FIM Technology

TPC (acquired by AVX Corporation in 1998) is at the forefront of high performance film capacitor technology improvements for 30 years.

In 1979, we developed CONTROLLED SELF-HEALING technology specifically to enhance the performance of film power capacitors.

This enables the capacitor to continue to function without catastrophic failure by insulating the weak points of the dielectric material. During operation, the capacitor behaves like a battery. It will consume capacitance via the gradual breakdown of individual cells until it decreases down to 2% of the original value.

Since 1988, FIM technology launching year, we continuously improve performances to meet DC filtering power applications.

FIM technology with polypropylene **F**ilm, vegetable oil **I**mpregnated and aluminium **M**etallization combines totally safe behavior and high energy density.

FIM technology is available in CAPAFIM, TRAFIM and FILFIM ranges for DC filtering applications.

Also available in DISFIM range for energy storage and discharge applications.

ELECTRICAL CHARACTERISTICS FOR DC FILTERING

C_n Capacitance	Nominal value of the capacitance measured at θ_{amb}=25±10°C.
V_n Rated DC voltage	Maximum operating peak voltage of either polarity (non-reversing type waveform), for which the capacitor has been designed for continuous operation.
V_w Working voltage	Value of the maximum operating recurrent voltage for a given hot spot temperature and an expected lifetime.
V_r Ripple voltage	Peak-to-peak alternating component of the unidirectional voltage.
V_I Insulation voltage	Rms rated value of the insulation voltage of capacitive elements and terminals to case.
L_s Stray inductance	Capacitor series self-inductance.
R_s Capacitor series resistance	Capacitor series resistance due to galvanic circuit.
tan δ Tangent of loss angle	Ratio between the equivalent series resistance and the capacitive reactance of a capacitor at a specified sinusoidal alternating voltage, frequency and temperature.
I_{rms} Working current	Rms current value for continuous operation.
I_{max} Maximum current	Maximum Rms current value for continuous operation.

THERMAL CHARACTERISTICS

θ_{amb} (°C) Cooling air temperature	Temperature of the cooling air measured at the hottest position of the capacitor, under steady-state conditions, midway between two units. NOTE If only one unit is involved, it is the temperature measured at a point approximately 0.1 m away from the capacitor container and at two-thirds of the height from its base.
θ_{HS} (°C) Hot spot temperature	Highest temperature obtained inside the case of the capacitor in thermal equilibrium.
θ (°C) Operating temperature	Temperature of the hottest point on the case of the capacitor in thermal equilibrium.
θ_{min} (°C) Minimum operating temperature	Lowest temperature of the dielectric at which the capacitor may be energized.
θ_{max} (°C) Maximum operating temperature	Highest temperature of the case at which the capacitor may be operated.

FIM Products

General Description

Three series, for DC filtering applications, are proposed with nominal voltage from 1200V up to 56kV.

CAPAFIM

DC filtering application up to 3.9kV

Capacitance up to 1620µF

TRAFIM

DC filtering application up to 6kV

Capacitance up to 16100µF

- Standard shape base 340x165

- Book shape base 340x117 which allows:

Lower thermal resistance	Higher Rms current capability
Lower serial resistance	Higher thermal exchange
Lower stray inductance	

