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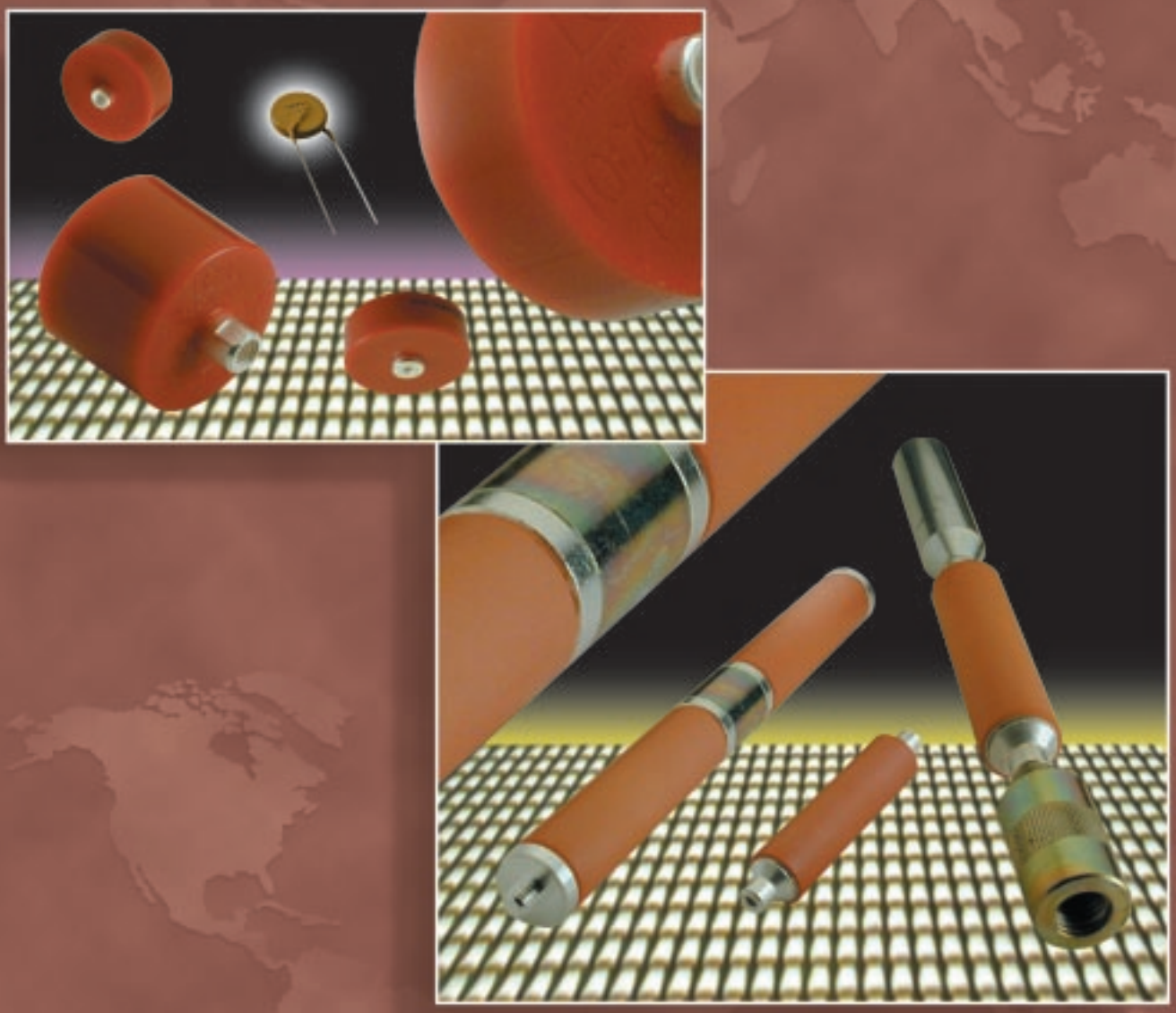


TPC
High Voltage Ceramic Capacitors

Contents

High Voltage Ceramic Capacitors

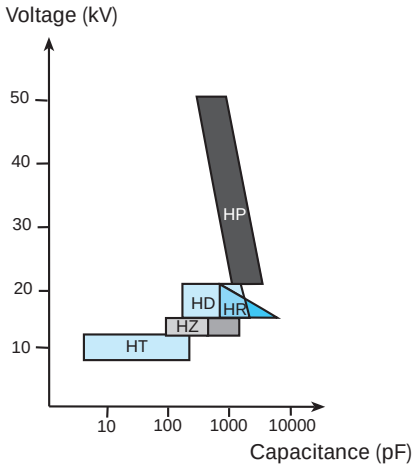
Introduction

High Voltage Ceramic Capacitors

HIGH VOLTAGE CERAMIC CAPACITORS are particularly suitable for applications requiring a high voltage (from 10 to 150 kV), while reactive current remains low. Ceramic capacitors also achieve very good performance under pulse and discharge conditions.

Various disc types cover a wide range of capacitances and voltages as shown in the following figure. Specific properties depend on the dielectric material used.

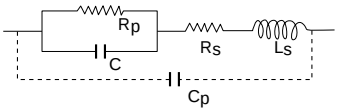
Other configurations such as rods (HF type), cascades (HC type) are used to meet specific applications.



Introduction

General Characteristics

The real characteristics of a capacitor can be described using conventional physical parameters and the following equivalent electrical circuit:



C — capacitance is a measure of the capacitors aptitude to store electrical charges Q under a voltage V ($C = Q/V$).

K — the dielectric constant, specific to each material (less than 500 for type I materials, from 1000 up to 10,000 for type II materials),

A — the area of the electrodes, and

t — the thickness of the dielectric layer are the parameters determining the capacitor value

$$C = K \frac{A}{t} \qquad (K = \varepsilon_r)$$

T.C. — the temperature coefficient of the capacitance is expressed in ppm/°C for stable type I dielectrics.

ΔC/C — is used for type II dielectrics and is expressed in % of change of the capacitance in a fixed temperature range.

V_R — the rated voltage is the maximum voltage that can be applied to the capacitor on continuous operation. It can be constituted by:

V_{DC} — a direct current component

V_{RMS} — an alternating current component

V_P — the peak voltage

V_E — the test voltage

R_P — the parallel resistance

IR — the insulation resistance under $V_{DC.}$

R_S — or ESR (Equivalent Series Resistance) accounts for the conductivity of the electrodes and connections.

L_S — or ESL (Equivalent Series Inductance) depends on the geometry of electrodes dielectric and connections, leads...

C_P — takes into account dielectric environment of the capacitor (coating...) but is generally neglected except to describe very high frequency behavior of the capacitor or for very low capacitance value.

Rp, Rs, Ls, Cp can be considered as parasitic effects. They generate energy losses and a dephasing

φ — difference between voltage and current from 90°. The loss angle δ (90° - φ) is commonly used.

tg δ — the tangent of loss angle

DF — the dissipation factor (same as tg δ)

Q — the quality factor is the ratio between the stored energy and the dissipated energy. It measures the quality of the capacitor and can be expressed as $Q = 1/\text{tg}\,\delta$ or $1/_{D.F.}$

f — being the frequency of the AC signal

ω — the pulsation of this signal with $\omega = 2\pi f$

Z — the complex impedance of the capacitor is given by the relation (neglecting Cp):

$$Z = R_S + j\,L_S\,\omega + \frac{1}{\frac{1}{R_P} + j\,C\omega} = R + j\,X$$

the tangent of the loss angle tg δ can also be expressed as $\text{tg}\,\delta = \frac{R}{X}$

so, neglecting Ls for $L_S\,\omega < \frac{1}{C\,\omega}$

$$\text{tg}\,\delta = R_S C\omega + \frac{1}{R_P C\omega} + \frac{1}{R_P^2\,C\omega}$$

f_{RS} — the series resonance frequency of the capacitor is the frequency where the capacitance reactance is exactly equal to the inductive reactance due to L_S

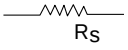
$$L_S\omega = \frac{1}{C\omega} \text{ or } \omega = \frac{1}{\sqrt{L_S C}} \text{ or } f_{RS} = \frac{1}{2\pi\sqrt{L_S C}}$$

f_{RP} — the parallel resonance frequency occurs when L_S is equal to C_P: $f_{RP} = \frac{1}{2\pi\sqrt{L_S C_P}}$

Between f_{RS} and f_{RP}, the capacitor reacts as an inductance, but still blocks DC.

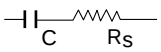
The equivalent electrical circuit can be simplified using approximations according to the frequency:

- At $f = f_{RS}$ the circuit is reduced to



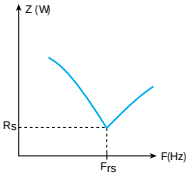
$Z = R_S$

- For high frequencies but below f_{RS}

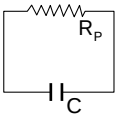


$Z = R_S + 1/jC\omega$

$\text{tg}\,\delta = R_S C\omega$



- For low frequencies $Z = \frac{1}{\frac{1}{R_P} + jC\omega}$



$\text{tg}\,\delta = \frac{1}{R_P C\omega}$

I_{RMS} — is the maximum RMS current that can be transmitted by the capacitor electrodes

W_R — is defined as the maximum reactive power and is expressed by $W_R = V^2_{RMS}\,C\omega = \frac{I^2_{RMS}}{C\omega}$

W_A — is the active power or dissipated power $W_A = W_R\,\text{tg}\,\delta = (2\pi f CV^2)(DF)$

Introduction

Dielectrics - Type I - Temperature Compensating

TYPE I CAPACITORS - GENERAL

(with specific temperature coefficient)

Type I capacitors are particularly suitable for applications where high stability of capacitance and low losses are required (tuning circuit capacitors). In addition, they offer linear capacitance change with temperature.

