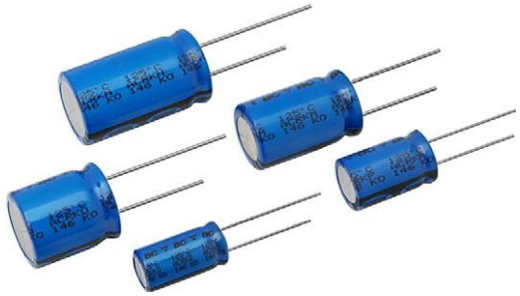
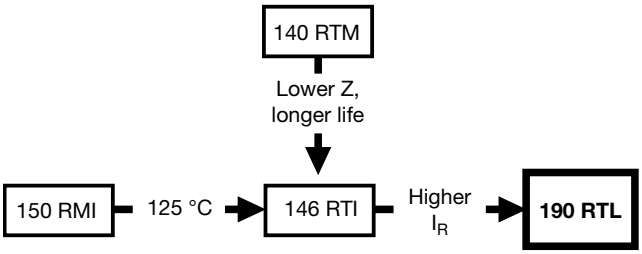
Aluminum Electrolytic Capacitors
Radial, High Temperature, Low Impedance





FEATURES

AUTOMOTIVE GRADE

Pb-free

RoHS COMPLIANT

- Very long useful life:
  2500 h to 6000 h at 125 °C
- High stability, high reliability
- Very low ESR
- AEC-Q200 qualified
- Excellent ripple current capability
- Polarized aluminum electrolytic capacitors, non-solid electrolyte
- Radial leads, cylindrical aluminum case with pressure relief, insulated with a blue PET sleeve
- Charge and discharge proof
- Material categorization: for definitions of compliance please see www.vishay.com/doc?99912

APPLICATIONS

- Power supplies (SMPS, DC/DC converters) for industrial, automotive, telecommunications and military
- Smoothing, filtering and buffering

MARKING

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

- Rated capacitance (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
- Logo of manufacturer
- Upper category temperature (125 °C)
- Negative terminal identification
- Series number (190)

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	100 µF to 6800 µF
Tolerance on C_R	± 20 %
Rated voltage range, U_R	16 V to 50 V
Category temperature range	-55 °C to +125 °C
Endurance test at 125 °C	2000 h to 5000 h
Useful life at 125 °C	2500 h to 6000 h
Useful life at 40 °C, 1.8 x I_R applied	400 000 h
Shelf life at 0 V, 125 °C	1000 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)			
	16	**25**	**35**	**50**
68	-	-	-	-
100	-	-	-	10 x 12
150	-	-	-	-
220	-	-	10 x 12	10 x 16
330	-	10 x 12	10 x 16	10 x 20
390	-	-	-	-
470	10 x 12	10 x 16	10 x 20	12.5 x 20
560	-	-	-	-
680	10 x 16	10 x 20	12.5 x 20	12.5 x 25
	-	-	-	-
820	-	-	-	16 x 20
1000	10 x 20	12.5 x 20	12.5 x 25	18 x 20
	-	-	-	16 x 25

SELECTION CHART FOR C_R, U_R, AND RELEVANT NOMINAL CASE SIZES (Ø D x L in mm)				
C_R (µF)	U_R (V)			
	16	25	35	50
1200	-	-	16 x 20	18 x 25
	-	-	-	16 x 31
1500	12.5 x 20	12.5 x 25	18 x 20	16 x 35
1800	-	16 x 20	16 x 25	18 x 31
2200	12.5 x 25	-	18 x 25	18 x 35
	-	-	16 x 31	-
2700	16 x 20	18 x 20	16 x 35	-
	-	16 x 25	18 x 31	-
3300	18 x 20	16 x 31	18 x 35	-
3900	16 x 25	18 x 25	-	-
4700	18 x 25	16 x 35	-	-
	16 x 31	18 x 31	-	-
5600	16 x 35	18 x 35	-	-
6800	18 x 31	-	-	-

