Aluminum Electrolytic Capacitors
Radial Miniature, High Voltage

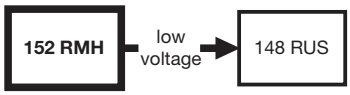

Fig. 1

FEATURES

- Long useful life: 3000 h to 4000 h at 105 °C
- AEC-Q200 qualified
- Miniaturized, ultra high CV-product per unit volume
- High reliability
- Polarized aluminum electrolytic capacitors, non-solid electrolyte
- Radial leads, cylindrical aluminum case, insulated with a blue sleeve
- Pressure relief
- Charge and discharge proof
- Material categorization: for definitions of compliance please see www.vishay.com/doc?99912

AUTOMOTIVE GRADE

Pb-free

RoHS COMPLIANT

APPLICATIONS

- Automotive
- High-reliability and professional applications
- Lighting, monitors, consumer electronics, general industrial
- Filtering of high voltages in power supplies

MARKING

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

- Rated capacitance value (in µF)
- Tolerance on rated capacitance, code letter in accordance with IEC 60062 (M for ± 20 %)
- Rated voltage (in V)
- Date code, in accordance with IEC 60062
- Code indicating factory of origin
- Name of manufacturer
- Upper category temperature (105 °C)
- Negative terminal identification
- Series number (152)

QUICK REFERENCE DATA	
DESCRIPTION	**VALUE**
Nominal case sizes (Ø D x L in mm)	10 x 12 to 18 x 35
Rated capacitance range, C_R	1.5 µF to 220 µF
Tolerance on C_R	± 20 %
Rated voltage range, U_R	200 V to 450 V
Category temperature range	-40 °C to +105 °C
Endurance test at 105 °C	2000 h
Useful life at 105 °C: Case Ø D = 10 mm and 12.5 mm Case Ø D = 16 mm and 18 mm	 3000 h 4000 h
Useful life at 40 °C, 1.6 x I_R applied: Case Ø D = 10 mm and 12.5 mm Case Ø D = 16 mm and 18 mm	 200 000 h 260 000 h
Shelf life at 0 V, 105 °C	1000 h
Based on sectional specification	IEC 60384-4 / EN 130300
Climatic category IEC 60068	40 / 105 / 56

SELECTION CHART FOR C_R, U_R, AND RELEVANT NOMINAL CASE SIZES (Ø D x L in mm)

C_R (µF)	U_R (V)			
	200	**250**	**400**	**450**
1.5	-	-	-	10 x 12
2.2	-	-	10 x 12	10 x 16
4.7	-	-	10 x 16	10 x 20
	-	-	10 x 12	-
6.8	-	-	10 x 16	12.5 x 20
10	10 x 12	10 x 16	10 x 20	12.5 x 20
22	10 x 16	12.5 x 20	12.5 x 25	16 x 25
	-	-	16 x 20	18 x 20
33	10 x 20	12.5 x 20	16 x 20	16 x 35
	-	-	-	18 x 25
47	12.5 x 20	12.5 x 25	16 x 25	18 x 35
	-	16 x 20	-	-
68	12.5 x 25	-	16 x 35	-
100	16 x 20	16 x 25	18 x 35	-
220	16 x 35	-	-	-

DIMENSIONS in millimeters AND AVAILABLE FORMS

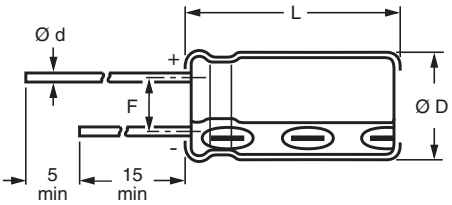

Fig. 2 - **Form CA:** Long leads

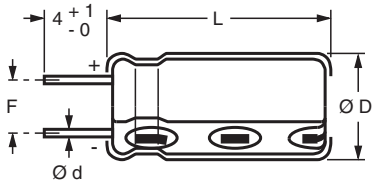

Fig. 3 - **Form CB:** Cut leads

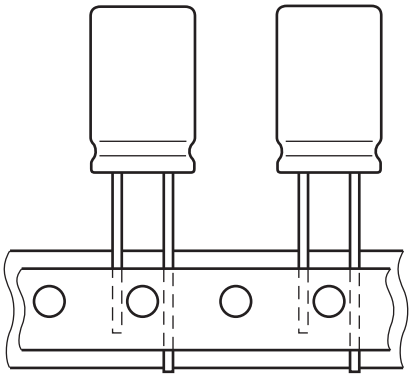

Fig. 4 - **Form TFA:** Taped in box (ammopack)