DIELECTRIC SELECTION - STANDARDIZATION

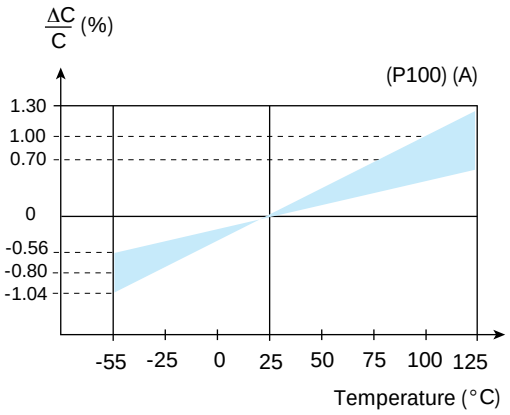
Temp. coeff.* ($\Delta\theta$ = -55 +125°C)		Specification Code			
Value (ppm/°C)	Tolerance** (ppm/°C)	TPC	CECC CEI MIL	DIN	EIA
(P100)	+100 ± 30	A	AG / 1B	P100/1B	M7G
(NP0)	0 ± 30	C	CG / 1B	NP0/1B	C0G
(N33)	-33 ± 30	H	HG / 1B	N33/1B	H2G
(N150)	-150 ± 30	P	PG / 1B	N150/1B	P2G
(N470)	-470 ± 120	T	TJ / 1B	N470/1B	T2J
(N750)	-750 ± 120	U	UJ / 1B	N750/1B	U2J
(N1500)	-1500 ± 250	V	VK / 1B	N1500/1B	V2K

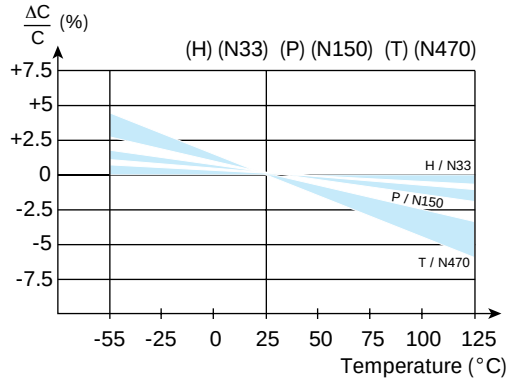
* Reference temperature (CECC): 25°C
** If not otherwise specified in data sheets

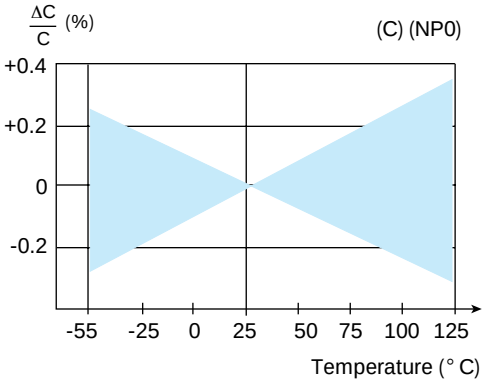
DIELECTRIC CHARACTERISTICS (typical values - non-exhaustive list)

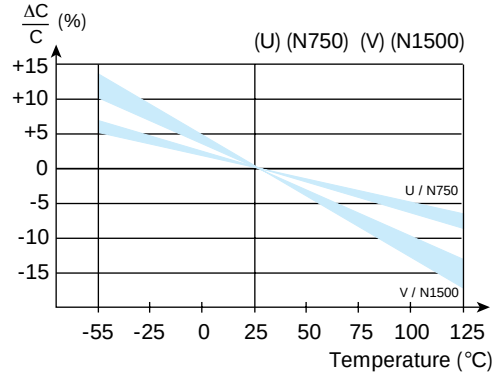
TPC code	A	C	H	P	T	U	V
Dielectric class	P100	NP0	N33	N150	N470	N750	N1500
Temperature coefficient of the capacitance (ppm/°C)	+100	0	-33	-150	-470	-750	-1500
Operating temperature range (°C)	-25 +95	-25 +95	-25 +95	-25 +95	-25 +95	-25 +95	-25 +95
Typical dielectric constant	15	18	30	70	50	125	270
Dielectric strength kV_{DC}/mm	20	20	20	8	8	8	6
Dissipation factor (1MHz/25°C)	5.10^{-4}	5.10^{-4}	5.10^{-4}	5.10^{-4}	5.10^{-4}	10.10^{-4}	10.10^{-4}
Insulation resistance (500V/25°C)	> 100 G	> 100 G	> 100 G	> 100 G	> 100 G	> 100 G	> 100 G

TYPICAL CHANGE OF CAPACITANCE WITH TEMPERATURE

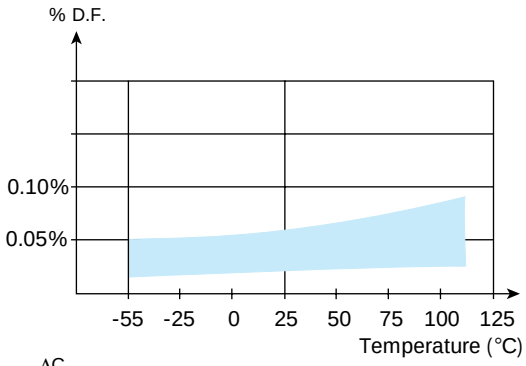


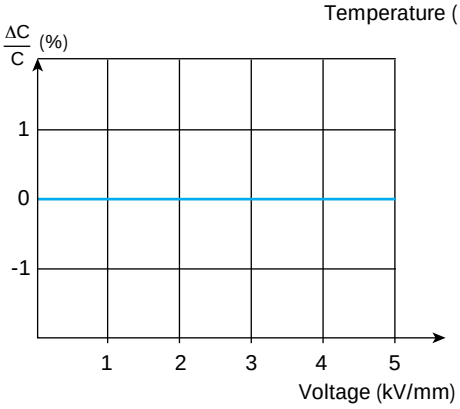


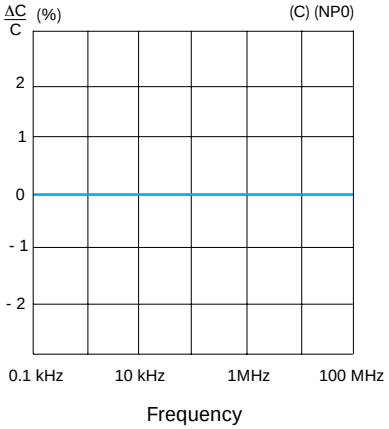


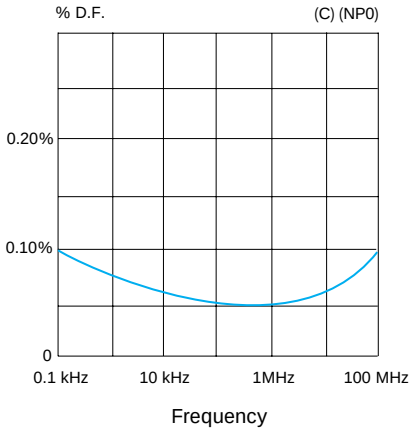


PARAMETER CHANGE WITH TEMPERATURE, VOLTAGE AND FREQUENCY









PARAELECTRIC DIELECTRICS - GENERAL

These strontium-based dielectrics exhibit a high dielectric constant (>1500) and excellent electrical properties including high dielectric strength, low dissipation factor and low capacitance change with applied voltage.

They are particularly suitable for high energy discharges applications as they present no electro-striction or piezo-electric phenomenon.

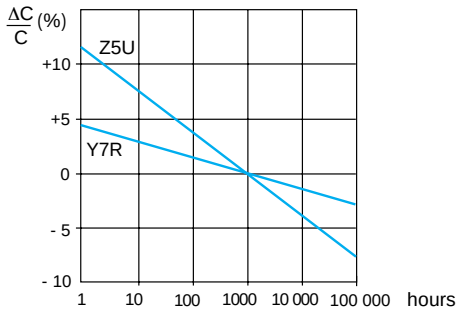
TYPE II DIELECTRICS - GENERAL

(with non-specific temperature coefficient)

Type II dielectrics are characterized by a high permitivity (higher than 1000), giving large capacitance with small size.

They are particularly suitable for filtering, decoupling and any applications for which capacitance changes and dielectric losses are of lesser importance.

They also present a drift effect of the capacitance as shown below due to natural aging of the ceramic dielectric.



DIELECTRIC SELECTION - STANDARDIZATION

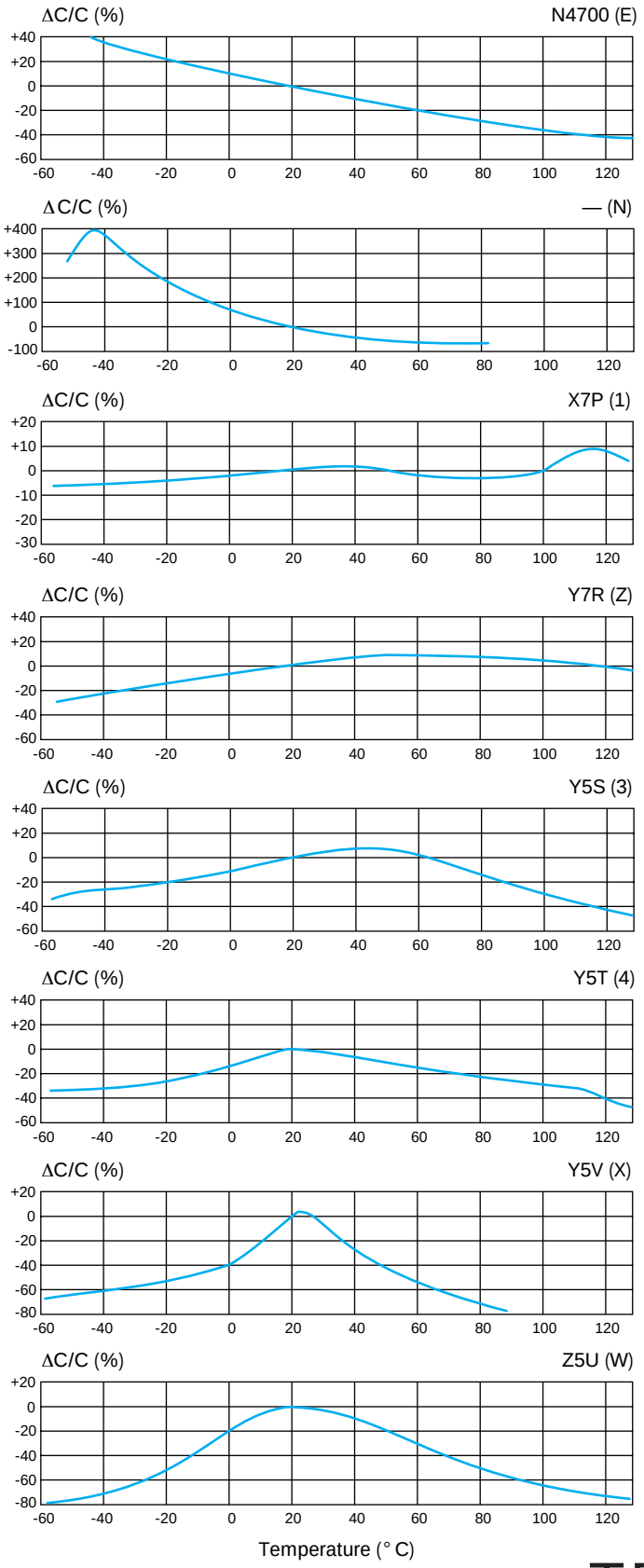
Temperature		Classes			
ΔC / C		TPC	CEI CECC	EIA	DIN
Paraelectric dielectrics					
ΔC / C	Temperature				
+22 -33%	-30 +85°C	E		(Y5T)	N4700
+300 -82%	-30 +85°C	N			
Type II					
±10%	-55 +125°C	1	(2B1)	X7P	
±15%	-30 +125°C	Z	(2R4)	Y7R	
±22%	-30 +85°C	3	(2C4)	Y5S	
+22 -33%	-30 +85°C	4	(2E4)	Y5T	
+22 -82%	-30 +85°C	X	(2F4)	Y5V	
+22 -56%	+10 +85°C	W	(2E6)	Z5U	

