Aluminum Capacitors
Radial Miniature Long Life

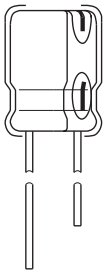
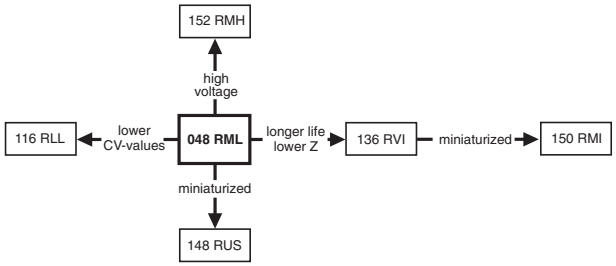


Fig.1 Component outline.



FEATURES

- Polarized aluminum electrolytic capacitors, non-solid electrolyte
- Radial leads, cylindrical aluminum case with pressure relief, insulated with a blue vinyl sleeve
- Charge and discharge proof
- Miniaturized, high CV-product per unit volume
- Very long useful life: 3000 to 4000 hours at 105 °C, high reliability.

APPLICATIONS

- EDP, telecommunication, industrial, automotive and audio-video
- Smoothing, filtering, buffering in SMPS, timing
- Portable and mobile equipment (small size, low mass).

QUICK REFERENCE DATA	
DESCRIPTION	**VALUE**
Nominal case sizes (∅D × L in mm)	10 × 12 to 18 × 35
Rated capacitance range, C_R	100 to 10 000 µF
Tolerance on C_R	±20%
Rated voltage range, U_R	6.3 to 63 V
Category temperature range	–40 to +105 °C
Endurance test at 105 °C	2000 hours
Useful life at 105 °C case ∅D = 10 and 12.5 mm case ∅D = 16 and 18 mm	 3000 hours 4000 hours
Useful life at 40 °C, 1.6 × I_R applied case ∅D = 10 and 12.5 mm case ∅D = 16 and 18 mm	 200 000 hours 260 000 hours
Shelf life at 0 V, 105 °C	1000 hours
Based on sectional specification	IEC 60384-4/EN130300
Climatic category IEC 60068	40/105/56

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.
- Name of manufacturer.
- Upper category temperature (105 °C).
- Negative terminal identification.
- Series number (048).

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

C_R (µF)	U_R (V)							
	6.3	**10**	**16**	**25**	**35**	**40**	**50**	**63**
100	–	–	–	–	–	–	–	10 × 12
220	–	–	–	–	10 × 12	–	10 × 16	10 × 20
330	–	–	–	–	–	–	–	12.5 × 20
470	–	–	10 × 12	10 × 16	10 × 20	–	12.5 × 20	12.5 × 25
1000	–	10 × 16	10 × 20	12.5 × 20	12.5 × 25	–	16 × 25	16 × 31
2200	–	12.5 × 20	12.5 × 25	16 × 25	16 × 31	16 × 35	18 × 35	18 × 35
3300	–	12.5 × 25	16 × 25	16 × 31	18 × 35	18 × 35	18 × 35	–
4700	–	16 × 25	16 × 31	18 × 35	18 × 35	–	–	–
6800	16 × 25	16 × 31	16 × 35	–	–	–	–	–
10000	16 × 35	18 × 35	18 × 35	–	–	–	–	–

DIMENSIONS in millimeters, **AND AVAILABLE FORMS**

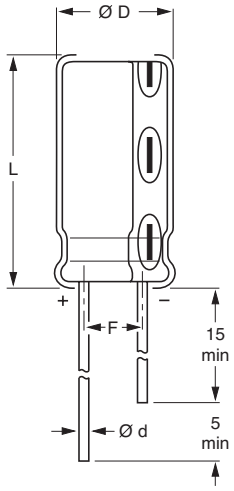


Fig.2 **Form CA**: Long leads.