DIMENSIONS in millimeters AND AVAILABLE FORMS

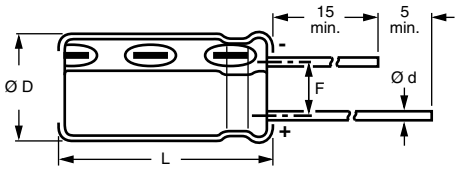


Fig. 2 - **Form CA**: Long leads

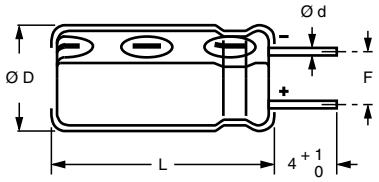


Fig. 3 - **Form CB:** Cut leads

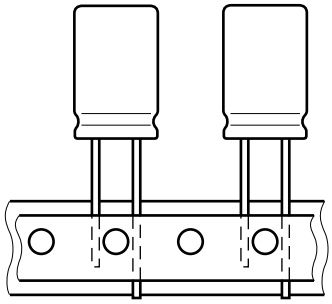


Fig. 4 - **Form TFA**: Taped in box (ammopack)

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
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	250
18 x 25	1825	0.8	18.5	27.0	7.5 ± 0.5	≈ 10.0	100	100	250
18 x 31	1831	0.8	18.5	33.5	7.5 ± 0.5	≈ 12.5	100	100	250
18 x 35	22	0.8	18.5	37.5	7.5 ± 0.5	≈ 14.5	100	100	-

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_{L2}	Max. leakage current after 2 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 190 RTL series

470 µF / 25 V; ± 20 %

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

Ordering code: MAL219036471E3

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 kHz 125 °C (mA)	I_{L2} 2 min (µA)	tan δ 100 Hz	Z 100 kHz (Ω)	ORDERING CODE MAL2190.....		
							BULK PACKAGING		TAPED
							FORM CA	FORM CB	FORM TFA
16	470	10 x 12	770	75	0.16	0.106	55471E3	65471E3	35471E3
	680	10 x 16	1160	112	0.16	0.069	55681E3	65681E3	35681E3
	1000	10 x 20	1310	163	0.16	0.053	55102E3	65102E3	35102E3
	1500	12.5 x 20	1760	243	0.16	0.038	55152E3	65152E3	35152E3
	2200	12.5 x 25	2200	355	0.18	0.030	55222E3	65222E3	35222E3
	2700	16 x 20	2100	435	0.18	0.027	55272E3	65272E3	35272E3
	3300	18 x 20	2100	531	0.18	0.031	55332E3	65332E3	35332E3
	3900	16 x 25	2630	627	0.18	0.022	55392E3	65392E3	35392E3
	4700	18 x 25	3150	755	0.18	0.020	55472E3	65472E3	35472E3
	4700	16 x 31	2940	755	0.18	0.024	95475E3	95476E3	95473E3
	5600	16 x 35	3360	899	0.18	0.017	55562E3	65562E3	-
	6800	18 x 31	3260	1091	0.18	0.021	55682E3	65682E3	35682E3
25	330	10 x 12	770	82	0.14	0.106	56331E3	66331E3	36331E3
	470	10 x 16	1160	121	0.14	0.069	56471E3	66471E3	36471E3
	680	10 x 20	1310	173	0.14	0.053	56681E3	66681E3	36681E3
	1000	12.5 x 20	1760	253	0.14	0.038	56102E3	66102E3	36102E3
	1500	12.5 x 25	2200	378	0.14	0.030	56152E3	66152E3	36152E3
	1800	16 x 20	2100	453	0.14	0.027	56182E3	66182E3	36182E3
	2700	18 x 20	2630	678	0.16	0.022	56272E3	66272E3	36272E3
	2700	16 x 25	2100	678	0.16	0.031	96275E3	96276E3	96273E3
	3300	16 x 31	3150	828	0.16	0.020	56332E3	66332E3	36332E3
	3900	18 x 25	2940	978	0.16	0.024	56392E3	66392E3	36392E3
	4700	16 x 35	3360	1178	0.16	0.017	56472E3	66472E3	-
	4700	18 x 31	3260	1178	0.16	0.021	96475E3	96476E3	96473E3
	5600	18 x 35	3300	1403	0.16	0.019	56562E3	66562E3	-
35	220	10 x 12	770	77	0.12	0.106	50221E3	60221E3	30221E3
	330	10 x 16	1160	119	0.12	0.069	50331E3	60331E3	30331E3
	470	10 x 20	1310	168	0.12	0.053	50471E3	60471E3	30471E3
	680	12.5 x 20	1760	241	0.12	0.038	50681E3	60681E3	30681E3
	1000	12.5 x 25	2200	353	0.12	0.030	50102E3	60102E3	30102E3
	1200	16 x 20	2100	423	0.12	0.027	50122E3	60122E3	30122E3
	1500	18 x 20	2100	528	0.12	0.031	50152E3	60152E3	30152E3
	1800	16 x 25	2630	633	0.12	0.022	50182E3	60182E3	30182E3
	2200	18 x 25	3150	773	0.14	0.020	50222E3	60222E3	30222E3
	2200	16 x 31	2940	773	0.14	0.024	90225E3	90226E3	90223E3
	2700	16 x 35	3360	948	0.14	0.017	50272E3	60272E3	-
	2700	18 x 31	3260	948	0.14	0.021	90275E3	90276E3	90273E3
	3300	18 x 35	3300	1158	0.14	0.019	50332E3	60332E3	-