Note: classes with ( ) = approximate classes

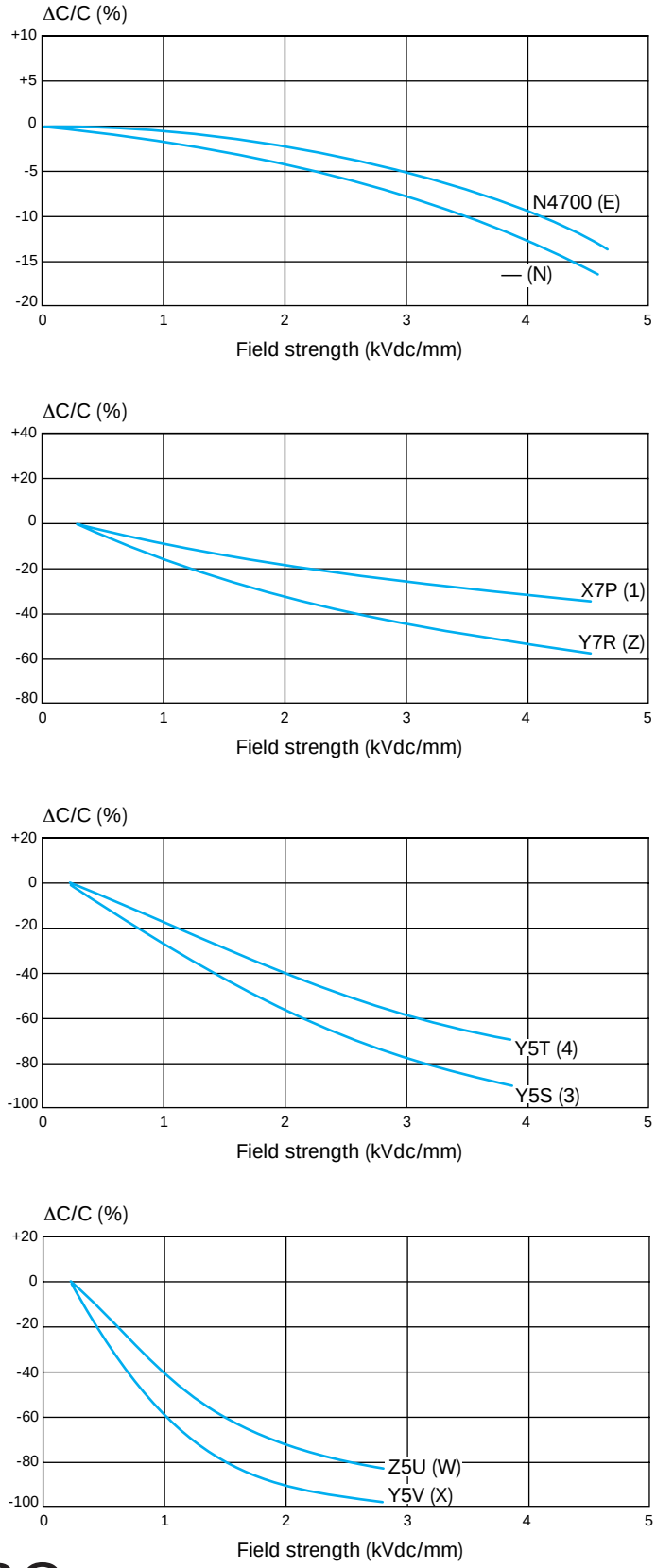
DIELECTRIC CHARACTERISTICS (typical values - non-exhaustive list)

TPC code	E*	N*	1	Z	3	4	X	W
Dielectric class	N4700	See curves on page 7	X7P	Y7R	Y5S	Y5T	Y5V	Z5U
Operating temperature range (°C)	-30 +85	-30 +85	-55 +125	-30 +125	-30 +85	-30 +85	-30 +85	+10 +85
Capacitance change with temperature (%)	+22 -33	(+300 -82)	±10	±15	±22	+22 -33	+22 -82	+22 -56
Typical dielectric constant at 0.25 kV/mm	1850	2000	1000	2600	3300	3500	6500	7000
Dielectric strength kV_{DC}/mm	8.0	7.0	6.0	5.5	5.5	5.5	4.0	5.0
Dissipation factor (1 kHz/1 V_{rms}/20°C)	5.10^{-4}	20.10^{-4}	100.10^{-4}	200.10^{-4}	100.10^{-4}	150.10^{-4}	200.10^{-4}	100.10^{-4}
Insulation resistance (500V/20°C)	> 10 G	> 10 G	> 10 G	> 10 G	> 10 G	> 10 G	> 10 G	> 10 G

TYPICAL CHANGE OF CAPACITANCE WITH TEMPERATURE



TYPICAL CHANGE OF CAPACITANCE WITH APPLIED D.C. VOLTAGE



High Voltage Ceramic Capacitors

How To Order

ORDERING CODE

HP40	E	3	0102	M	— —
Type/Size	Class	Voltage	Capacitance (EIA code)	Tolerance	Suffix

Type/Size

High Voltage Radial-leaded Discs

09
12
HZ 16
20
22

Coated Discs

HT 30
HD 40
HR 60

30
HP 40
50
60

Uncoated Discs

HU 30
HE 40
HS 60

Rods

HB 30
HF 40
60

Class

Type I

A = P 100
C = NP0
H = N33
T = N470
U = N750
V = N1500

Type II

E = N4700
N = N10000
W = +22 -56%
X = +22 -82%

Voltage

1000 V: L
1600 V: M
2000 V: N
2500 V: P
3000 V: Q
4000 V: R
5000 V: S
6000/6300 V: T
8000/9000 V: U
10,000 V: V
12,500 V: W
15/16 kV: X
20/25 kV: Y
30 kV: 3
40 kV: 4
50 kV: 5

For the following types whose class or voltage is not specified but inferred by the type, the size and the value: write 0 (zero) in the 5th (class) or 6th digit case (voltage).

Class not specified

HD
HE
HR
HS
HB
HF

Voltage not specified

HT
HU
HB
HF

Capacitance (EIA code)

Capacitance expressed by 2 significant figures

1st digit: 0 (zero)

2nd and 3rd digits: the 2 significant figures of the capacitance value.

4th digit:

- for values ≥ 10pF and ≤ 990µF: the number of ZEROS to be added to the capacitance values
- for values ≥ 1pF and ≤ 9.9pF: the figure 9 signifying that the capacitance value is to be multiplied by 0.1

Examples: 1000pF: 0102
8.2pF: 0829

Capacitance expressed by 3 significant figures

1st, 2nd and 3rd digits: the 3 significant figures of the capacitance value.

4th digit:

- for values > 100pF and ≤ 999 µF: the number of ZEROS to be added to the capacitance value
- for values > 10pF and < 100pF: the figure 9 signifying that the capacitance value is to be multiplied by 0.01.
- for values > 1pF and ≤ 10pF: the figure 8 signifying that the capacitance value is to be multiplied by 0.01.

