperature $T_{max.} = 85  ^{\circ}\text{C}$ and $85  ^{\circ}\text{C}$ relative humidity, and derated permissible maximum operation voltage U = 2.6 V, following parameters are valid within a timeframe of 1000 h:				
Temperature	85 °C	No visible damage No leakage of electrolyte ΔC/C: within ± 30 % of minimum initial specified value ESR: less than 3 x initial specified value Leakage: less than initial specified value				

TEST PROCEDURES	AND REQUIR	EMENTS (1)					
NAME OF TEST	PROCEDURE (quick reference)						
Capacitance C <sub>R</sub> and ESR <sub>DC</sub>	Measured by DC d	Measured by DC discharging method as described in "Measuring of Characteristics". (2)					
Maximum peak current	Maximum operatin Usually to be teste	Non-repetitive current for maximum 1 s at specified operating temperature.  Maximum operating voltage (refer to derating table) must not be exceeded.  Usually to be tested with constant current discharge from U <sub>R</sub> to 0.5 x U <sub>R</sub> .  Maximum current should not be used in normal operation and is only provided as reference value.					
Leakage current I <sub>L</sub>		apacitor is charged to the rated voltage at 20 $^{\circ}\text{C}$ . Leakage current is the current at specified d to keep the capacitor charged at the rated voltage.					
	After loading the capermissible maxim specified in Table 3	apacitor of specified time at maximum category temperature $T_{max.} = 85^{\circ}\text{C}$ and derated um operating voltage U = 2.6 V, following parameters are valid within a timeframe as 3:					
Endurance	Capacitance	Within ± 30 % of minimum initial specified value					
	ESR	Less than 3 x initial specified value					
	Leakage	Within specified value					
	After loading the ca permissible maxim specified in Table 3	apacitor of specified time at maximum category temperature $T_{max.} = 85$ °C and derated um operating voltage U = 2.6 V, following parameters are valid within a timeframe as 3:					
Useful life	Capacitance	Within ± 50 % of minimum initial specified value					
	ESR	Less than 4 x initial specified value					
	Leakage	Within specified value					
	After loading the capacitor of specified time at maximum category temperature T <sub>max.</sub> = 85 °C and without charge and under 40 % RH, following parameters are valid within a timeframe of 1000 h:						
Storage at upper	Capacitance Within ± 30 % of minimum initial specified value						
category temperature	ESR	Less than 3 x initial specified value					
	Leakage	Within specified value					
Shelf life	Stored uncharged at 20 °C. Parameter within initial specification						
	Cycles at 20 °C bet charge and dischar	ween rated voltage and half of rated voltage $U_{R}$ with constant current and 1 s rest betwee rge: $>$ 500 000 cycles					
Cycle life	Capacitance	Within ± 30 % of minimum initial specified value					
	ESR	Less than 3 x initial specified value					
0	$E[Wh] = \frac{1}{2} \times C \times ($	U <sub>R</sub> ) <sup>2</sup> x 1/3600					
Stored energy E, specific energy Ed and Ev	Ed [Wh/kg] = $\frac{1}{2}$ x C x (U <sub>R</sub> ) <sup>2</sup> x 1/3600 x 1/mass						
specific energy Lu and Lv	Ev [Wh/L] = $\frac{1}{2}$ x C x (U <sub>R</sub> ) <sup>2</sup> x 1/3600 x 1/volume						
Soldering	Hand or wave soldering allowed. For details refer to soldering requirements for radial aluminum electrolytic capacitors in supplementary document.						
Cleaning	For printed circuit board cleaning apply non-aggressive cleaning agents only.  For details refer to cleaning requirements for aluminum electrolytic capacitors in supplementary document.						
Environmental conditions	Do not expose capacitors to  • temperatures outside specified range  • high humidity atmospheres  • corrosive atmospheres, e.g. halogenides, sulphurous or nitrous gases, acid or alkaline solutions, etc.  • environments containing oil and grease						

#### Notes

- General remark: temperatures to be measured at capacitor case
- (1) Conditions: electrical measurements at 20 °C, unless otherwise specified
- $^{(2)}\,$  Rated capacitance  $C_R$  and  $\text{ESR}_{DC}$

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#### **MEASURING OF CHARACTERISTICS**

#### **CAPACITANCE (C)**

Capacitance shall be measured by constant current discharge method.

- Constant current charge with 10 mA/F to UR
- Constant voltage charge at UR
- Constant current discharge with 10 mA/F to 0.1 V

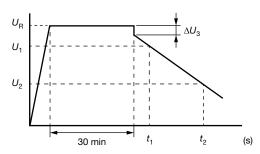


Fig. 3 - Voltage Diagram for Capacitance Measurement

Capacitance value C<sub>R</sub> is given by discharge current I<sub>D</sub>, time t and rated voltage U<sub>B</sub>, according to the following equation:

$$C_{R}[F] = \frac{I_{D}[A] \times (t_{2}[s] - t_{1}[s])}{U_{1}[V] - U_{2}[V]}$$

 $C_R$ Rated capacitance, in F  $U_{\mathsf{R}}$ Rated voltage, in V

U<sub>1</sub> Starting voltage, 0.8 x U<sub>R</sub> in V U2 Ending voltage, 0.4 x U<sub>R</sub> in V

Voltage drop at internal resistance, in V  $\Delta U_3$ 

Time from start of discharge until voltage U<sub>1</sub> is t<sub>1</sub>

reached, in s

Time from start of discharge until voltage U2 is  $t_2$ 

reached, in s

 $I_D$ Absolute value of discharge current, in A

#### EQUIVALENT SERIES RESISTANCE (ESRDC)

- Constant current charge to UR

- Constant voltage charge at UR

- Constant current discharge to 0.1 V

$$\mathsf{ESR}_{\mathsf{DC}}\left[\Omega\right] = \frac{\Delta \mathsf{U}_3\left[\mathsf{V}\right]}{\mathsf{I}_{\mathsf{D}}\left[\mathsf{A}\right]}$$

ESR<sub>DC</sub> Equivalent series resistance, in  $\Omega$  $\Delta U_R$ Voltage drop at internal resistance, in V Absolute value of discharge current, in A  $I_D$ 

Statements about product lifetime are based on calculations and internal testing. They should only be interpreted as estimations. Also due to external factors, the lifetime in the field application may deviate from the calculated lifetime. In general, nothing stated herein shall be construed as a guarantee of durability.



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