Table 1

DIMENSIONS in millimeters, MASS AND PACKAGING QUANTITIES									
NOMINAL CASE SIZE Ø D x L	CASE CODE	Ø d	Ø $D_{max.}$	$L_{max.}$	F	MASS (g)	PACKAGING QUANTITIES		
							FORM CA	FORM CB	FORM TFA
10 x 12	14	0.6	10.5	13.5	5.0 ± 0.5	≈ 1.6	1000	500	800
10 x 16	15	0.6	10.5	17.5	5.0 ± 0.5	≈ 1.9	500	500	800
10 x 20	16	0.6	10.5	22.0	5.0 ± 0.5	≈ 2.2	500	500	800
12.5 x 20	17	0.6	13.0	22.0	5.0 ± 0.5	≈ 4.0	500	500	500
12.5 x 25	18	0.6	13.0	27.0	5.0 ± 0.5	≈ 5.0	250	250	500
16 x 20	19a	0.8	16.5	22.0	7.5 ± 0.5	≈ 6.0	250	250	250
16 x 25	19	0.8	16.5	27.0	7.5 ± 0.5	≈ 8.0	250	250	250
16 x 35	21	0.8	16.5	37.5	7.5 ± 0.5	≈ 11.0	100	100	-
18 x 20	1820	0.8	18.5	22.0	7.5 ± 0.5	≈ 8.0	100	100	-
18 x 25	1825	0.8	18.5	27.0	7.5 ± 0.5	≈ 10.0	100	100	-
18 x 35	22	0.8	18.5	37.5	7.5 ± 0.5	≈ 14.5	100	100	-

Note

- For detailed tape dimensions please see www.vishay.com/doc?28360

ELECTRICAL DATA	
SYMBOL	DESCRIPTION
C_R	Rated capacitance at 100 Hz, tolerance ± 20 %
I_R	Rated RMS ripple current at 100 Hz, 105 °C
I_{L1}	Max. leakage current after 1 min at U_R
tan δ	Max. dissipation factor at 100 Hz
Z	Max. impedance at 10 kHz

Note

- Unless otherwise specified, all electrical values in Table 2 apply at T_{amb} = 20 °C, P = 86 kPa to 106 kPa, RH = 45 % to 75 %.