Examples: 196pF: 1960
47.2pF: 4729
8.28pF: 8288

Tolerance

C < 10pF	Code
± 1pF	F
± 2pF	G

C ≥10pF	Code
±5%	J
±10%	K
±20%	M
-20 +50%	S
-20 +80%	Z

Suffix

--
PY
WH

NOTE: Special drawing number

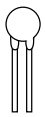
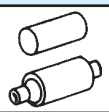
If customer requirements differ from the standard type, the codification of the product is modified as follows:

5th, 6th digit: –
7th digit: H for high voltage types
8th, 9th, 10th digit: drawing number
11th digit: –
12th, 13th digit: two digits number for revised edition number

HIGH VOLTAGE CERAMIC CAPACITORS

High Voltage Ceramic Capacitors

Selection Guide

Main Signal Component	Applications	Series	Type / Size / Finish
PULSES	Medium energy pulses	Radial leaded discs	HZ 09 12 16 18 20 22 26 
	High energy pulses	Molded discs with connections	HP 30 40 50 60 
AC	Live - line indication	Rods	HB HF 30 40 60 
	AC voltage dividers at line frequency	Molded discs with connectors	HD (HE) 30 40 60 
	Voltage dividers	Custom products	Complete dividers
DC	High voltage decoupling	Molded discs with connections	HR (HS) 30 40 60 
	Low reactive power coupling or tuning		HT (HU) 30 40 60 

High Voltage Ceramic Capacitors

Selection Guide

Dimensions millimeters (inches) Diam.	Thick.	Height	Dielectric Class	Reference	Capacitance C_R (pF)	Electrical Characteristics Peak Rated Voltage (V_R) (kV)	Test Voltage V_E (kV)	Max. tg δ (DF)	Detailed specification on page
9.5 (0.374) 12 (0.472) 16 (0.630) 18 (0.709) 20 (0.787) 22 (0.866) 26 (1.024)	9 (0.354) 9 (0.354) 9 (0.354) 9 (0.354) 9 (0.354) 10 (0.394) 11 (0.433)	14.5 (0.571) 16 (0.630) 20 (0.787) 22 (0.866) 24 (0.945) 26 (1.024) 30 (1.180)	N4700	HZ .. EW .. M --	100 ⋮ 2700	6, 9, 12	9, 14, 18	10.10^{-4}	13
28 (1.100) 38 (1.500) 48 (1.900) 58 (2.283)	23 (0.906) ··· 32 (1.260)	17 (0.669) ... 26 (1.024)	N4700	Y HP .. E3 .... M-- 4	390 ⋮ 4000	20/30/40/50	22/33/44/53	10.10^{-4}	14
17 (0.669)	50.5 (1.988) 60 (2.362) 81 (3.189)	30.5 (1.201) 40 (1.575) 61 (2.402)	Y5T	HB.. 00 ... M-- HB .. 00 ... M-- HF.. 00 ... M--	16 ⋮ 250	8 ⋮ 15	30 ⋮ 60	150.10^{-4}	15
26.5 (1.043) 39.5 (1.555) 56.5 (2.224)	33 (1.300) 33 (1.300) 40 (1.575)/ 45 (1.772)	16 (0.630) 16 (0.630) 19 (0.748)/ 21 (0.827)	(N)	X HD .. 0^{Y}....S-- HE .. 0^{Y}....S--	250/500 1000 2000/3000	15 15 15/20	20 20 20/30	20.10^{-4}	16
precise dividing ratio according to customer requirements									
27 (1.063)/ 34 (1.339) 39 (1.535)/ 44 (1.732) 54 (2.126)/ 55 (2.165)	37 (1.457)/ 40 (1.575) 37 (1.457)/ 40 (1.575) 40 (1.575)/ 47 (1.850)	23 (0.906)/ 28 (1.100) 23 (0.906)/ 28 (1.100) 21 (0.827)/ 28 (1.100)	Z5U	X HR .. 0^{Y}....S-- HS .. 0^{Y}....S--	470 ⋮ 5000	16/20	24/30	200.10^{-4}	18
25.5 (1.004) 38 (1.500) 56 (2.205)	50 (1.969) 50 (1.969) 55 (2.165)	30 (1.180) 30 (1.180) 35 (1.378)	P100 N33 N470 N750	A0 HT .. HO .... F-- HU .. T0 .... K-- HU .. U0 .... M--	4.7 ⋮ 270	10/17	15/25	20.10^{-4}	19

High Voltage Ceramic Capacitors

General Characteristics

HIGH VOLTAGE USES AND REQUIREMENTS

- High voltage uses are numerous but they can be divided into 3 main applications:
  - high voltage / AC or power frequency
  - high voltage / DC
  - high energy pulses
- Each of them requires specific properties leading to the use of different kinds of ceramic dielectrics and product types.

HIGH VOLTAGE / AC USES

- The main applications include live line indicators, AC dividers, grading systems for power distribution network, protection for HV switches and power circuit breakers. Coupling, by-passing high frequencies circuits where an important reactive power is needed also use ceramic HV capacitors.
- These applications require:
  - a high internal resistance
  - a high dielectric strength

  together with:
  - low or moderate losses at working frequencies (from 50 Hz up to a few kHz).

    The active power (or losses) being:

    $Wa = 2\Pi FC \cdot tg\ \delta \cdot V^2 = k\ (C \cdot tg\ \delta)\ (F \cdot V^2)$,

    this shows that improved performance is obtained when both
    - good dielectric properties (low tg δ) and
    - no long term overvoltage occurs
  - capacitors free of “partial discharge” (corona) effect, up to rated rms voltage.

    TPC is able to perform discharge free test and may guarantee a rate as low as 5 picocoulombs at V_{rms} upon request.
- High voltage capacitors for AC uses are mainly made of type II dielectrics. These materials exhibit a significant non-linearity: the capacitance value depends on the voltage across the component and on the frequency of the applied signal.

HIGH VOLTAGE / DC USES

- The main applications are coupling, decoupling, multipliers circuits, HV DC power supplies.
- They require
  - a high internal resistance, even at elevated temperature
  - a very high dielectric strength
  - a low ripple current
- Type I or type II capacitors can be used depending on the particular application.

HIGH ENERGY PULSES

- Laser pulses circuitry, high energy/high voltage test equipment (HV accelerators, physics research) require products especially adapted to their specific requirements.
- Because of the high energy involved, the design of the capacitors have to provide:
  - a very low ESR (equivalent series resistance) to minimize the lossed energy

    $$W = \int_{o}^{ip} (ESR \cdot I^2)\ di$$
  - a very low ESL (equivalent series inductance) to keep the correct pulse shape.

    Typically, TPC products exhibit

    ESR 10 mΩ
    ESL 30 nH
    peak current up to 50 kA
  - a high withstanding of very large $\frac{dV}{dt}$ or short signal rise time
  - a high energy density J

    $J = \frac{1}{2}\ k\ \varepsilon_o\ \varepsilon_r\ E^2$

    even under high electric field, implying that ε_r is very little voltage dependent.

    Through the use of almost linear or non-voltage dependent capacitors, the stored energy can reach 50 to 100 J/liter for TPC products.
- To ensure these properties, traditional ferroelectric type II capacitors cannot be used due to their electrostrictive and piezoelectric properties. TPC capacitors use quasi “para-electric”, strontium-based, ceramic material.

High Voltage Ceramic Capacitors

HZ Type - Strontium-based Dielectric

FEATURES

- Good energy pulses ability
- Excellent heat-proof, humidity-proof characteristics
- High dielectric strength
- Epoxy coating
- High insulation resistance
- Small size and low cost
- Excellent Corona-proof

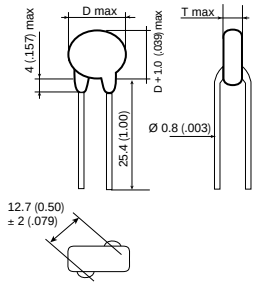
APPLICATIONS

- High-voltage DC Supply (X-Ray, Gas laser, ...)
- Lightning arrester in voltage distribution systems
- TV doubler & tripler
- Electrostatic copying machines

MARKING

- On each part: type (HZ), capacitance
- On packaging: reference, lot number

Style



HZ RANGE – RADIAL TYPE (Ue=1.5XUR)

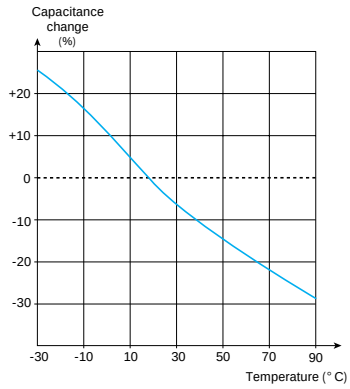
Reference Size	Cap. ±20% (pF)	UR (kVdc) T 6	U 9	W 12	Dimensions millimeters (inches) D	T
HZ09...	100				9.50 (0.374)	9.00 (0.354)
	150				9.50 (0.374)	9.00 (0.354)
	220				9.50 (0.374)	9.00 (0.354)
HZ12...	250				12.00 (0.472)	9.00 (0.354)
	330				12.00 (0.472)	9.00 (0.354)
	430				12.00 (0.472)	9.00 (0.354)
HZ16...	500				16.00 (0.630)	9.00 (0.354)
	680				16.00 (0.630)	9.00 (0.354)
	820				16.00 (0.630)	9.00 (0.354)
HZ18...	750				18.00 (0.709)	9.00 (0.354)
	1000				18.00 (0.709)	9.00 (0.354)
	1300				18.00 (0.709)	9.00 (0.354)
HZ20...	1000				20.00 (0.787)	9.00 (0.354)
	1300				20.00 (0.787)	9.00 (0.354)
	1800				20.00 (0.787)	9.00 (0.354)
HZ22...	1250				22.00 (0.866)	10.00 (0.394)
	1600				22.00 (0.866)	10.00 (0.394)
	2200				22.00 (0.866)	10.00 (0.394)
HZ26...	1500				26.00 (1.024)	11.00 (0.433)
	2000				26.00 (1.024)	11.00 (0.433)
	2700				26.00 (1.024)	11.00 (0.433)

ELECTRICAL CHARACTERISTICS

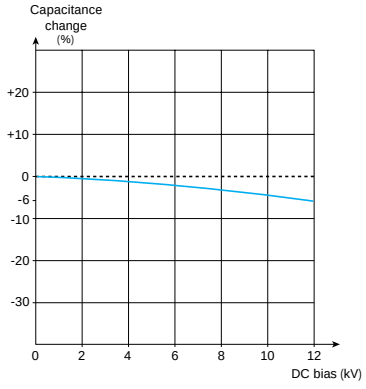
• Rated voltage	6.9, 12 kVdc
• Test voltage (in oil)	1.5xUR
• Capacitance change vs DC voltage	±10%
• Temperature characteristic within +10, +85°C	N4700
• Dissipation factor	< 10.10^{-4}
• Insulation resistance (1000 V_{DC} / 60 s)	> 10 G Ω
• Capacitance range (25°C - 1 kHz - 1 V_{rms})	100pF to 2700pF
• Tolerance on capacitance	±20% (M)

