Aluminum Electrolytic Capacitors
Radial, High Temperature Miniature

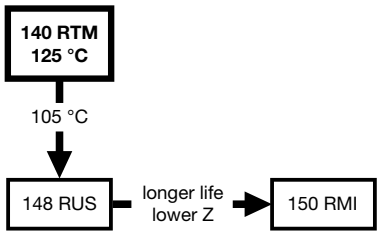


Fig. 1

FEATURES

AUTOMOTIVE GRADE

Pb-free

RoHS COMPLIANT

- Very long useful life: 2500 h to 4000 h at 125 °C
- High stability, high reliability
- AEC-Q200 qualified
- Extended temperature range up to 125 °C
- High ripple current capability
- Polarized aluminum electrolytic capacitors, non-solid electrolyte
- Radial leads, cylindrical aluminum case with pressure relief, insulated with a blue sleeve
- Charge and discharge proof
- Material categorization: for definitions of compliance please see www.vishay.com/doc?99912

APPLICATIONS

- EDP, telecommunication, industrial, automotive and military
- Smoothing, filtering, buffering in SMPS
- High ambient temperature environments

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 (125 °C)
- Negative terminal identification
- Series number (140)

QUICK REFERENCE DATA	
DESCRIPTION	**VALUE**
Nominal case sizes (Ø D x L in mm)	10 x 12 to 18 x 31
Rated capacitance range, C_R	22 µF to 4700 µF
Tolerance on C_R	± 20 %
Rated voltage range, U_R	6.3 V to 63 V
Category temperature range	-55 °C to +125 °C
Endurance test at 125 °C	2000 h
Useful life at 125 °C	2500 h to 4000 h
Useful life at 40 °C, 1.6 x I_R applied	300 000 h
Shelf life at 0 V, 125 °C	500 h
Based on sectional specification	IEC 60384-4 / EN 130300
Climatic category IEC 60068	55 / 125 / 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)						
	6.3	**10**	**16**	**25**	**35**	**50**	**63**
22	-	-	-	-	-	-	10 x 12
47	-	-	-	-	-	10 x 12	10 x 12
100	-	-	-	-	10 x 12	10 x 16	10 x 20
220	-	-	10 x 12	10 x 16	10 x 16	12.5 x 20	16 x 20
330	-	10 x 12	10 x 16	10 x 20	-	12.5 x 20	16 x 20
470	-	10 x 16	10 x 16	10 x 20	12.5 x 20	12.5 x 25	16 x 25
	-	-	-	-	-	16 x 20	-
1000	-	10 x 20	12.5 x 20	12.5 x 25	16 x 25	16 x 31	18 x 31
	-	-	-	16 x 20	-	-	-
1200	10 x 16	-	-	-	-	-	-
2200	10 x 20	12.5 x 25	16 x 25	16 x 31	18 x 31	-	-
	-	16 x 20	-	-	-	-	-
3300	-	16 x 25	16 x 31	18 x 31	-	-	-
4700	-	16 x 31	18 x 31	-	-	-	-