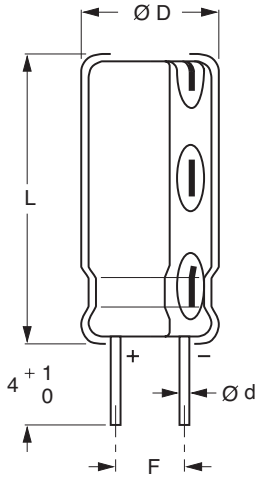


Fig.3 **Form CB**: Cut leads.

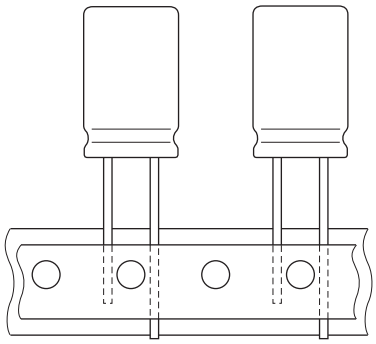


Fig.4 **Form TFA:** Taped in box (ammopack).

Table 1

DIMENSIONS in millimeters, **MASS AND PACKAGING QUANTITIES**									
NOMINAL CASE SIZE ∅D × L	**CASE CODE**	**∅d**	**∅D_{max}**	**L_{max}**	**F**	**MASS (g)**	**PACKAGING QUANTITIES**		
							FORM CA	**FORM CB**	**FORM TFA**
10 × 12	14	0.6	10.5	13.5	5.0 ±0.5	≈1.6	1000	500	800
10 × 16	15	0.6	10.5	17.5	5.0 ±0.5	≈1.9	500	500	800
10 × 20	16	0.6	10.5	22.0	5.0 ±0.5	≈2.2	500	500	800
12.5 × 20	17	0.6	13.0	22.0	5.0 ±0.5	≈4.0	500	500	500
12.5 × 25	18	0.6	13.0	27.0	5.0 ±0.5	≈5.0	250	250	500
16 × 25	19	0.8	16.5	27.0	7.5 ±0.5	≈8.0	250	250	250
16 × 31	20	0.8	16.5	33.5	7.5 ±0.5	≈9.0	100	100	250
16 × 35	21	0.8	16.5	37.5	7.5 ±0.5	≈11.5	100	100	–
18 × 35	22	0.8	18.5	37.5	7.5 ±0.5	≈14.5	100	100	–

Note

1. Detailed tape dimensions see section ‘PACKAGING’.

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 minute at U_R
Tan δ	max. dissipation factor at 100 Hz
Z	max. impedance at 100 kHz

Note

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

ORDERING EXAMPLE

Electrolytic capacitor 048 series

2200 µF/16 V; ±20%

Nominal case size: ∅12.5 × 25 mm; Form TFA

Catalog number: 2222 048 35222.