TYPICAL CURVES

Capacitance changes vs temperature



Capacitance change vs DC bias



High Voltage Ceramic Capacitors

HP Type - Strontium-based Dielectric

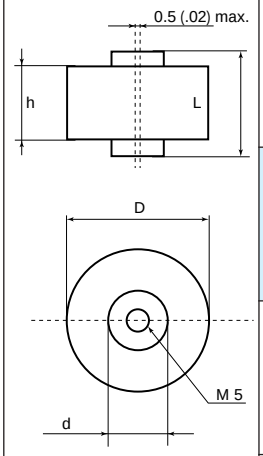
FEATURES

- Excellent behavior on pulse and discharge conditions
- Excellent capacitance vs voltage characteristic
- Optimized size, epoxy coating
- Low dissipation factor
- Very low Corona effect

APPLICATIONS

- High-voltage supply for gas lasers
- Marx generators
- Power generators
- Copying machines
- Electronic microscopes

REFERENCES - VOLTAGE AND CAPACITANCE RANGE



Style	Rated Voltage kVdc	Test Voltage kVrms	Reference	AC Corona inception voltage (kV) <5 pico C 50Hz	Capacitance ± 20% (pF)	Dimensions millimeters (inches) D ±1	d	L ±1	h ±2
	20	22	HP 30 E Y 0751 M.-.-	10	750	28 (1.100)	12 (0.472)	23 (0.906)	17 (0.669)
			HP 40 E Y 0142 M.-.-		1400	38 (1.500)	12 (0.472)	23 (0.906)	17 (0.669)
			HP 40 E Y 0152 M.-.-		1500	38 (1.500)	12 (0.472)	23 (0.906)	17 (0.669)
			HP 50 E Y 0202 M.-.-		2000	48 (1.900)	12 (0.472)	23 (0.906)	17 (0.669)
			HP 50 E Y 0252 M.-.-		2500	48 (1.900)	12 (0.472)	23 (0.906)	17 (0.669)
			HP 60 E Y 0302 M.-.-		3000	58 (2.283)	15 (0.591)	23 (0.906)	17 (0.669)
			HP 60 E Y 0402 M.-.-		4000	58 (2.283)	15 (0.591)	23 (0.906)	17 (0.669)
	30	33	HP 30 E 3 0511 M.-.-	15	510	28 (1.100)	12 (0.472)	26 (1.024)	20 (0.787)
			HP 40 E 3 0941 M.-.-		940	38 (1.500)	12 (0.472)	26 (1.024)	20 (0.787)
			HP 40 E 3 0102 M.-.-		1000	38 (1.500)	12 (0.472)	26 (1.024)	20 (0.787)
			HP 50 E 3 0152 M.-.-		1500	48 (1.900)	12 (0.472)	26 (1.024)	20 (0.787)
			HP 50 E 3 0172 M.-.-		1700	48 (1.900)	12 (0.472)	26 (1.024)	20 (0.787)
			HP 60 E 3 0202 M.-.-		2000	58 (2.283)	15 (0.591)	26 (1.024)	20 (0.787)
			HP 60 E 3 0272 M.-.-		2700	58 (2.283)	15 (0.591)	26 (1.024)	20 (0.787)
	40	44	HP 30 E 4 0391 M.-.-	20	390	28 (1.100)	12 (0.472)	30 (1.180)	24 (0.945)
			HP 40 E 4 0701 M.-.-		700	38 (1.500)	12 (0.472)	30 (1.180)	24 (0.945)
			HP 40 E 4 0721 M.-.-		720	38 (1.500)	12 (0.472)	30 (1.180)	24 (0.945)
			HP 50 E 4 0102 M.-.-		1000	48 (1.900)	12 (0.472)	30 (1.180)	24 (0.945)
			HP 50 E 4 0132 M.-.-		1300	48 (1.900)	12 (0.472)	30 (1.180)	24 (0.945)
			HP 60 E 4 0152 M.-.-		1500	58 (2.283)	15 (0.591)	32 (1.260)	26 (1.024)
			HP 60 E 4 0202 M.-.-		2000	58 (2.283)	15 (0.591)	32 (1.206)	26 (1.024)
	50	53	HP 40 E 5 0561 M.-.-	25	560	38 (1.500)	12 (0.472)	35 (1.378)	29 (1.142)
			HP 50 E 5 0112 M.-.-		1100	48 (1.900)	12 (0.472)	35 (1.378)	29 (1.142)
			HP 60 E 5 0172 M.-.-		1700	58 (2.283)	15 (0.591)	35 (1.378)	29 (1.142)

- Other tolerance on capacitance value, 50 kV voltage: please consult us.
- Tightening torque: 0.3 m.daN max

MARKING

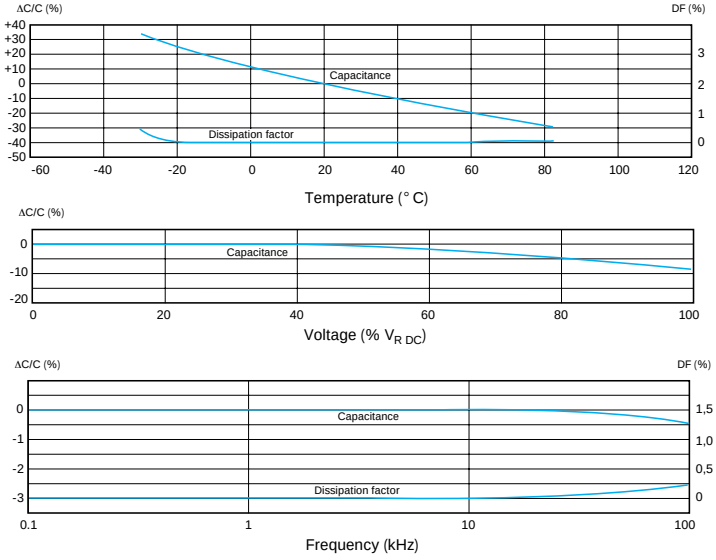
- On each part: logo, type, capacitance, rated voltage, manufacturing date
- On packaging: reference, lot number

ELECTRICAL CHARACTERISTICS

• Rated voltage (V_R)	20 to 50 kVdc
• Test voltage (V_E) (50Hz, in oil, 60 s without destruction)	22 to 53 kV_{RMS}
• Temperature ranges storage operating	-40 +125°C -30 +85°C
• Temperature characteristic	N4700
• Dissipation factor (25°C, 1 kHz, 1 V_{rms})	< 10.10^{-4}
• Insulation resistance (1000 V_{DC} / 60 s)	> 100 G Ω
• Capacitance range (25°C - 1 kHz - 1 V_{rms})	390pF to 4000pF
• Tolerance	±20%
• Self-inductance	60 nH

TYPICAL CURVES

Capacitance and dissipation factor changes vs temperature, DC voltage, frequency



TPC

High Voltage Ceramic Capacitors

HB/HF Types - Type II

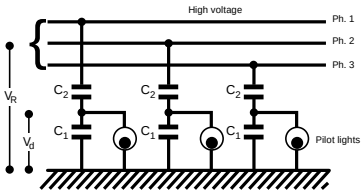
FEATURES

- These rod capacitors are designed for capacitive AC voltage dividers at 50/60 Hz frequency.
- Two versions are available:
  - HF type: unprotected rod with connections
  - HB type: unprotected metallized rod
- HB/HF types are for the high voltage section of the divider (C_2).

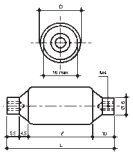
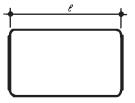
APPLICATIONS

- In HV mains supply (V_R), phase presence is checked by pilot lights. These lamps are supplied with a low voltage (Vd) which is obtained by means of capacitive divider according to the formula:

$$Vd = \left(\frac{C_2}{C_1 + C_2}\right) V_R$$



REFERENCES - VOLTAGE AND CAPACITANCE RANGE

Style	Reference	C_R (pF)	V_R kV_{RMS}	V_E kV_{RMS}	Corona level <5 pico C kV_{RMS}	Dimensions millimeters (inches) D	L	l	Weight g
HF 	HF60001250M.-.-	125	15	60	>14	17 (0.669)	81 (3.189)	61 (2.402)	115
	HF60000101M.-.-	100	15	60	>14	17 (0.669)	81 (3.189)	61 (2.402)	115
	HF60000500M.-.-	50	15	60	>14	17 (0.669)	81 (3.189)	61 (2.402)	115
	HF60000250M.-.-	25	15	60	>14	17 (0.669)	81 (3.189)	61 (2.402)	115
	HF60000160M.-.-	16	15	60	>14	17 (0.669)	81 (3.189)	61 (2.402)	115
	HF40000181M.-.-	180	11	42	>11	17 (0.669)	60 (2.362)	40 (1.575)	80
	HF40000750M.-.-	75	11	42	>11	17 (0.669)	60 (2.362)	40 (1.575)	80
	HF40000360M.-.-	36	11	42	>11	17 (0.669)	60 (2.362)	40 (1.575)	80
	HF40000240M.-.-	24	11	42	>11	17 (0.669)	60 (2.362)	40 (1.575)	80
	HF30000251M.-.-	250	8	30	>8	17 (0.669)	50.5 (1.988)	30.5 (1.201)	65
	HF30000101M.-.-	100	8	30	>8	17 (0.669)	50.5 (1.988)	30.5 (1.201)	65
	HF30000480M.-.-	48	8	30	>8	17 (0.669)	50.5 (1.988)	30.5 (1.201)	65
	HF30000320M.-.-	32	8	30	>8	17 (0.669)	50.5 (1.988)	30.5 (1.201)	65
HB 	HB60001250M.-.-	125	15	60	>14	17 (0.669)	/	61 (2.402)	110
	HB60000101M.-.-	100	15	60	>14	17 (0.669)	/	61 (2.402)	110
	HB60000500M.-.-	50	15	60	>14	17 (0.669)	/	61 (2.402)	110
	HB60000250M.-.-	25	15	60	>14	17 (0.669)	/	61 (2.402)	110
	HB60000160M.-.-	16	15	60	>14	17 (0.669)	/	61 (2.402)	110
	HB40000181M.-.-	180	11	42	>11	17 (0.669)	/	40 (1.575)	70
	HB40000750M.-.-	75	11	42	>11	17 (0.669)	/	40 (1.575)	70
	HB40000360M.-.-	36	11	42	>11	17 (0.669)	/	40 (1.575)	70
	HB40000240M.-.-	24	11	42	>11	17 (0.669)	/	40 (1.575)	70
	HB30000251M.-.-	250	8	30	>8	17 (0.669)	/	30.5 (1.201)	55
	HB30000101M.-.-	100	8	30	>8	17 (0.669)	/	30.5 (1.201)	55
	HB30000480M.-.-	48	8	30	>8	17 (0.669)	/	30.5 (1.201)	55
	HB30000320M.-.-	32	8	30	>8	17 (0.669)	/	30.5 (1.201)	55

Important:

Handling of uncoated types must be done under strict cleanliness conditions.