DIMENSIONS in millimeters **AND AVAILABLE FORMS**

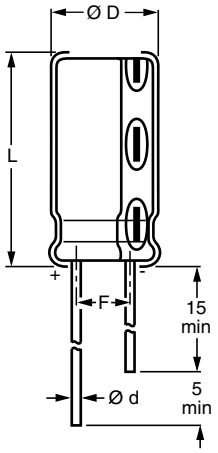


Fig. 2 - **Form CA:** Long leads

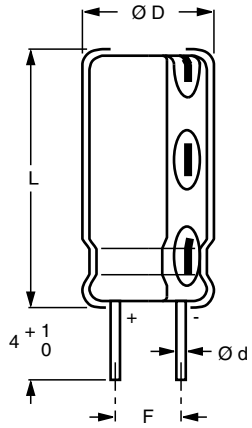


Fig. 3 - **Form CB:** Cut leads

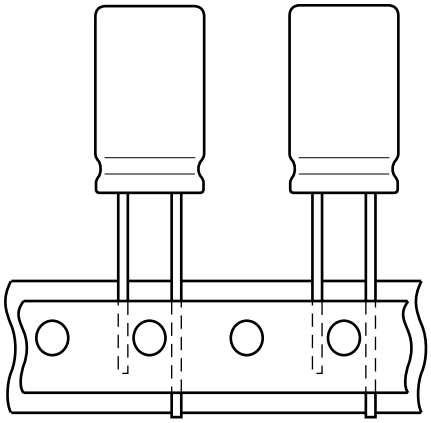


Fig. 4 - **Form TFA:** Taped in box (ammopack)

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 31	20	0.8	16.5	33.5	7.5 ± 0.5	≈ 9.0	100	100	250
18 x 31	1831	0.8	18.5	33.5	7.5 ± 0.5	≈ 12.5	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 kHz, 125 °C
I_{L1}	Max. leakage current after 1 min at U_R
tan δ	Max. dissipation factor at 100 Hz
Z	Max. impedance at 100 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 140 series

220 µF / 25 V; ± 20 %

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

Ordering code: MAL214036221E3
Former 12NC: 2222 140 36221

ELECTRICAL DATA AND ORDERING INFORMATION

U_R (V)	C_R 100 Hz (µF)	NOMINAL CASE SIZE Ø D x L (mm)	I_R 100 kHz 125 °C (mA)	I_{L1} 1 min (µA)	tan δ 100 Hz	Z 100 kHz + 20 °C (Ω)	Z 100 kHz - 40 °C (Ω)	ORDERING CODE MAL2140		
								BULK PACKAGING		TAPED
								FORM CA	FORM CB	FORM TFA
6.3	1200	10 x 16	760	79	0.28	0.150	1.10	53122E3	63122E3	33122E3
	2200	10 x 20	850	142	0.28	0.120	0.85	53222E3	63222E3	33222E3
10	330	10 x 12	480	36	0.20	0.200	1.40	54331E3	64331E3	34331E3
	470	10 x 16	760	50	0.20	0.150	1.10	54471E3	64471E3	34471E3
	1000	10 x 20	850	103	0.20	0.120	0.85	54102E3	64102E3	34102E3
	2200	12.5 x 25	1400	223	0.24	0.050	0.40	94225E3	94226E3	94223E3
	2200	16 x 20	1400	223	0.24	0.050	0.40	54222E3	64222E3	34222E3
	3300	16 x 25	1900	333	0.24	0.034	0.25	54332E3	64332E3	34332E3
	4700	16 x 31	2200	473	0.24	0.030	0.20	54472E3	64472E3	34472E3
16	220	10 x 12	480	38	0.16	0.200	1.40	55221E3	65221E3	35221E3
	330	10 x 16	760	56	0.16	0.150	1.10	55331E3	65331E3	35331E3
	470	10 x 16	760	78	0.16	0.150	1.10	55471E3	65471E3	35471E3
	1000	12.5 x 20	1200	163	0.16	0.073	0.50	55102E3	65102E3	35102E3
	2200	16 x 25	1900	355	0.18	0.034	0.25	55222E3	65222E3	35222E3
	3300	16 x 31	2200	531	0.18	0.030	0.20	55332E3	65332E3	35332E3
	4700	18 x 31	2200	755	0.18	0.030	0.20	55472E3	65472E3	-
25	220	10 x 16	750	58	0.14	0.150	1.10	56221E3	66221E3	36221E3
	330	10 x 20	850	86	0.14	0.120	0.85	56331E3	66331E3	36331E3
	470	10 x 20	850	121	0.14	0.120	0.85	56471E3	66471E3	36471E3
	1000	12.5 x 25	1400	253	0.14	0.050	0.40	96105E3	96106E3	96103E3
	1000	16 x 20	1400	253	0.14	0.050	0.40	56102E3	66102E3	36102E3
	2200	16 x 31	2200	553	0.16	0.030	0.20	56222E3	66222E3	36222E3
	3300	18 x 31	2200	828	0.16	0.030	0.20	56332E3	66332E3	-
35	100	10 x 12	480	38	0.12	0.200	1.40	50101E3	60101E3	30101E3
	220	10 x 16	760	80	0.12	0.150	1.10	50221E3	60221E3	30221E3
	470	12.5 x 20	1200	168	0.12	0.073	0.50	50471E3	60471E3	30471E3
	1000	16 x 25	1500	353	0.12	0.034	0.25	50102E3	60102E3	30102E3
	2200	18 x 31	2200	773	0.14	0.030	0.20	50222E3	60222E3	-
50	47	10 x 12	300	27	0.10	0.300	2.00	51479E3	61479E3	31479E3
	100	10 x 16	380	53	0.10	0.200	1.40	51101E3	61101E3	31101E3
	220	12.5 x 20	580	113	0.10	0.120	0.85	51221E3	61221E3	31221E3
	330	12.5 x 20	870	168	0.10	0.120	0.85	51331E3	61331E3	31331E3
	470	12.5 x 25	1100	238	0.10	0.085	0.60	91475E3	91476E3	91473E3
	470	16 x 20	1100	238	0.10	0.085	0.60	51471E3	61471E3	31471E3
	1000	16 x 31	1700	503	0.10	0.045	0.30	51102E3	61102E3	31102E3
63	22	10 x 12	380	17	0.10	0.300	2.00	58229E3	68229E3	38229E3
	47	10 x 12	380	33	0.10	0.300	2.00	58479E3	68479E3	38479E3
	100	10 x 20	650	66	0.10	0.160	1.10	58101E3	68101E3	38101E3
	220	16 x 20	1100	142	0.10	0.085	0.60	58221E3	68221E3	38221E3
	330	16 x 20	1100	211	0.10	0.085	0.60	58331E3	68331E3	38331E3
	470	16 x 25	1500	299	0.10	0.055	0.40	58471E3	68471E3	38471E3
	1000	18 x 31	1800	633	0.10	0.040	0.28	58102E3	68102E3	-