FILFIM

High voltage DC filtering available up to 100kV on specific design

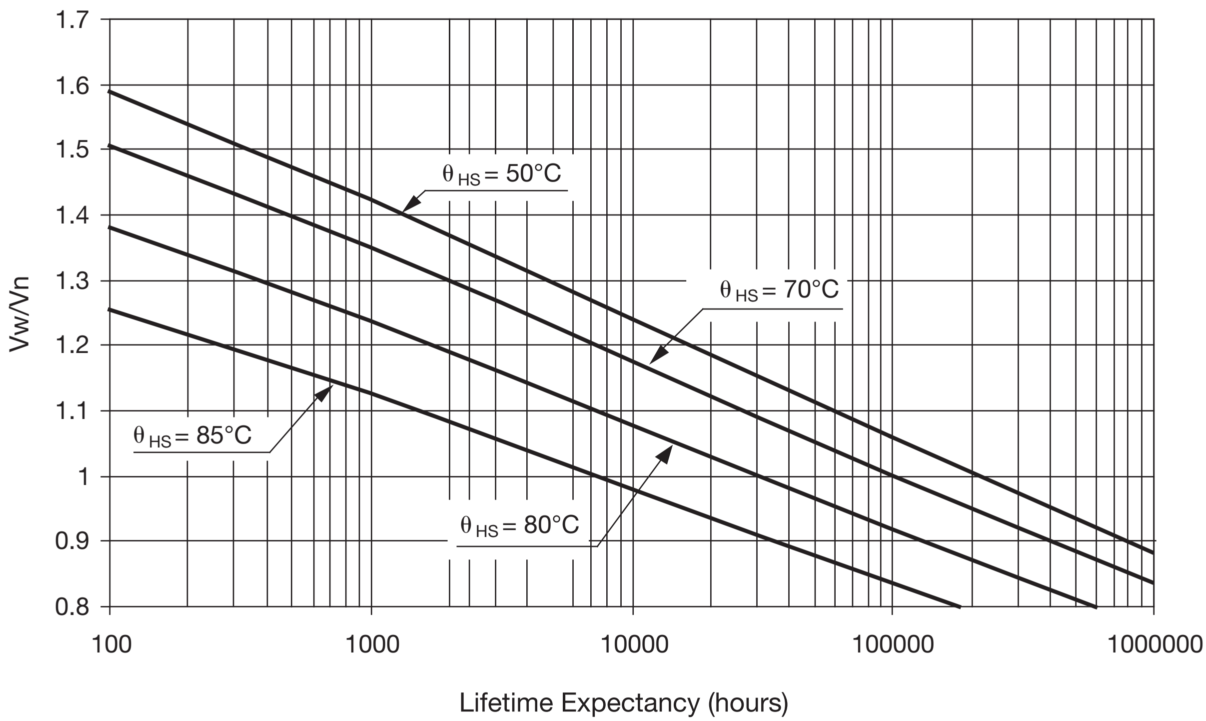
Capacitance up to 612µF

For any specific request about capacitance value, voltage, size or shape, contact your AVX local representative request by using the form on page 30.

