

## Aluminum Capacitors Radial, High Temperature Miniature

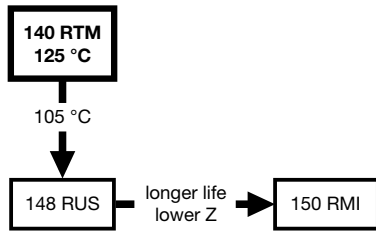


Fig. 1

### FEATURES

- 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](http://www.vishay.com/doc?99912)


**RoHS  
COMPLIANT**

### 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  $\mu\text{F}$ )
- Tolerance on rated capacitance, code letter in accordance with IEC 60062 (M for  $\pm 20\%$ )
- 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 ( $\varnothing$ D x L in mm)	10 x 12 to 18 x 31
Rated capacitance range, $C_R$	22 $\mu\text{F}$ to 4700 $\mu\text{F}$
Tolerance on $C_R$	$\pm 20\%$
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 ( $\varnothing$ D x L in mm)							
$C_R$ ( $\mu\text{F}$ )	$U_R$ (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	-	-	-	-

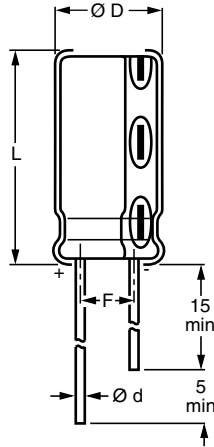
**DIMENSIONS** in millimeters **AND AVAILABLE FORMS**


Fig. 2 - Form CA: Long leads

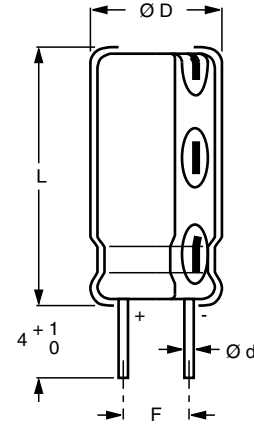


Fig. 3 - Form CB: Cut leads

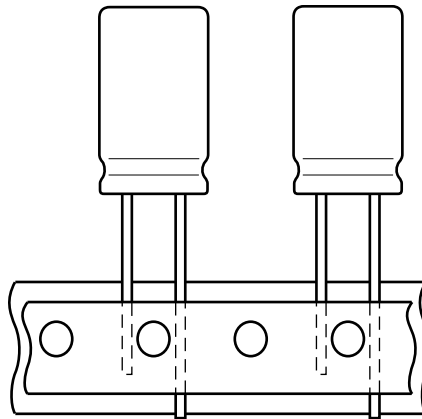


Fig. 4 - Form TFA: Taped in box (ammopack)

**Table 1**

<b>DIMENSIONS</b> in millimeters, <b>MASS, AND PACKAGING QUANTITIES</b>									
NOMINAL CASE SIZE Ø D x L	CASE CODE	Ø d	Ø D <sub>max.</sub>	L <sub>max.</sub>	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](http://www.vishay.com/doc?28360)



ELECTRICAL DATA	
SYMBOL	DESCRIPTION
$C_R$	Rated capacitance at 100 Hz, tolerance $\pm 20\%$
$I_R$	Rated RMS ripple current at 100 kHz, 125 °C
$I_{L1}$	Max. leakage current after 1 min at $U_R$
$\tan \delta$	Max. dissipation factor at 100 Hz
Z	Max. impedance at 100 kHz

**Note**

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

**ORDERING EXAMPLE**

Electrolytic capacitor 140 series

220  $\mu\text{F}/25\text{ V}$ ;  $\pm 20\%$

Nominal case size:  $\varnothing 10\text{ mm} \times 16\text{ mm}$ ; form TFA

Ordering code: MAL214036221E3

Former 12NC: 2222 140 36221

**ELECTRICAL DATA AND ORDERING INFORMATION**

$U_R$ (V)	$C_R$ 100 Hz ( $\mu\text{F}$ )	NOMINAL CASE SIZE $\varnothing D \times L$ (mm)	$I_R$ 100 kHz 125 °C (mA)	$I_{L1}$ 1 min ( $\mu\text{A}$ )	$\tan \delta$ 100 Hz	Z 100 kHz + 20 °C ( $\Omega$ )	Z 100 kHz - 40 °C ( $\Omega$ )	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
<b>Voltage</b>		
Surge voltage		$U_s \leq 1.15 \times U_R$
Reverse voltage		$U_{rev} \leq 1 \text{ V}$
<b>Current</b>		
Leakage current	After 1 min at $U_R$	$I_{L1} \leq 0.01 C_R \times U_R + 3 \mu\text{A}$
	After 5 min at $U_R$	$I_{L5} \leq 0.002 C_R \times U_R + 3 \mu\text{A}$
<b>Inductance</b>		
Equivalent series inductance (ESL)	Case $\varnothing D = 10 \text{ mm}$	Typ. 16 nH
	Case $\varnothing D \geq 12.5 \text{ mm}$	Typ. 18 nH
<b>Resistance</b>		
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 AND USEFUL LIFE AS A FUNCTION OF CASE SIZE			
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