ADDITIONAL ELECTRICAL DATA		
PARAMETER	**CONDITIONS**	**VALUE**
Voltage		
Surge voltage		$U_s \leq 1.15 \times U_R$
Reverse voltage		$U_{rev} \leq 1$ V
Current		
Leakage current	After 1 min at U_R	$I_{L1} \leq 0.01\ C_R \times U_R + 3$ µA
	After 5 min at U_R	$I_{L5} \leq 0.002\ C_R \times U_R + 3$ 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 $\delta/2\ \pi\ f\ C_R$

CAPACITANCE (C)

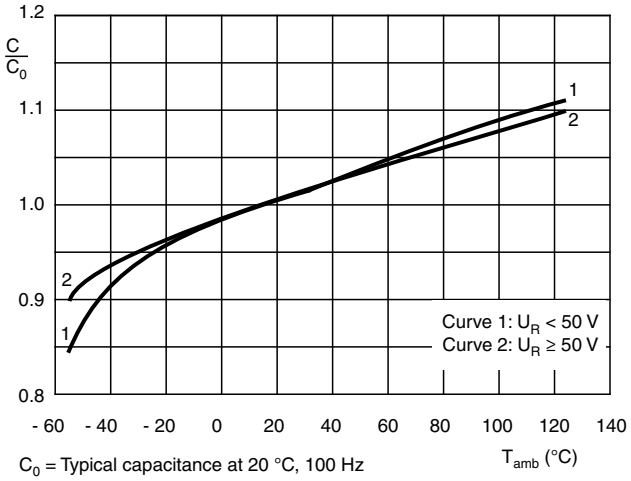


Fig. 5 - Typical multiplier of capacitance as a function of ambient temperature

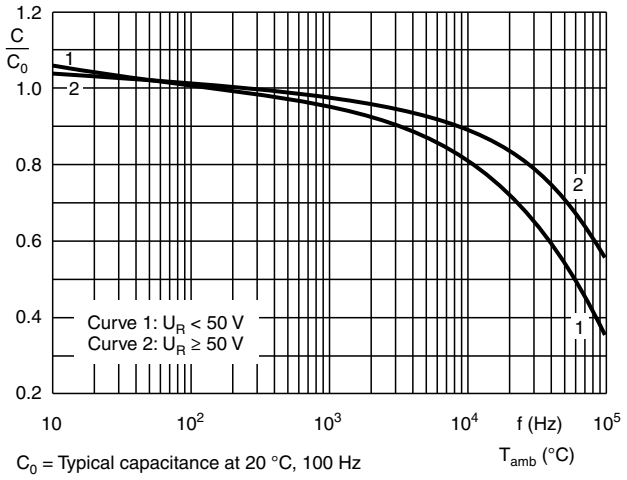


Fig. 6 - Typical multiplier of capacitance as a function of frequency

EQUIVALENT SERIES RESISTANCE (ESR)