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_{L2} 2 min (µA)	tan δ 100 Hz	Z 100 kHz (Ω)	ORDERING CODE MAL2190.....		
							BULK PACKAGING		TAPED
							FORM CA	FORM CB	FORM TFA
50	100	10 x 12	560	50	0.10	0.175	51101E3	61101E3	31101E3
	220	10 x 16	945	113	0.10	0.118	51221E3	61221E3	31221E3
	330	10 x 20	1050	168	0.10	0.088	51331E3	61331E3	31331E3
	470	12.5 x 20	1320	238	0.10	0.062	51471E3	61471E3	31471E3
	680	12.5 x 25	1790	343	0.10	0.053	51681E3	61681E3	31681E3
	820	16 x 20	1730	413	0.10	0.043	51821E3	61821E3	31821E3
	1000	18 x 20	2330	503	0.10	0.029	51102E3	61102E3	31102E3
	1000	16 x 25	1900	503	0.10	0.037	91105E3	91106E3	91103E3
	1200	18 x 25	2700	603	0.10	0.026	51122E3	61122E3	31122E3
	1200	16 x 31	2530	603	0.10	0.029	91125E3	91126E3	91123E3
	1500	16 x 35	2950	753	0.10	0.021	51152E3	61152E3	-
	1800	18 x 31	2850	903	0.10	0.025	51182E3	61182E3	31182E3
	2200	18 x 35	3150	1103	0.12	0.021	51222E3	61222E3	-

ADDITIONAL ELECTRICAL DATA

PARAMETER	CONDITIONS	VALUE
Voltage		
Surge voltage		$U_s \leq 1.15 \times U_R$
Reverse voltage		$U_{rev} \leq 0.5$ V
Current		
Leakage current	After 2 min at U_R	$I_{L2} \leq 0.01\ C_R \times U_R + 3$ 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)

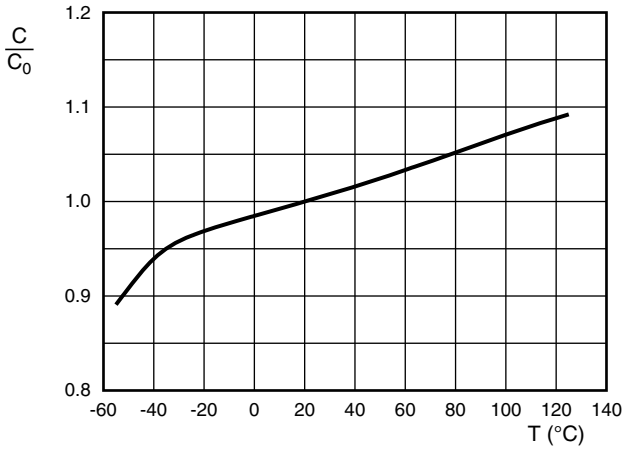


Fig. 5 - Typical multiplier of capacitance at 100 Hz as a function of temperature (C_0 = C at 20 °C)

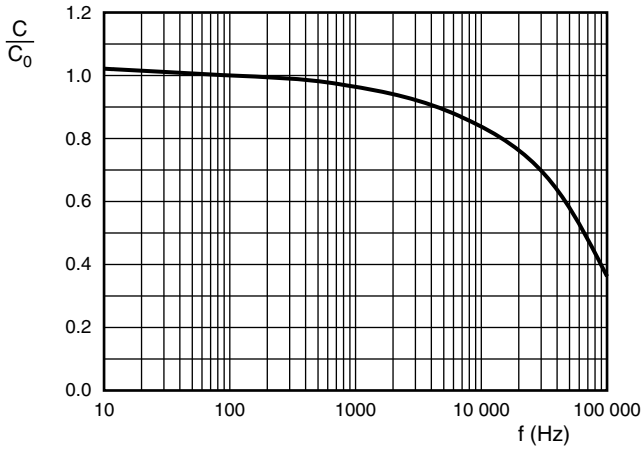


Fig. 6 - Typical multiplier of capacitance as a function of frequency at 20 °C (C_0 = C at 100 Hz)