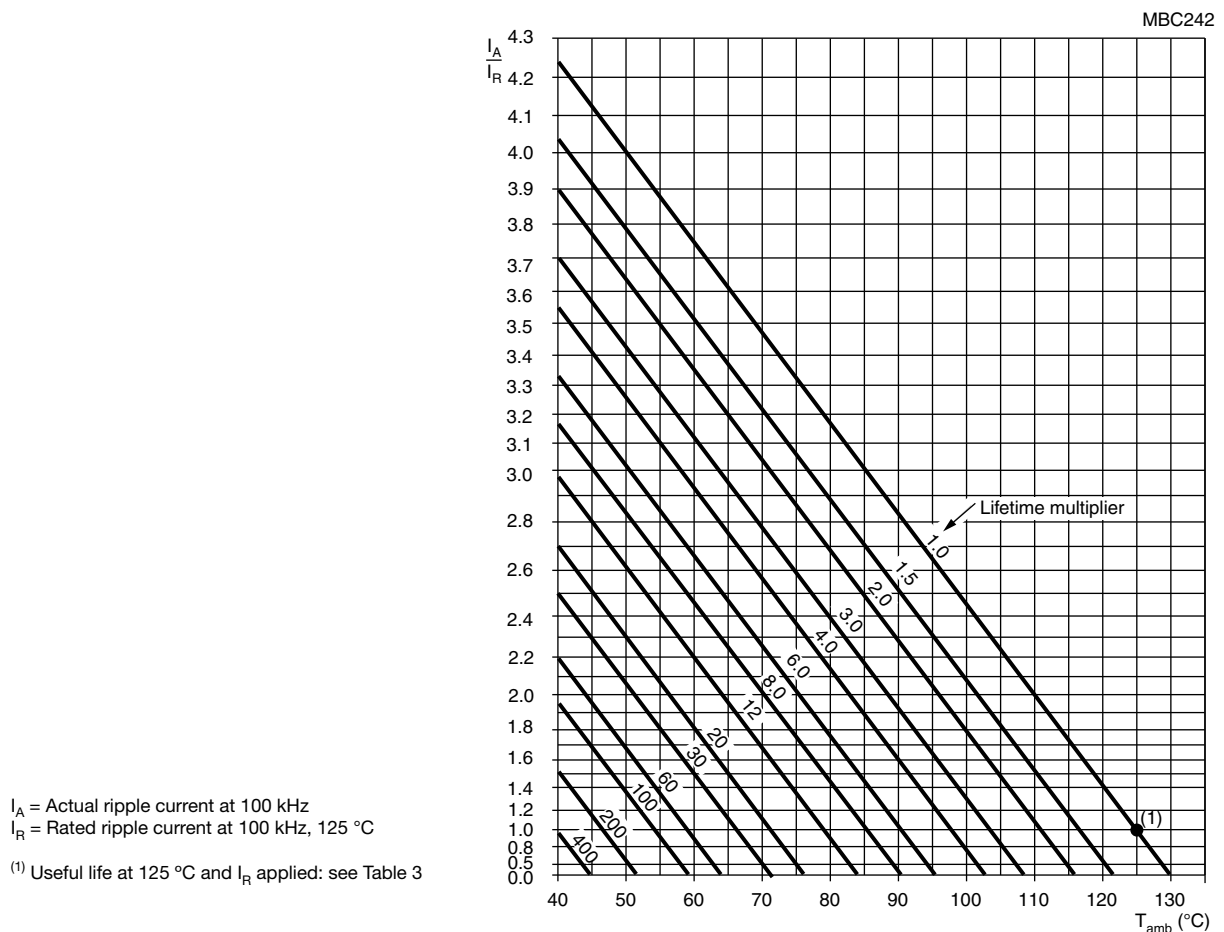


Fig. 9 - Multiplier of useful life as a function of ambient temperature and ripple current load

**Table 3**

<b>MULTIPLIER OF RIPPLE CURRENT (<math>I_R</math>) AS A FUNCTION OF FREQUENCY</b>			
<b>FREQUENCY (Hz)</b>	<b><math>I_R</math> MULTIPLIER</b>		
	<b><math>U_R = 6.3 \text{ V TO } 25 \text{ V}</math></b>	<b><math>U_R = 35 \text{ V}</math></b>	<b><math>U_R = 50 \text{ V AND } 63 \text{ V}</math></b>
50	0.60	0.50	0.35
100	0.70	0.65	0.50
300	0.85	0.80	0.65
1000	0.90	0.85	0.80
3000	0.95	0.90	0.90
10 000	1.00	0.95	0.90
100 000	1.00	1.00	1.00

**Table 4**

<b>TEST PROCEDURES AND REQUIREMENTS</b>			
<b>TEST</b>		<b>PROCEDURE (quick reference)</b>	<b>REQUIREMENTS</b>
<b>NAME OF TEST</b>	<b>REFERENCE</b>		
Endurance	IEC 60384-4/ EN 130300 subclause 4.13	$T_{amb} = 125 \text{ }^\circ\text{C}$ ; $U_R$ applied; 2000 h	$\Delta C/C: \pm 15 \%$ $\tan \delta \leq 1.3 \times \text{spec. limit}$ $Z \leq 2 \times \text{spec. limit}$ $I_{L5} \leq \text{spec. limit}$
Useful life	CECC 30301 subclause 1.8.1	$T_{amb} = 125 \text{ }^\circ\text{C}$ ; $U_R$ and $I_R$ applied; for test duration see Table 3	$\Delta C/C: \pm 30 \%$ $\tan \delta \leq 3 \times \text{spec. limit}$ $Z \leq 3 \times \text{spec. limit}$ $I_{L5} \leq \text{spec. limit}$ no short or open circuit total failure percentage: $\leq 1 \%$
Shelf life	IEC 60384-4/ EN 130300 subclause 4.17	$T_{amb} = 125 \text{ }^\circ\text{C}$ ; no voltage applied; 500 h After test: $U_R$ to be applied for 30 min, 24 h to 48 h before measurement	$\Delta C/C: \pm 15 \%$ $\tan \delta \leq 1.3 \times \text{spec. limit}$ $Z \leq 2 \times \text{spec. limit}$ $I_{L5} \leq 2 \times \text{spec. limit}$



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