Special types

Other models with different dimensions and capacitance can also be supplied upon request.

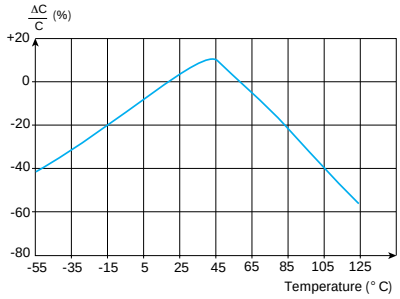
ELECTRICAL CHARACTERISTICS

• Capacitance range (at V_{Rrms})	16 to 250pF
• Capacitance tolerance	±20% (±10%: consult us)
• Rated voltage (V_R)	8 kV_{rms} to 15 kV_{rms}
• Test voltage (V_E) -measurement made in a dielectric fluid (ref. F113) during 1 min	30 kV_{rms} to 60 kV_{rms}
• Dissipation factor (at V_{rms})	tg δ 150.10^{-4}
• Ionization or corona voltage	Ui 8 kV_{rms} to 14 kV_{rms}
• Shock wave behavior (HB/HF types)	140 kVc (1.2/50 µs wave)
• Main parameters change vs temperature, voltage	See typical curves

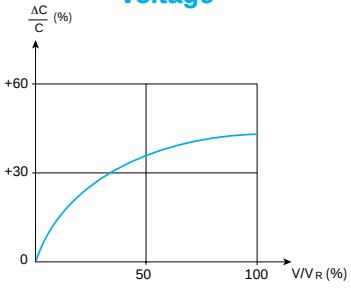
Note: For other electrical characteristics, please consult us.

TYPICAL CURVES

Capacitance change vs temperature



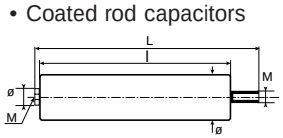
Capacitance change vs voltage



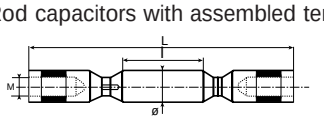
SPECIAL TYPES

According to specific customer requirements, TPC has developed special types to mold like:

- Coated rod capacitors



- Rod capacitors with assembled terminals



Dimensions, electrical characteristics can be adapted upon request.

High Voltage Ceramic Capacitors

HD/HE Types - Type II (N)

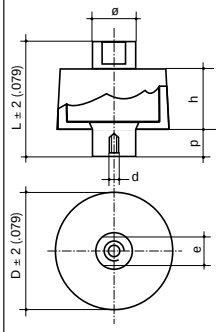
FEATURES

- Disc capacitor, type II
- Excellent capacitance vs voltage characteristic
- Low dissipation factor
- Good behavior on frequency
- Two available versions:
  - HD: Molded type with connections
  - HE: Uncoated type without connections (silvered ceramic)

APPLICATIONS

- AC voltage dividers at industrial frequency
- High frequency decoupling
- Other special applications

REFERENCES - VOLTAGE AND CAPACITANCE RANGE

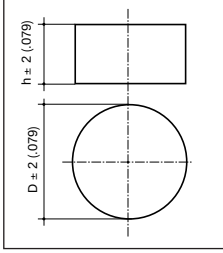
Style	Reference	C_R (pF)	V_R (kVc~)	V_E (kVc~)	Dimensions millimeters (inches) D	L	h	∅	d	p	e	Torque S (m.daN)	Weight (g)
	HD 30 0X 0251S--	250	15	20	26.5 (1.043)	33 (1.300)	16 (0.630)	8 (0.315)	5 (0.197)	9 (0.354)	7 (0.276)	0.3	30
	HD 30 0X 0501S--	500	15	20	26.5 (1.043)	33 (1.300)	16 (0.630)	8 (0.315)	5 (0.197)	9 (0.354)	7 (0.276)	0.3	30
	HD 40 0X 0102S--	1000	15	20	39.5 (1.555)	33 (1.300)	16 (0.630)	8 (0.315)	5 (0.197)	9 (0.354)	7 (0.276)	0.3	60
	HD 60 0Y 0202S--	2000	20	30	56.5 (2.224)	45 (1.772)	21 (0.827)	12 (0.472)	8 (0.315)	11 (0.433)	10 (0.394)	1	160
	HD 60 0X 0302S--	3000	15	20		40 (1.575)	19 (0.748)						135

Important: HD type

In order to improve capacitor mounting, connections ends are designed with two flats. Thus, tightening torque is only applied on the screw (consult chart above for torque "S" value).

Hardware supplied for capacitor mounting

2 x screws TCB M5 L8 or TCB M8 L12 according to ∅
2 x washers

Style	Reference	C_R (pF)	V_R (kVc~)	V_E (kVc~)	D	L	h
	HB 30 0X 0251S--	250	15	20	12 (0.472)	—	8 (0.315)
	HB 30 0X 0501S--	500	15	20	17 (0.669)	—	9 (0.354)
	HB 40 0X 0102S--	1000	15	20	26 1.024)	—	9 (0.354)
	HB 60 0Y 0202S--	2000	20	30	42 (1.654)	—	12 (0.472)
	HB 60 0X 0302S--	3000	15	20	42 (1.654)	—	9 (0.354)

Important: HE type

Handling of uncoated types must be done under strict cleanliness conditions.

MARKING

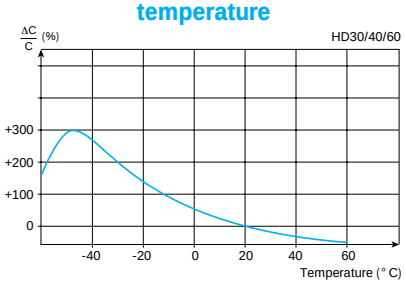
- TPC - Reference (HTD)
- Capacitance
- Rated voltage

ELECTRICAL CHARACTERISTICS

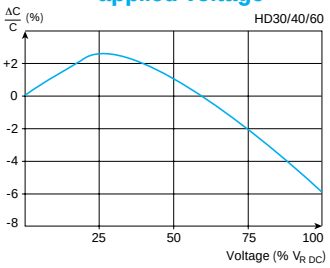
• Operating temperature range	-30 +85°C (+125°C: consult us)
• Rated voltage (V_{rms}/50 Hz)	15 kV or 20 kV
• Test voltage (V_{rms}/50 Hz)	20 kV or 30 kV
• Capacitance range	250 to 3000pF
• Capacitance tolerance	-20 +50% (S)
• Dissipation factor	tg δ ≤ 20.10^{-4}
• Self-inductance	L ≤ 30 nH
• Main parameters change vs applied voltage, temperature and frequency	See typical curves

TYPICAL CURVES

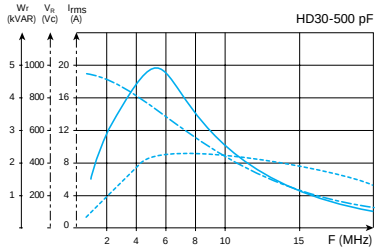
Capacitance change vs temperature

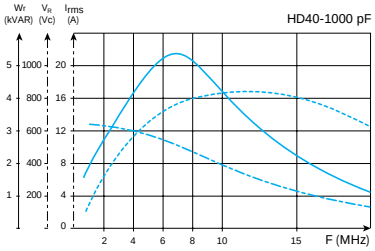


Capacitance change vs applied voltage



Maximum reactive power (W_R), voltage (V_R), current (I_{RMS}) vs frequency





High Voltage Ceramic Capacitors

Custom Designed Live-Line Dividers

APPLICATIONS

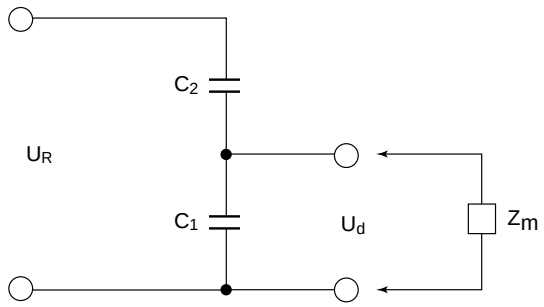
TPC is able to study and design live-line dividers to customers specifications, up to 150 KV_{rms}.

They can be used for:

- voltage presence indication
- voltage presence alarm
- voltage measurement

PRINCIPLE OF USE

• Using the following equivalent circuit



with:

V_R : rated voltage of the line
V_d : low voltage output
C_1 : low voltage / high value capacitor
C_2 : high voltage / low value capacitor
Z_m : measuring impedance
Z_t : impedance of C_1 at 50/60 Hz

the low voltage output is obtained by

$$V_d = \left(\frac{C_2}{C_1 + C_2}\right) V_R$$

the ratio $\frac{C_2}{C_1 + C_2}$ being adjusted to the expected value.

• For measurement application, the measurement impedance Zm must be larger than at least 10 times Z_t in order not to affect the dividing ratio where:

$$Z_t = \frac{1}{\left(\frac{C_1 \cdot C_2}{C_1 + C_2}\right) \omega}$$

FEATURES

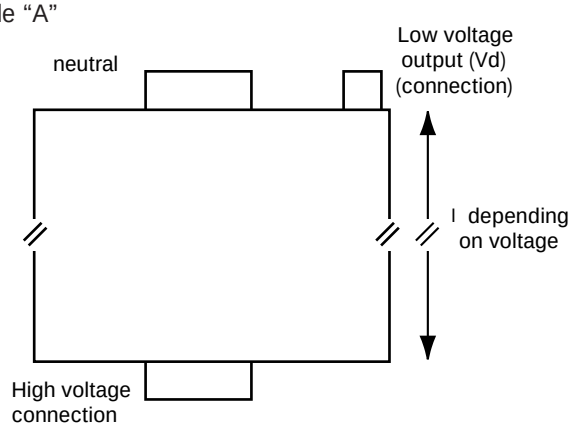
The high and low voltage elements can be supplied either separately or in the same molding.