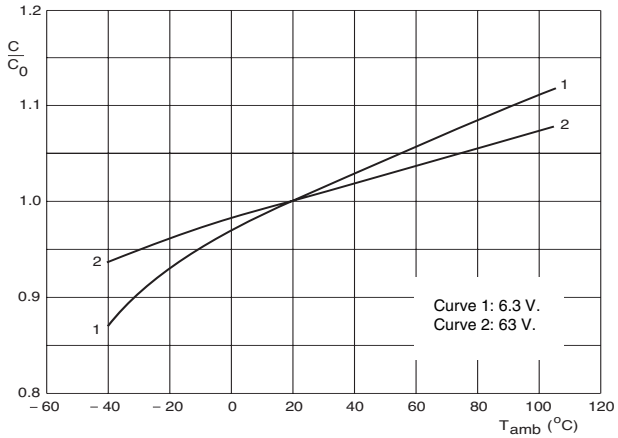
Table 2

ELECTRICAL DATA AND ORDERING INFORMATION

U_R (V)	C_R 100 Hz (µF)	NOMINAL CASE SIZE ∅D × L (mm)	I_R 100 Hz 105 °C (mA)	I_{L1} 1 min (µA)	Tan δ 100 Hz	Z 100 kHz (mΩ)	CATALOG NUMBER 2222 048		
							BULK PACKAGING		TAPED
							FORM CA	FORM CB	FORM TFA
6.3	6800	16 × 25	1350	430	0.32	56	53682	63682	33682
	10000	16 × 35	1700	630	0.40	42	53103	63103	–
10	1000	10 × 16	470	100	0.19	180	54102	64102	34102
	2200	12.5 × 20	800	220	0.21	90	54222	64222	34222
	3300	12.5 × 25	1000	330	0.23	68	54332	64332	34332
	4700	16 × 25	1270	470	0.25	56	54472	64472	34472
	6800	16 × 31	1550	680	0.29	45	54682	64682	34682
	10000	18 × 35	1870	1000	0.37	36	54103	64103	–
16	470	10 × 12	360	78	0.16	250	55471	65471	35471
	1000	10 × 20	600	160	0.16	140	55102	65102	35102
	2200	12.5 × 25	1000	360	0.18	70	55222	65222	35222
	3300	16 × 25	1220	530	0.20	56	55332	65332	35332
	4700	16 × 31	1500	760	0.22	45	55472	65472	35472
	6800	16 × 35	1690	1100	0.26	42	55682	65682	–
	10000	18 × 35	1980	1600	0.34	34	55103	65103	–
25	470	10 × 16	440	120	0.14	180	56471	66471	36471
	1000	12.5 × 20	720	250	0.14	100	56102	66102	36102
	2200	16 × 25	1120	550	0.16	56	56222	66222	36222
	3300	16 × 31	1450	830	0.18	45	56332	66332	36332
	4700	18 × 35	1720	1200	0.20	36	56472	66472	–
35	220	10 × 12	310	80	0.12	280	50221	60221	30221
	470	10 × 20	500	170	0.12	150	50471	60471	30471
	1000	12.5 × 25	900	350	0.12	75	50102	60102	30102
	2200	16 × 31	1340	770	0.14	45	50222	60222	30222
	3300	18 × 35	1600	1200	0.16	36	50332	60332	–
	4700	18 × 35	1950	1600	0.18	34	50472	60472	–
40	2200	16 × 35	1500	880	0.13	45	57222	67222	–
	3300	18 × 35	1600	1300	0.15	36	57332	67332	–
50	220	10 × 16	340	110	0.10	250	51221	61221	31221
	470	12.5 × 20	620	240	0.10	110	51471	61471	31471
	1000	16 × 25	1030	500	0.10	60	51102	61102	31102
	2200	18 × 35	1500	1100	0.12	50	51222	61222	–
	3300	18 × 35	1900	1700	0.14	40	51332	61332	–
63	100	10 × 12	240	66	0.09	310	58101	68101	38101
	220	10 × 20	400	140	0.09	200	58221	68221	38221
	330	12.5 × 20	550	210	0.09	120	58331	68331	38331
	470	12.5 × 25	700	300	0.09	80	58471	68471	38471
	1000	16 × 31	1150	630	0.09	49	58102	68102	38102
	2200	18 × 35	1600	1400	0.11	45	58222	68222	–

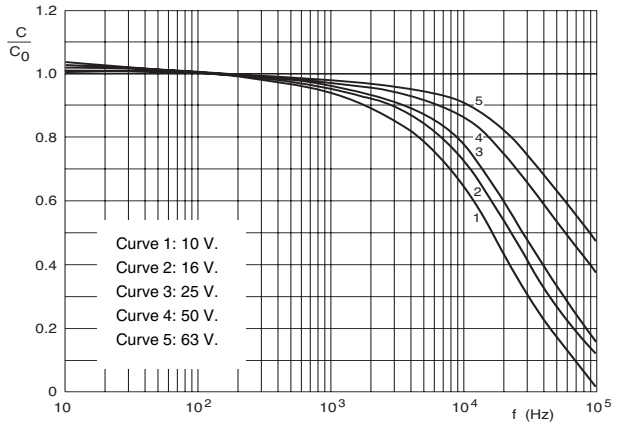
ADDITIONAL ELECTRICAL DATA		
PARAMETER	**CONDITIONS**	**VALUE**
Voltage		
Surge voltage		$U_s \leq 1.15\ U_R$
Reverse voltage		$U_{rev} \leq 1$ V
Current		
Leakage current	after 1 minute at U_R	$I_{L1} \leq 0.01\ C_R \times U_R + 3\ \mu A$
	after 5 minutes at U_R	$I_{L5} \leq 0.002\ C_R \times U_R + 3\ \mu A$
Inductance		
Equivalent series inductance (ESL)	case ∅D = 10 mm	typ. 16 nH
	case ∅D ≥ 12.5 mm	typ. 18 nH
Resistance		
Equivalent series resistance (ESR)	calculated from tan δ_{max} and C_R (see Table 2)	ESR = tan δ / $2\pi f C_R$

CAPACITANCE (C)



C_0 = typical capacitance at 20 °C, 100 Hz.