ORDERING EXAMPLE

Electrolytic capacitor 152 series

4.7 µF / 400 V; ± 20 %

Nominal case size: Ø 10 mm x 16 mm; form TFA

Ordering code: MAL215236478E3
Former 12NC: 2222 152 36478

Table 2

ELECTRICAL DATA AND ORDERING INFORMATION									
U_R (V)	C_R 100 Hz (µF)	NOMINAL CASE SIZE Ø D x L (mm)	I_R 100 Hz 105 °C (mA)	I_{L1} 1 min (µA)	tan δ 100 Hz	Z 10 kHz (Ω)	ORDERING CODE MAL2152		
							BULK PACKAGING		TAPED
							FORM CA	FORM CB	FORM TFA
200	10	10 x 12	85	130	0.12	6.3	52109E3	62109E3	32109E3
	22	10 x 16	120	202	0.12	3.2	52229E3	62229E3	32229E3
	33	10 x 20	150	268	0.12	2.3	52339E3	62339E3	32339E3
	47	12.5 x 20	240	352	0.12	0.9	52479E3	62479E3	32479E3
	68	12.5 x 25	310	478	0.12	0.6	52689E3	62689E3	32689E3
	100	16 x 20	340	670	0.12	0.4	52101E3	62101E3	32101E3
	220	16 x 35	630	1390	0.12	0.2	52221E3	62221E3	-
250	10	10 x 16	105	145	0.12	6.3	53109E3	63109E3	33109E3
	22	12.5 x 20	180	235	0.12	2.3	53229E3	63229E3	33229E3
	33	12.5 x 20	180	318	0.12	1.5	53339E3	63339E3	33339E3
	47	12.5 x 25	310	423	0.12	0.9	53479E3	63479E3	33479E3
	47	16 x 20	310	423	0.12	0.9	93475E3	93476E3	93473E3
	100	16 x 25	340	820	0.12	0.4	53101E3	63101E3	33101E3
400	2.2	10 x 12	44	96	0.15	28.0	56228E3	66228E3	36228E3
	4.7	10 x 12	48	127	0.15	24.0	96475E3	96476E3	96473E3
	4.7	10 x 16	65	126	0.15	18.0	56478E3	66478E3	36478E3
	6.8	10 x 16	65	152	0.15	12.0	56688E3	66688E3	36688E3
	10	10 x 20	80	190	0.15	9.0	56109E3	66109E3	36109E3
	22	12.5 x 25	150	334	0.15	3.8	56229E3	66229E3	36229E3
	22	16 x 20	150	334	0.15	3.8	96225E3	96226E3	96223E3
	33	16 x 20	190	466	0.15	2.6	56339E3	66339E3	36339E3
	47	16 x 25	240	634	0.15	2.0	56479E3	66479E3	36479E3
	68	16 x 35	310	886	0.15	1.7	56689E3	66689E3	-
	100	18 x 35	380	1270	0.15	0.9	56101E3	66101E3	-
450	1.5	10 x 12	30	90	0.20	26.0	57158E3	67158E3	37158E3
	2.2	10 x 16	50	99	0.20	26.0	57228E3	67228E3	37228E3
	4.7	10 x 20	65	133	0.20	20.0	57478E3	67478E3	37478E3
	6.8	12.5 x 20	80	162	0.20	16.0	57688E3	67688E3	37688E3
	10	12.5 x 20	90	205	0.20	10.0	57109E3	67109E3	37109E3
	22	16 x 25	150	367	0.20	4.6	57229E3	67229E3	37229E3
	22	18 x 20	150	367	0.20	4.6	97225E3	97226E3	-
	33	16 x 35	200	516	0.20	3.4	57339E3	67339E3	-
	33	18 x 25	200	516	0.20	3.4	97335E3	97336E3	-
	47	18 x 35	260	705	0.20	2.0	57479E3	67479E3	-

ADDITIONAL ELECTRICAL DATA		
PARAMETER	**CONDITIONS**	**VALUE**
Voltage		
Surge voltage	U_R = 200 V to 250 V	$U_s \leq 1.15 \times U_R$
	U_R = 400 V to 450 V	$U_s \leq 1.10 \times U_R$
Reverse voltage		$U_{rev} \leq 1$ V
Current		
Leakage current	After 1 min at U_R	$I_{L1} \leq 0.03\ C_R \times U_R + 70$ µA
	After 5 min at U_R	$I_{L5} \leq 0.015\ C_R \times U_R + 30$ µA
Inductance		
Equivalent series inductance (ESL)	Case Ø D = 10 mm	Typ. 16 nH
	Case Ø D ≥ 12.5 mm	Typ. 18 nH
Resistance		
Equivalent series resistance (ESR)	Calculated from tan $\delta_{max.}$ and C_R (see Table 2)	ESR = tan $\delta/2\ \pi\ f\ C_R$

RIPPLE CURRENT AND USEFUL LIFE

Table 3

ENDURANCE TEST DURATION AND USEFUL LIFE			
NOMINAL CASE SIZE Ø D x L (mm)	ENDURANCE AT 105 °C (h)	USEFUL LIFE AT 105 °C (h)	USEFUL LIFE AT 40 °C 1.6 x I_R APPLIED (h)
10 x 12	2000	3000	200 000
10 x 16	2000	3000	200 000
10 x 20	2000	3000	200 000
12.5 x 20	2000	3000	200 000
12.5 x 25	2000	3000	200 000
16 x 20	2000	4000	260 000
16 x 25	2000	4000	260 000
16 x 35	2000	4000	260 000
18 x 20	2000	4000	260 000
18 x 25	2000	4000	260 000
18 x 35	2000	4000	260 000