EQUIVALENT SERIES RESISTANCE (ESR)

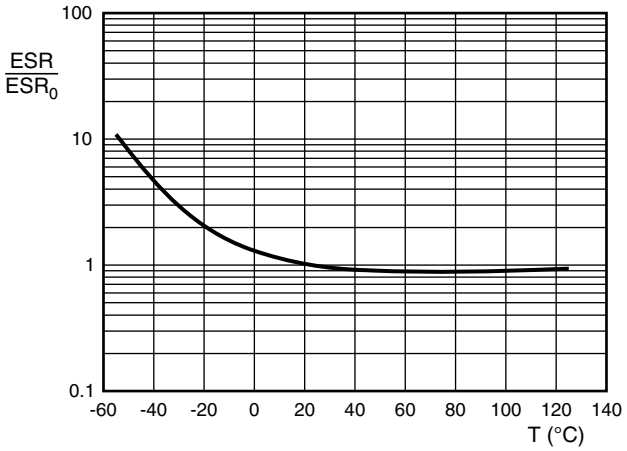


Fig. 7 - Typical multiplier of ESR at 100 Hz as a function of temperature (ESR_0 = ESR at 20 °C)

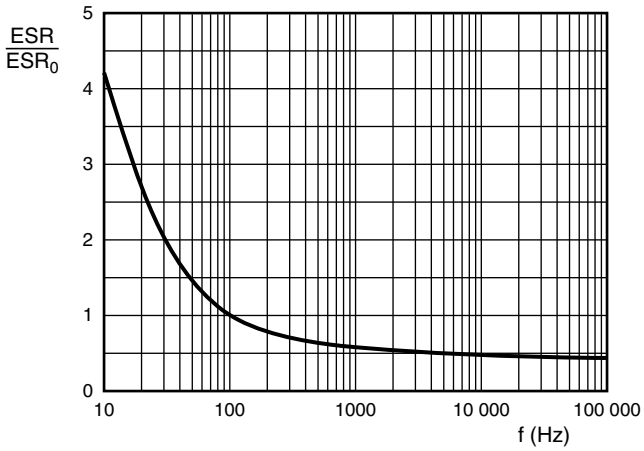


Fig. 8 - Typical multiplier of ESR at 20 °C as a function of frequency (ESR_0 = ESR at 100 Hz)

IMPEDANCE (Z)

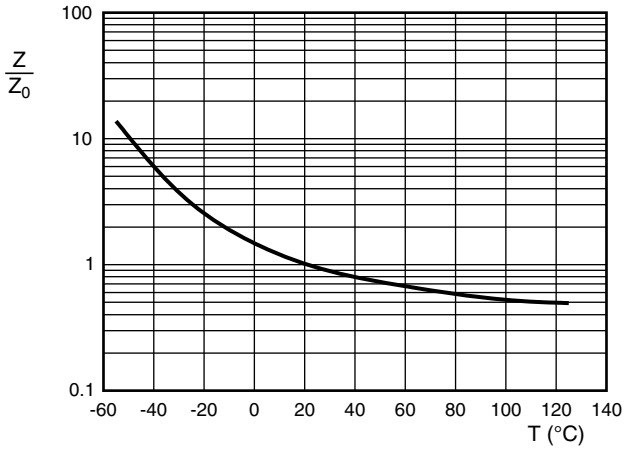


Fig. 9 - Typical multiplier of impedance at 100 kHz as a function of temperature (Z_0 = Z at 20 °C)