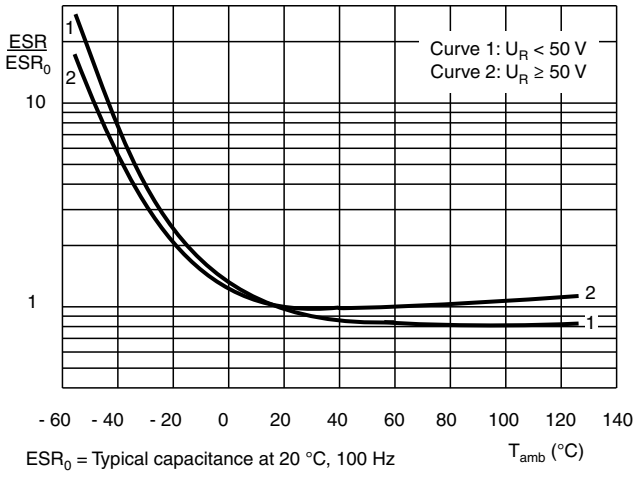


Fig. 7 - Typical multiplier of ESR as a function of ambient temperature

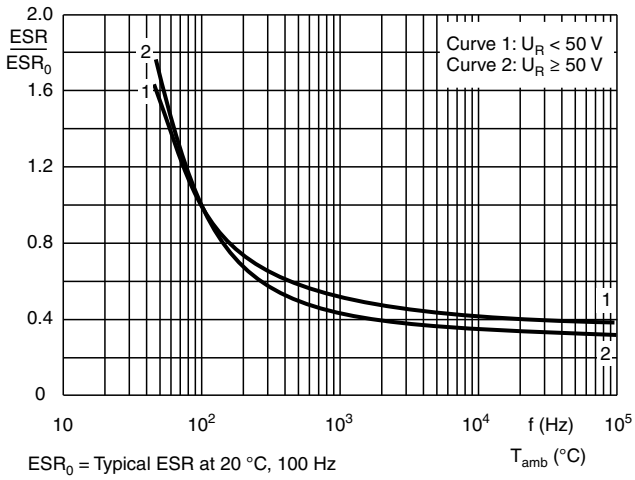


Fig. 8 - Typical multiplier of ESR as a function of frequency

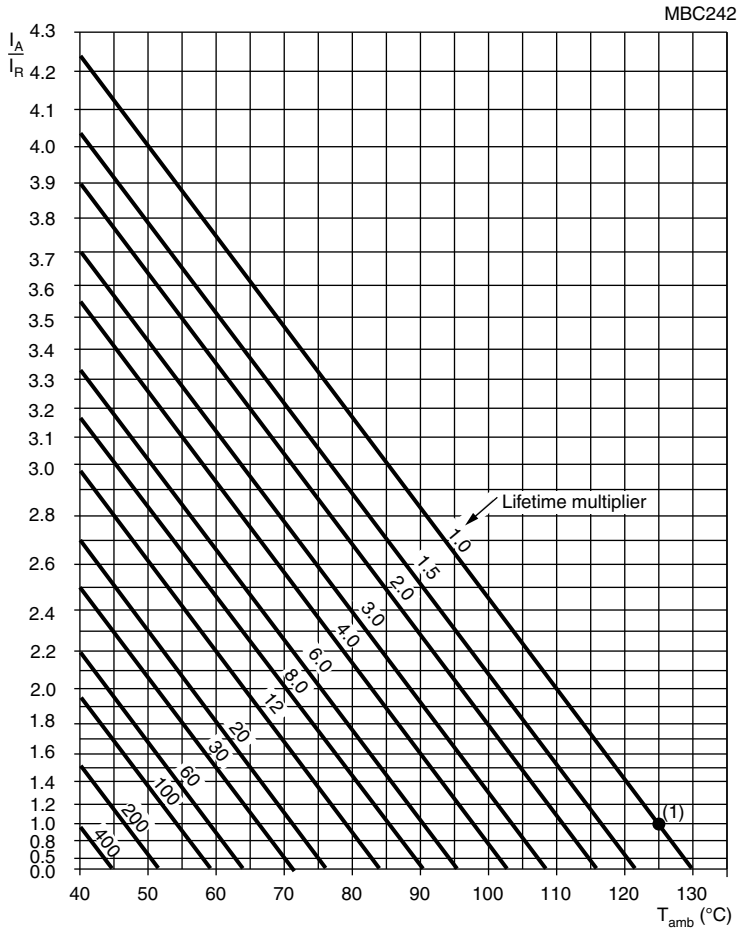
RIPPLE CURRENT AND USEFUL LIFE

Table 2

ENDURANCE TEST DURATION AND USEFUL LIFE			
NOMINAL CASE SIZE Ø D x L (mm)	CASE CODE	ENDURANCE TEST AT 125 °C (h)	USEFUL LIFE AT 125 °C (h)
10 x 12	14	2000	2500
10 x 16	15	2000	3000
10 x 20	16	2000	3000
12.5 x 20	17	2000	3000
12.5 x 25	18	2000	3000
16 x 20	19a	2000	3000
16 x 25	19	2000	4000
16 x 31	20	2000	4000
18 x 31	1831	2000	4000

Note

- Multiplier of useful life code: MBC242



I_A = Actual ripple current at 100 kHz
I_R = Rated ripple current at 100 kHz, 125 °C

(1) Useful life at 125 °C and I_R applied: see Table 3

Fig. 9 - Multiplier of useful life as a function of ambient temperature and ripple current load

Table 3

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						
6.3	0.60	0.70	0.85	0.90	0.95	1.00	1.00