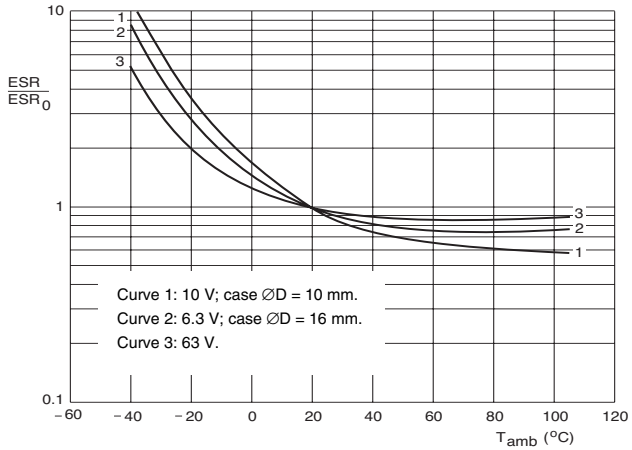
Fig.5 Typical multiplier of capacitance as a function of ambient temperature.



C_0 = typical capacitance at 20 °C, 100 Hz. T_{amb} = 20 °C.

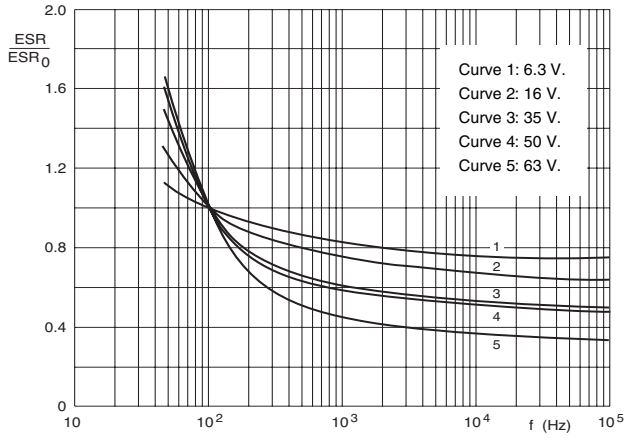
Fig.6 Typical multiplier of capacitance as a function of frequency.

EQUIVALENT SERIES RESISTANCE (ESR)



ESR_0 = typical ESR at 20 °C, 100 Hz.

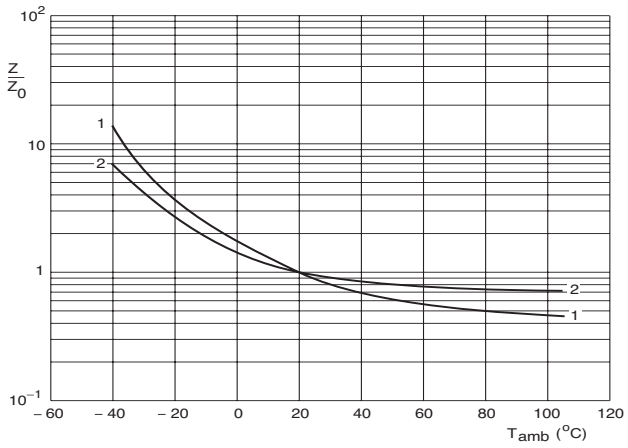
Fig.7 Multiplier of ESR as a function of ambient temperature.



ESR_0 = typical ESR at 20 °C, 100 Hz.

Fig.8 Multiplier of ESR as a function of frequency.