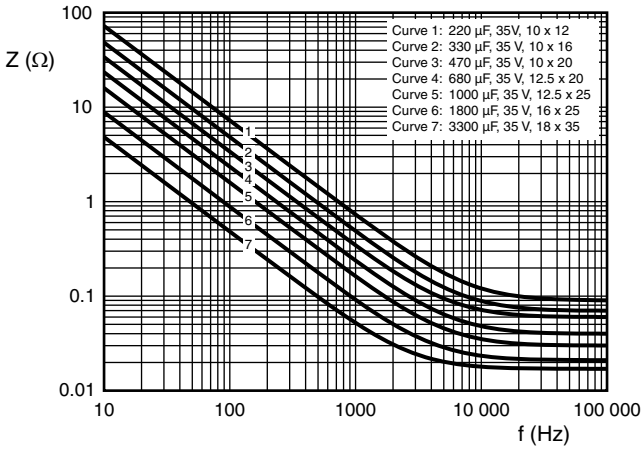


Fig. 10 - Typical impedance Z at 20 °C as a function of frequency

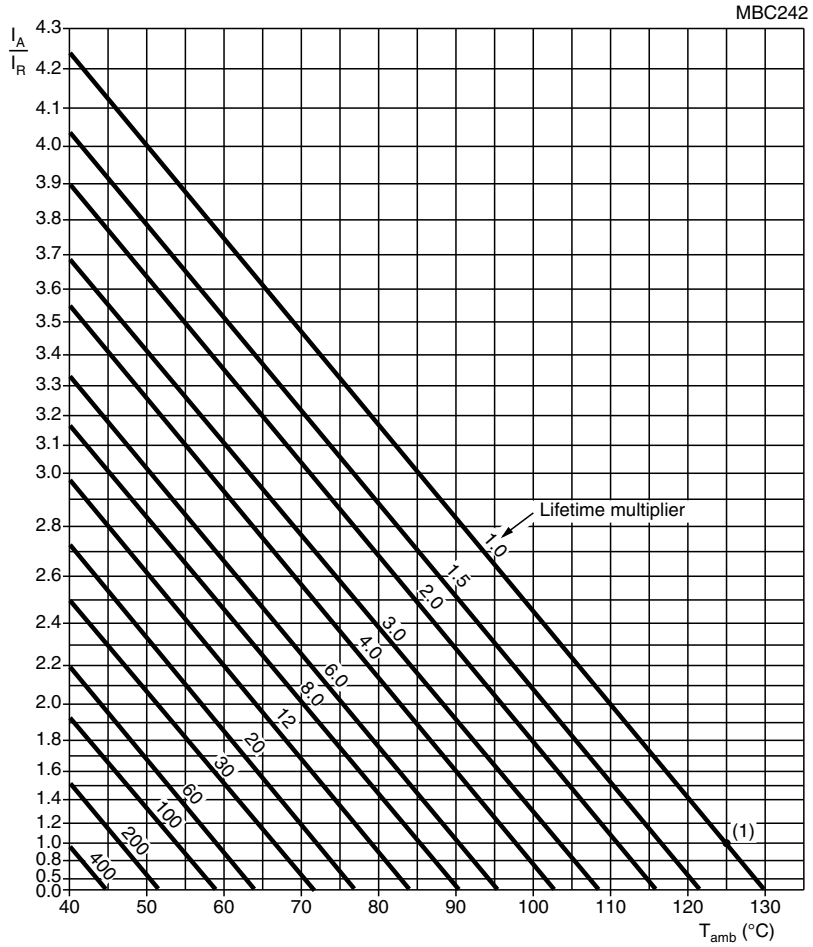
RIPPLE CURRENT AND USEFUL LIFE

Table 3

ENDURANCE TEST DURATION AND USEFUL LIFE			
NOMINAL CASE SIZE Ø D x L (mm)	CASE CODE	ENDURANCE AT 125 °C (h)	USEFUL LIFE AT 125 °C (h)
10 x 12	14	2000	2500
10 x 16	15	2000	2500
10 x 20	16	2000	3000
12.5 x 20	17	2000	3000
12.5 x 25	18	3000	5000
16 x 20	19a	3000	4000
16 x 25	19	3000	5000
16 x 31	20	4000	6000
16 x 35	21	5000	6000
18 x 20	1820	3000	4000
18 x 25	1825	3000	5000
18 x 31	1831	4000	6000
18 x 35	22	5000	6000

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 4

Fig. 11 - 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						
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

Table 5

TEST PROCEDURES AND REQUIREMENTS			
TEST		PROCEDURE (quick reference)	REQUIREMENTS
NAME OF TEST	REFERENCE		
Endurance	IEC 60384-4 / EN130300 subclause 4.13	T_{amb} = 125 °C; U_R applied; for test duration see Table 3	ΔC/C: ± 15 % tan δ ≤ 1.3 x spec. limit Z ≤ 2 x spec. limit I_{L2} ≤ 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_{L2} ≤ spec. limit no short or open circuit total failure percentage: ≤ 1 %
Shelf life	IEC 60384-4 / EN130300 subclause 4.17	T_{amb} = 125 °C; no voltage applied; 1000 h after test: U_R to be applied for 30 min, 24 h o 48 h before measurement	ΔC/C: ± 15 % tan δ ≤ 1.3 x spec. limit Z ≤ 3 x spec. limit I_{L2} ≤ 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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