The capacitor divider ratio can be adjusted between 1/200 and 1/10 together with a tolerance that can be as tight as 2%.

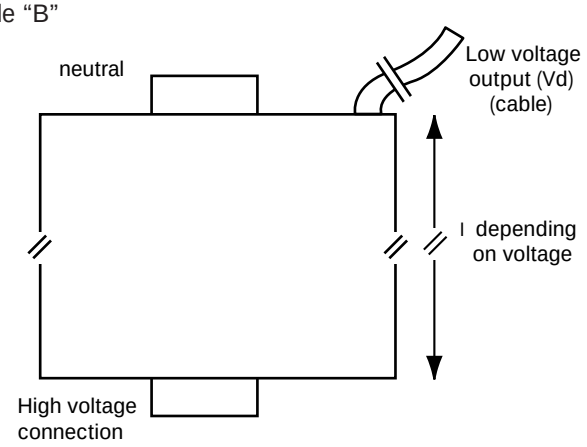
The products can be developed for rated line voltage from 10kV up to 150 KV_{rms}.

TYPICAL EXAMPLES

• Style “A”



• Style “B”



For dimensions, capacitances, voltages, ratio, please consult your local sales office.

High Voltage Ceramic Capacitors

HR/HS Types - Type II

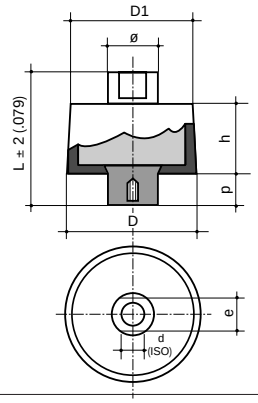
FEATURES

- Disc capacitor, type II
- Two available versions:
  - HR: Molded type with connections
  - HS: Uncoated type without connections (silvered ceramic)

APPLICATIONS

- DC high voltage applications

REFERENCES - VOLTAGE AND CAPACITANCE RANGE

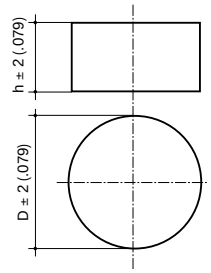
Style	Reference	C_R (pF)	V_R (kVc-)	V_E (kVc-)	Dimensions millimeters (inches) D	D_1	L	h	∅	d	p	e	Torque S (m.daN)	Weight (g)
	HR 30 0X 0471S--	470	16	24	27 (1.063)	25 (0.984)	37 (1.457)	23 (0.906)	8 (0.315)	5 (0.197)	9 (0.354)	7 (0.276)	0.3	32
	HR 30 0Y 0471S--	470	20	30	34 (1.339)	32 (1.260)	40 (1.575)	28 (1.100)	8 (0.315)	5 (0.197)	9 (0.354)	7 (0.276)	0.3	45
	HR 40 0X 0102S--	1000	16	24	39 (1.535)	37 (1.457)	37 (1.457)	23 (0.906)	8 (0.315)	5 (0.197)	9 (0.354)	7 (0.276)	0.3	65
	HR 40 0Y 0102S--	1000	20	30	44 (1.732)	42 (1.654)	40 (1.575)	28 (1.100)	8 (0.315)	5 (0.197)	9 (0.354)	7 (0.276)	0.3	90
	HR 60 0Y 0222S--	2200	20	30	54 (2.126)	52 (2.047)	47 (1.850)	28 (1.100)	12 (0.472)	8 (0.315)	13 (0.512)	10 (0.394)	1	180
	HR 60 0X 0502S--	5000	16	24	55 (2.165)	54 (2.126)	40 (1.575)	21 (0.827)	12 (0.472)	8 (0.315)	13 (0.512)	10 (0.394)	1	180

Important: HR type

In order to improve capacitor mounting, connections ends are designed with two flats. Thus, tightening torque is only applied on the screw (consult chart above for torque "S" value).

Hardware supplied for capacitor mounting

2 x screws TCB M5 L8 or TCB M8 L12 according to Ø
2 x washers

Style	Reference	C_R (pF)	V_R (kVc-)	V_E (kVc-)	Dimensions millimeters (inches) D	D_1	L	h
	HS 30 0X 0471S--	470	16	24	17 (0.669)	—	—	13 (0.512)
	HS 30 0Y 0471S--	470	20	30	19 (0.748)	—	—	17 (0.669)
	HS 40 0X 0102S--	1000	16	24	26 (1.024)	—	—	14 (0.551)
	HS 40 0Y 0102S--	1000	20	30	29 (1.142)	—	—	16 (0.630)
	HS 60 0Y 0222S--	2200	20	30	37 (1.457)	—	—	14 (0.551)
	HS 60 0X 0502S--	5000	16	24	42 (1.654)	—	—	8 (0.315)

Handling of uncoated types must be done under strict cleanliness conditions.

SPECIAL TYPES

Upon request:

- Metallized uncoated ceramic disc with connections
- Stacks with coated or uncoated units from standard ceramic disc

MARKING

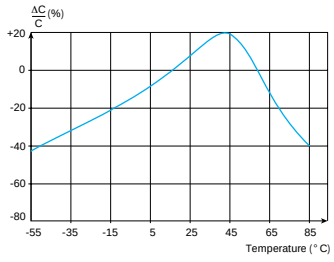
- Reference (HTX)
- Capacitance
- Rated voltage

ELECTRICAL CHARACTERISTICS

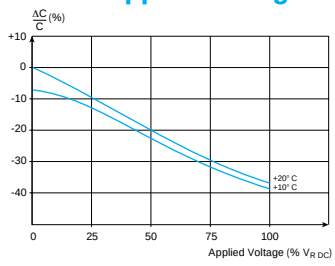
• Operating temperature range	-55 +85°C (+125°C: consult us)
• Rated voltage (V_{rms}/50 Hz)	16 kV or 20 kV
• Test voltage (V_{rms}/50 Hz)	24 kV or 30 kV
• Capacitance range (F = 1 kHz /T = 25°C / U_m = 1 V_{rms})	470 to 5000pF
• Capacitance tolerance on rated capacitance	-20 +50% (S)
• Dissipation factor	tg δ ≤ 200.10^{-4}
• Insulation resistance (Um = 1000 V / 1 mn)	Ri ≥ 10 G Ω
• Self-inductance	L ≤ 0.03 µH
• Main parameters change vs applied voltage, temperature	See typical curves

TYPICAL CURVES

Capacitance change vs temperature



Capacitance change vs applied voltage



TPC

High Voltage Ceramic Capacitors

HT/HU Types - Type I

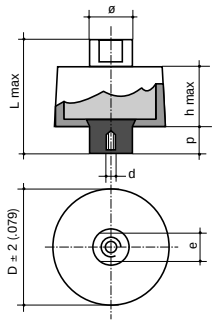
FEATURES

- Disc capacitor, type I
- Low reactive power
- High stability vs temperature
- No capacitance change vs voltage
- Two available versions:
  - HT: Molded type with connections
  - HU: Uncoated type without connections (silvered ceramic)

APPLICATIONS

- High voltage coupling
- High voltage tuning

TYPES AND DIMENSIONS

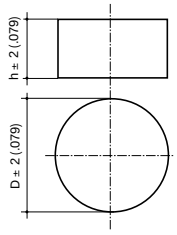
Style	Type/Size	Dimensions millimeters (inches) D	L	h	∅	d (ISO)	p	e	Tightening torque S (m.daN)
	HT 30	25.5 (1.004)	50 (1.969)	30 (1.180)	8 (0.315)	5 (0.197)	9 (0.354)	7 (0.276)	0.3
	HT 40	38 (1.500)	50 (1.969)	30 (1.180)	8 (0.315)	5 (0.197)	9 (0.354)	7 (0.276)	0.3
	HT 60	56 (2.205)	55 (2.165)	35 (1.378)	12 (0.472)	8 (0.315)	13 (0.512)	10 (0.394)	1

Important: HT type

In order to improve capacitor mounting, connections ends are designed with two flats. Thus, tightening torque is only applied on the screw (consult chart above for torque "S" value).

Hardware supplied for capacitor mounting

2 x screws TCB M5 L8 or TCB M8 L12 according to Ø
2 x washers

	HU 30	22 (0.866)	_
	HU 40	30 (1.180)	_
	HU 60	42 (1.654)	_

Height h: Depending on capacitance please consult us

Important: HU type

Handling of uncoated types must be done under strict cleanliness conditions.

TABLE OF VALUES

Type	Rated capacitance C_R (pF)	Rated voltage V_R (kV)	Test voltage V_E (kV / 50 Hz)	Capacitance vs temperature TC (ppm/°C)
HT/HU30A	4.7-5.6	17	25	+100 ±100
HT/HU30A	6.8	10	15	
HT/HU40A	8.2	17	25	
HT/HU40A	10-15	10	15	
HT/HU60A	18-22	17	25	
HT/HU60A	27-47	10	15	
HT/HU30H	10	17	25	-33 ±60
HT/HU30H	12	10	15	
HT/HU40H	15-22	17	25	
HT/HU40H	27-33	10	15	
HT/HU60H	39-47	17	25	
HT/HU60H	56-100	10	15	
HT/HU30T	22	10	15	-470 ±160
HT/HU40T	27-33	17	25	
HT/HU40T	39-56	10	15	
HT/HU60T	68-82	17	25	
HT/HU60T	100-150	10	15	
HT/HU30U	22-27	17	25	-750 ±250
HT/HU30U	33-39	10	15	
HT/HU40U	47-56	17	25	
HT/HU40U	68-100	10	15	
HT/HU60U	120-150	17	25	
HT/HU60U	180-270	10	15	

MARKING

- Reference (HT)
- Capacitance, tolerance
- Rated voltage

ELECTRICAL CHARACTERISTICS

• Climatic category	-55 +85°C, 21 days damp heat
• Rated voltage (DC voltage + HF peak)	10 kV or 17 kV
• Test voltage (V_{rms}/50 Hz)	15 kV or 25 kV
• Dissipation factor C ≤50pF C >50pF	 tg δ ≤ 20.10^{-4} tg δ ≤ $20\left(\frac{15}{C}+0.7\right).10^{-4}$
• Temperature coefficient	TC = +100 to -750 ppm/°C depending on capacitance value
• Tolerances and associated series	±1pF (F) ±10% (K) ±20% (M) C < 10pF E 12 E 6

LOT RELEASE

Every high voltage and power capacitor is inspected individually during manufacture.