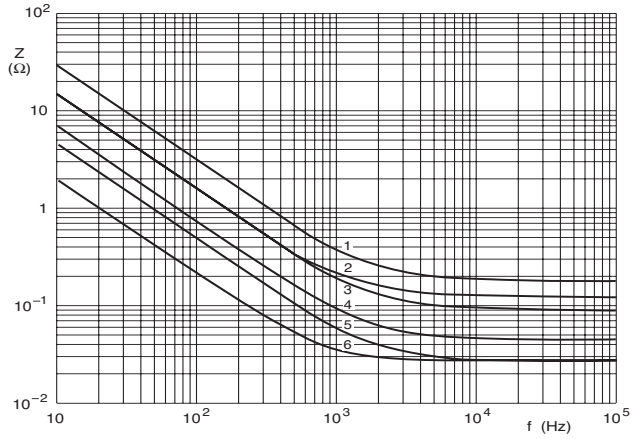
IMPEDANCE (Z)



Curve 1: case ∅D = 10 mm.
Curve 2: case ∅D = 16 mm.

Z_0 = typical impedance at 20 °C, 10 kHz.

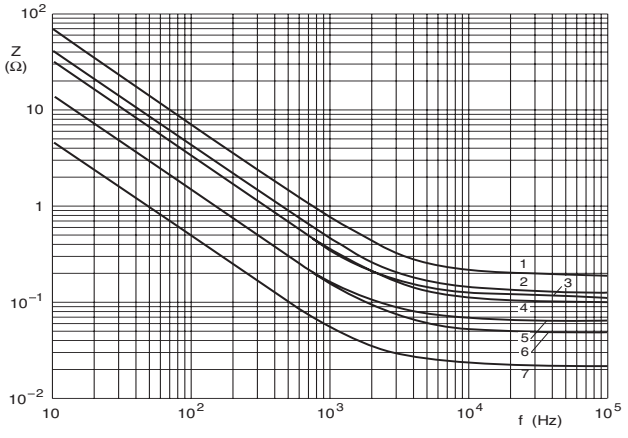
Fig.9 Typical multiplier of impedance as a function of ambient temperature.



T_{amb} = 20 °C.

Curve 1: 470 µF, 16 V; ∅10 × 12 mm.
Curve 2: 1000 µF, 10 V; ∅10 × 16 mm.
Curve 3: 1000 µF, 16 V; ∅10 × 20 mm.
Curve 4: 2200 µF, 16 V; ∅12.5 × 25 mm.
Curve 5: 3300 µF, 16 V; ∅16 × 25 mm.
Curve 6: 6800 µF, 6.3 V; ∅16 × 25 mm.

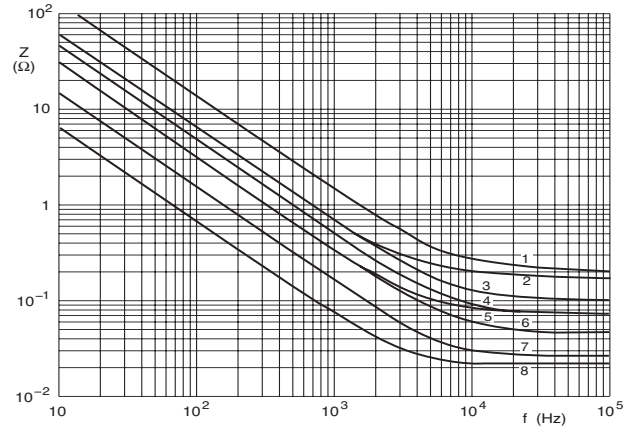
Fig.10 Typical impedance as a function of frequency.



T_{amb} = 20 °C.

Curve 1: 220 µF, 35 V; ∅10 × 12 mm.
Curve 2: 330 µF, 35 V; ∅10 × 16 mm.
Curve 3: 470 µF, 25 V; ∅10 × 16 mm.
Curve 4: 470 µF, 35 V; ∅10 × 20 mm.
Curve 5: 1000 µF, 25 V; ∅12.5 × 20 mm.
Curve 6: 1000 µF, 35 V; ∅12.5 × 25 mm.
Curve 7: 3300 µF, 25 V; ∅16 × 31 mm.