10	0.60	0.70	0.85	0.90	0.95	1.00	1.00
16	0.60	0.70	0.85	0.90	0.95	1.00	1.00
25	0.60	0.70	0.85	0.90	0.95	1.00	1.00
35	0.50	0.65	0.80	0.85	0.90	0.95	1.00
50	0.35	0.50	0.65	0.80	0.90	0.90	1.00
63	0.35	0.50	0.65	0.80	0.90	0.90	1.00

Table 4

TEST PROCEDURES AND REQUIREMENTS			
TEST		PROCEDURE (quick reference)	REQUIREMENTS
NAME OF TEST	REFERENCE		
Endurance	IEC 60384-4 / EN 130300 subclause 4.13	T_{amb} = 125 °C; U_R applied; 2000 h	ΔC/C: ± 15 % tan δ ≤ 1.3 x spec. limit Z ≤ 2 x spec. limit I_{L5} ≤ spec. limit
Useful life	CECC 30301 subclause 1.8.1	T_{amb} = 125 °C; U_R and I_R applied; for test duration see Table 3	ΔC/C: ± 30 % 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	IEC 60384-4 / EN 130300 subclause 4.17	T_{amb} = 125 °C; no voltage applied; 500 h After test: U_R to be applied for 30 min, 24 h to 48 h before measurement	ΔC/C: ± 15 % tan δ ≤ 1.3 x spec. limit Z ≤ 2 x spec. limit I_{L5} ≤ 2 x 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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