Note

- Multiplier of useful life code: CCC206

I_A = Actual ripple current at 100 Hz
I_R = Rated ripple current at 100 Hz, 105 °C

(1) Useful life at 105 °C and I_R applied
Case Ø D = 10 mm and 12.5 mm: 3000 h
Case Ø D = 16 mm and 18 mm: 4000 h

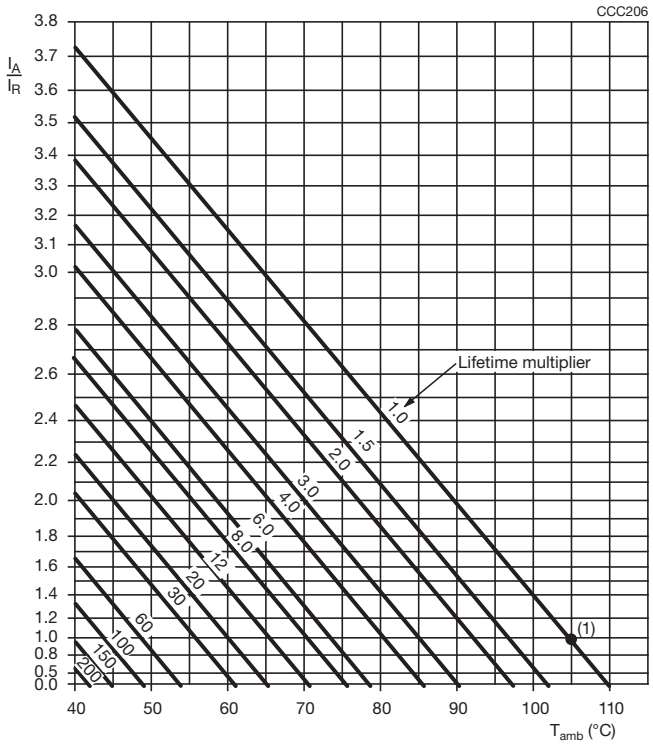

Fig. 5 - Multiplier of useful life as a function of ambient temperature and ripple current load

Table 4

MULTIPLIER OF RIPPLE CURRENT (I_R) AS A FUNCTION OF FREQUENCY							
U_R (V)	FREQUENCY (Hz)						
	50	100	300	1000	3000	10 000	≥ 100 000
	I_R MULTIPLIER						
200	0.75	1.00	1.50	2.00	2.20	2.50	3.00
250	0.75	1.00	1.50	2.00	2.20	2.50	3.00
400	0.75	1.00	1.30	1.60	1.90	2.20	2.50
450	0.75	1.00	1.30	1.60	1.90	2.20	2.50

Table 5

TEST PROCEDURES AND REQUIREMENTS			
TEST		PROCEDURE (quick reference)	REQUIREMENTS
NAME OF TEST	REFERENCE		
Endurance	IEC 60384-4 / EN 130300 subclause 4.13	T_{amb} = 105 °C; U_R applied; 2000 h	ΔC/C: ± 20 % tan δ ≤ 2 x spec. limit Z ≤ 2 x spec. limit I_{L5} ≤ spec. limit
Useful life	CECC 30301 subclause 1.8.1	T_{amb} = 105 °C; U_R and I_R applied; Case Ø D = 10 mm and 12.5 mm: 3000 h Case Ø D = 16 mm and 18 mm: 4000 h	ΔC/C: ± 50 % tan δ ≤ 3 x spec. limit Z ≤ 3 x spec. limit I_{L5} ≤ spec. limit no short or open circuit total failure percentage: ≤ 1 %
Shelf life (storage at high temperature)	IEC 60384-4 / EN 130300 subclause 4.17	T_{amb} = 105 °C; no voltage applied; 1000 h After test: U_R to be applied for 30 min, 24 h to 48 h before measurement	ΔC/C: ± 20 % tan δ ≤ 2 x spec. limit Z ≤ 2 x spec. limit I_{L5} ≤ 2 x spec. limit
Reverse voltage	IEC 60384-4 / EN 130300 subclause 4.15	T_{amb} = 105 °C: 125 h at U = -1 V, followed by 125 h at U_R	ΔC/C: ± 15 % I_{L5} ≤ spec. limit tan δ ≤ spec. limit

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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