Fig.10 Typical impedance as a function of frequency.

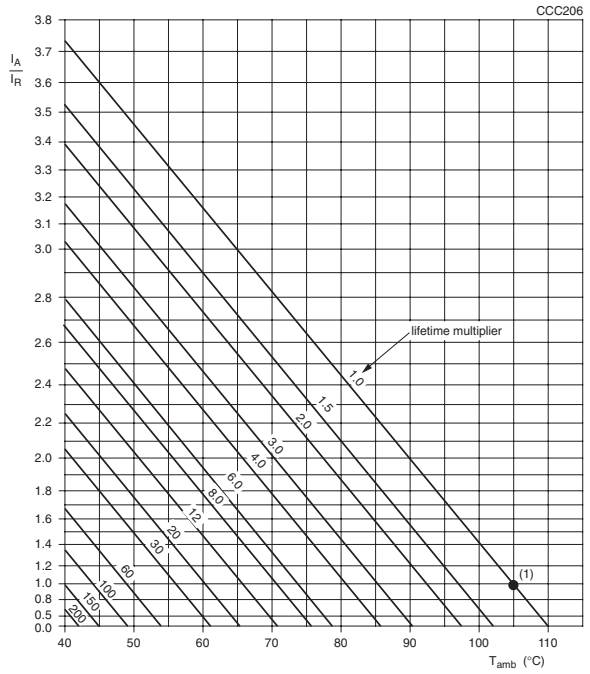


T_{amb} = 20 °C.

Curve 1: 100 µF, 63 V; ∅10 × 12 mm.
Curve 2: 220 µF, 50 V; ∅10 × 16 mm.
Curve 3: 220 µF, 63 V; ∅10 × 20 mm.
Curve 4: 330 µF, 63 V; ∅12.5 × 20 mm.
Curve 5: 470 µF, 50 V; ∅12.5 × 20 mm.
Curve 6: 470 µF, 63 V; ∅12.5 × 25 mm.
Curve 7: 1000 µF, 63 V; ∅16 × 31 mm.
Curve 8: 2200 µF, 40 V; ∅16 × 35 mm.

Fig.11 Typical impedance as a function of frequency.

RIPPLE CURRENT AND USEFUL LIFE



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 (see table 4)

Fig.13 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			
FREQUENCY (Hz)	I_R MULTIPLIER		
	U_R = 6.3 to 25 V	U_R = 35 and 40 V	U_R = 50 and 63 V
50	0.95	0.85	0.80
100	1.00	1.00	1.00
300	1.07	1.20	1.25
1000	1.12	1.30	1.40
3000	1.15	1.35	1.50
≥10000	1.20	1.40	1.60

Table 4

TEST PROCEDURES AND REQUIREMENTS			
TEST		PROCEDURE (quick reference)	REQUIREMENTS
NAME OF TEST	REFERENCE		
Endurance	IEC 60384-4/ EN130300 subclause 4.13	T_{amb} = 105 °C; U_R applied; 2000 hours	$U_R \leq 6.3$ V; ΔC/C: +15/–30% $U_R > 6.3$ V; ΔC/C: ±15% tan δ ≤ 1.3 × spec. limit Z ≤ 2 × 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 ØD = 10 and 12.5 mm: 3000 hours case ØD = 16 and 18 mm: 4000 hours	$U_R \leq 6.3$ V; ΔC/C: +45/–50% $U_R > 6.3$ V; ΔC/C: ±45% tan δ ≤ 3 × spec. limit Z ≤ 3 × spec. limit I_{L5} ≤ spec. limit no short or open circuit total failure percentage: ≤ 1%
Shelf life (storage at high temperature)	IEC 60384-4/ EN130300 subclause 4.17	T_{amb} = 105 °C; no voltage applied; 1000 hours after test: U_R to be applied for 30 minutes, 24 to 48 hours before measurement	$U_R \leq 6.3$ V; ΔC/C: +15/–30% $U_R > 6.3$ V; ΔC/C: ±15% tan δ ≤ 1.3 × spec. limit Z ≤ 2 × spec. limit I_{L5} ≤ 2 × spec. limit