They must, before shipping, satisfy the criteria of the quality control department.

Each lot is checked in accordance with defined sampling plans.

The tests are performed in accordance with the specifications hereunder.

MECHANICAL TESTS

Dimensions of each unit are inspected and must be in accordance with the characteristics specified on the particular data sheet.

OPERATING CLIMATIC CONDITIONS

TPC power capacitors temperature range, in normal utilization, is from -30°C to +85°C.

However if provided power is decreased as previously indicated, it is possible to use them at higher temperatures.

Please refer to us.

ELECTRICAL TESTS

- **Capacitance and tangent of loss angle (DF)**
  Tests are made at room temperature and the measurement conditions are:

Type I - C < 1000pF:
- measuring frequency: 1 MHz
- measuring voltage: ≤ 10 Vrms

C ≥ 1000 pF:
- measuring frequency: 1 kHz
- measuring voltage: ≤ 10 Vrms

Type II - C < 100pF:
- measuring frequency: 1 MHz
- measuring voltage: ≤ 1 Vrms

C ≥ 100pF:
- measuring frequency: 1 kHz
- measuring voltage: ≤ 1 Vrms

- **Dielectric strength**
  This test is realized with DC or AC/50 Hz voltage (refer to individual data sheet for each type). Units are kept under applied voltage for 1 min.
- **Insulation resistance**
  Insulation resistance value is warranted higher than 10 GΩ after 1 min at 1000 VDC.
- **Temperature coefficient**
  Temperature coefficients are measured with voltage less than 10V in temperature range from +20°C to +85°C. Temperature coefficients are within the tolerances specified in particular data sheets.

High Voltage Ceramic Capacitors

Manufacturing Process

MANUFACTURING OF DIELECTRIC AND SEMI-FINISHED CAPACITORS

Incoming raw material	Inspection: every batch
Weighing - Mixing - Grinding - Drying	Ratio of materials, duration: every batch
Calcination	Temperature, duration, particle size: every batch
Weighing - Mixing - Grinding	Ratio of materials, duration: every batch
Slurry production	Viscosity: every batch
Spray-drying	Particle size, moisture content: every batch
Qualification of dielectric	Electrical characteristics: every batch
Shaping	Dimensions, visual: by sampling
Sintering	Temperature, duration
Qualification of semi-finished products	Dimensions, electrical characteristics: every batch

MANUFACTURING OF COATED CAPACITORS

Metallization	Visual inspection: every batch
Soldering	Visual inspection: every batch
Coating/marking	Visual inspection: every batch
Curing	Temperature, duration: every batch
Final manufacturing inspection	Capacitance, tg δ, IR, dielectric strength: 100%
Quality control	Dimensions, visual inspection, electrical parameters: sampling plan
Packaging	
Quality acceptance	QA report: every batch
Shipping consignment	
Outgoing shipping-inspection	Every batch, every shipment: packaging, documentation

High Voltage Ceramic Capacitors

Marking - Packaging - Identification

MARKING

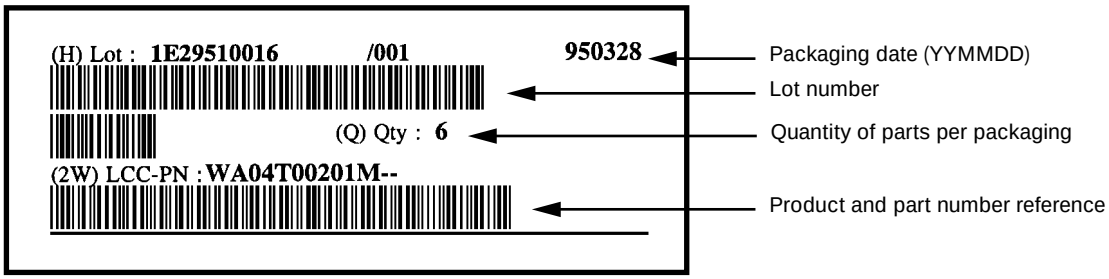
Each part is marked with the following indications:

- Logo
- Reference
- Rated capacitance (EIA code)
- Tolerance on capacitance (EIA code)
- Rated voltage

IDENTIFICATION - TRACEABILITY

On the packaging of all shipped capacitors, you will find a bar code label (code 39). This label gives systematic information on the type of product, part number, lot number, packing date and quantity.

An example is given below:



This information allows traceability of the entire manufacturing process, from critical raw materials to shipment. This is extremely useful for any information request, customer complaint or product return.

CROSS REFERENCES PREVIOUS REFERENCES / NEW REFERENCES

High Voltage	
Previous Reference	**New Reference**
HT030 ... 060	HT30 ... 60
HT030D ... 060D	HU30 ... 60
HTD230 ... 360	HD30 ... 60
HTD230D ... 360D	HE30 ... 60
HTX230 ... 360	HR30 ... 60
HTX230D ... 360D	HS30 ... 60
HTZ130 ... 160	HB30 ... 60
HTZ131 ... 161	HF30 ... 60

High Voltage Ceramic Capacitors

Questionnaire: How to Define a Capacitor

CUSTOM DESIGN REQUIREMENTS

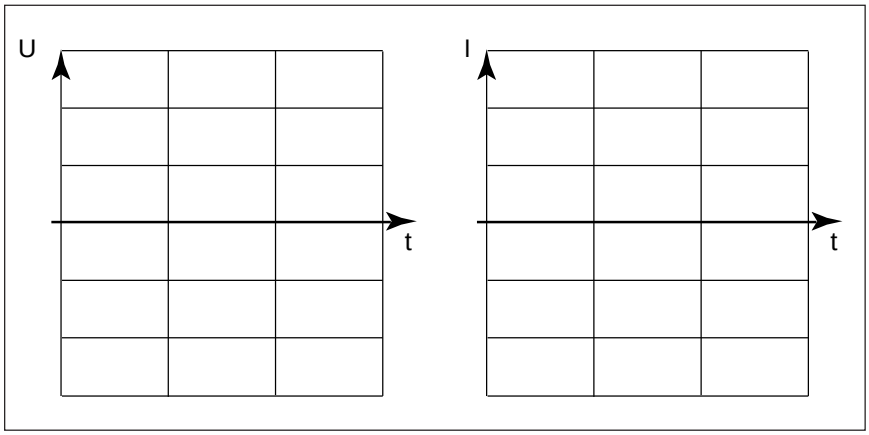
Customer: _____ Date: _____

Country: _____

- **What is your application:**
  - ❑ Coupling / Decoupling: _____ ❑ Tuning: _____
  - ❑ Smoothing: _____ ❑ High energy pulses: _____
  - ❑ Voltage divider: _____ ❑ Voltage multiplier: _____
- **What are the critical parameters in this application:**
  - ❑ Low cap. variation vs temperature: _____
  - ❑ Guaranteed minimum cap. value (under T°C + Udc or ac): _____
  - ❑ Low dielectric losses: _____ At low frequency: _____
  - ❑ Low ESR: _____ At high frequency: _____
  - ❑ Minimum I.R (M): _____ At what temperature: _____
  - ❑ Other (describe): _____

_____

- **Signal**
  1. Pulse Signal
     - Peak voltage: _____
     - Rise time or dV/dt: _____
     - Peak current: _____
     - Recurrent frequency: _____
     - Energy stored: _____
  2. Sine Wave
     - rms voltage: _____
     - rms current: _____
     - Frequency: _____
     - DC bias if any: _____
     - Reactive power: _____
     - Divider ratio: _____



- **Physical parameters**
  - Operating temperature range: _____ • Maximum weight: _____
  - Mounting requirements: _____ • Maximum dimensions: _____
- **Other requirements:** _____

_____

_____

_____

- **Recommended product:**
  - Type / Size: _____ • Voltage: _____ • Capacitance: _____ • Tolerance: _____

High Voltage Ceramic Capacitors

Standard Series and Associated Tolerances

E 6 ±20%	E 12 ±10%	E 24 ±5%	E 48 ±2%	E 96 ±1%
100	100	100	100	100
				102
			105	105
				107
		110	110	110
				113
			115	115
				118
	120	120	121	121
				124
			127	127
		130		130
			133	133
				137
			140	140
				143
			147	147
150	150	150		150
			154	154
		160		158
			162	162
				165
			169	169
				174
	180	180	178	178
				182
			187	187
				191
			196	196
		200		200
			205	205
				210
			215	215
220	220	220		221
			226	226
				232
		240	237	237
				243
			249	249
				255
			261	261
	270	270		267
			274	274
				280
			287	287
				294
		300	301	301
				309

E 6 ±20%	E 12 ±10%	E 24 ±5%	E 48 ±2%	E 96 ±1%
			316	316
				324
330	330	330	332	332
				340
			348	348
		360		357
			365	365
				374
			383	383
	390	390		392
			402	402
				412
			422	422
		430		432
			442	442
				453
			464	464
470	470	470		475
			487	487
		510		499
			511	511
				523
			536	536
	560	560		549
			562	562
				576
			590	590
				604
		620	619	619
				634
			649	649
				665
680	680	680	681	681
				698
			715	715
				732
		750	750	750
				768
			787	787
	820	820		806
			825	825
				845
			866	866
				887
		910	909	909
				931
			953	953
				976

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