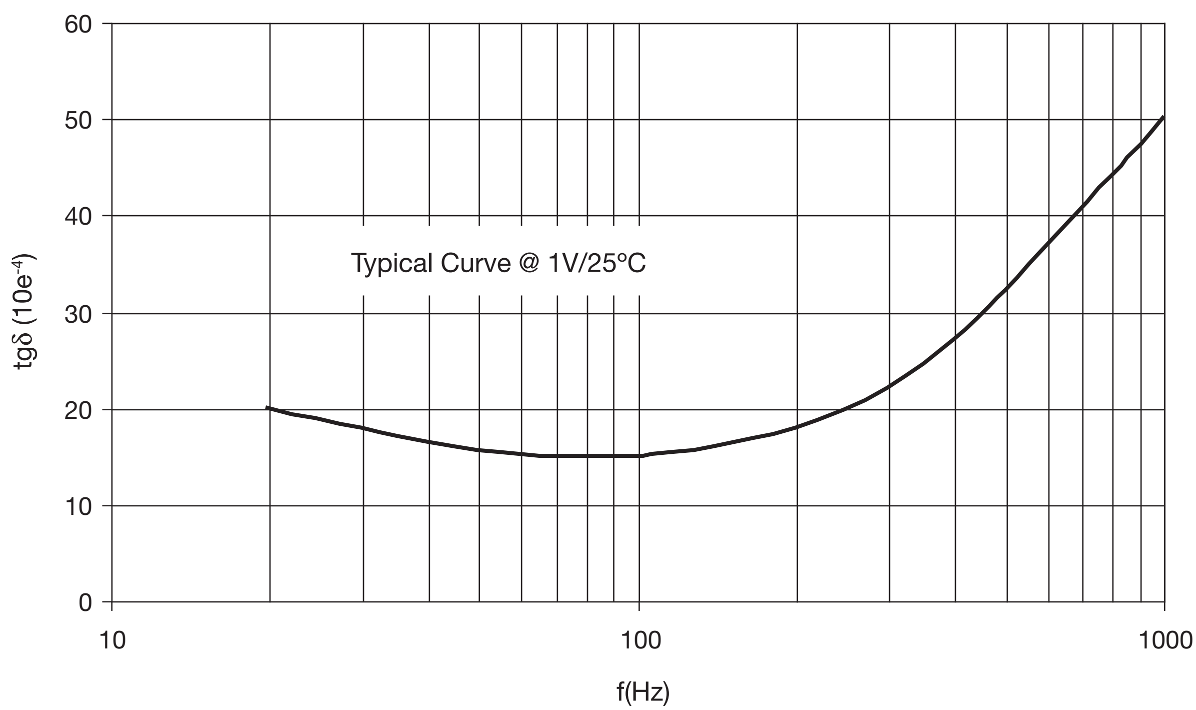
STANDARDS

IEC61071	Capacitors for power electronics
IEC61881	Capacitors for power electronics, railway applications, rolling stock equipment
IEC61373	Railway applications, rolling stock equipment, shock and vibration tests
IEC60068	Environmental testing
NFF16-101	Railway rolling stock, fire behavior
NFF16-102	Railway rolling stock, fire behavior

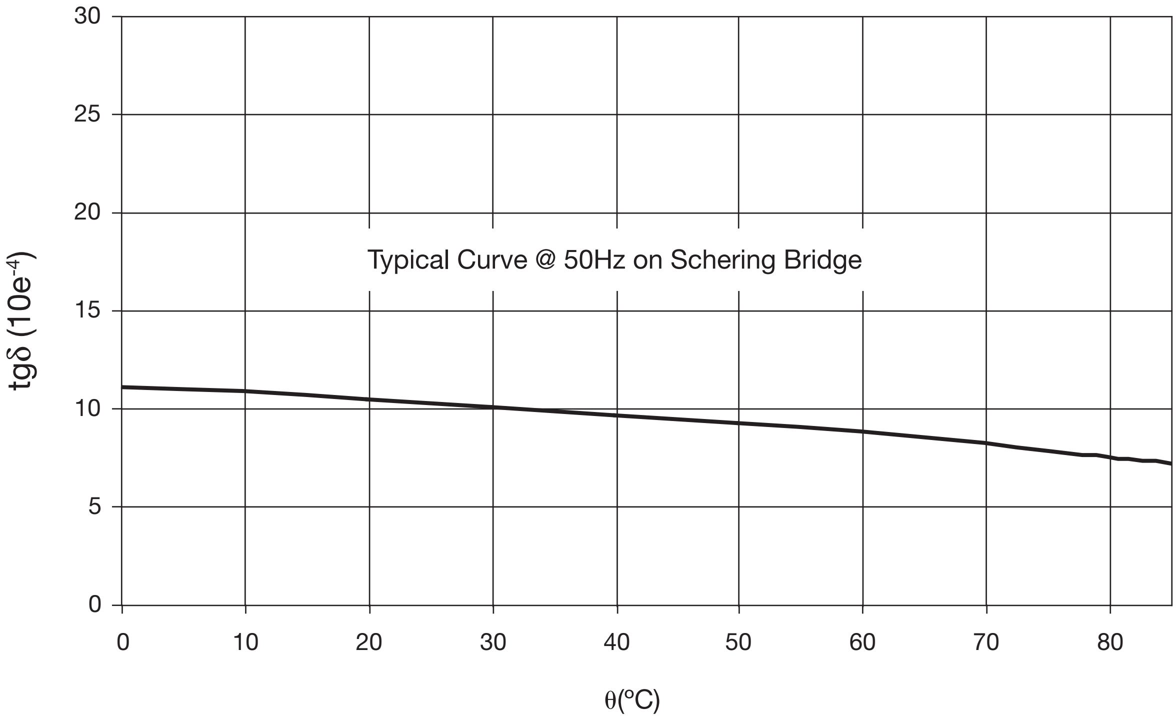
LIFETIME EXPECTANCY VS HOT SPOT TEMPERATURE AND VOLTAGE



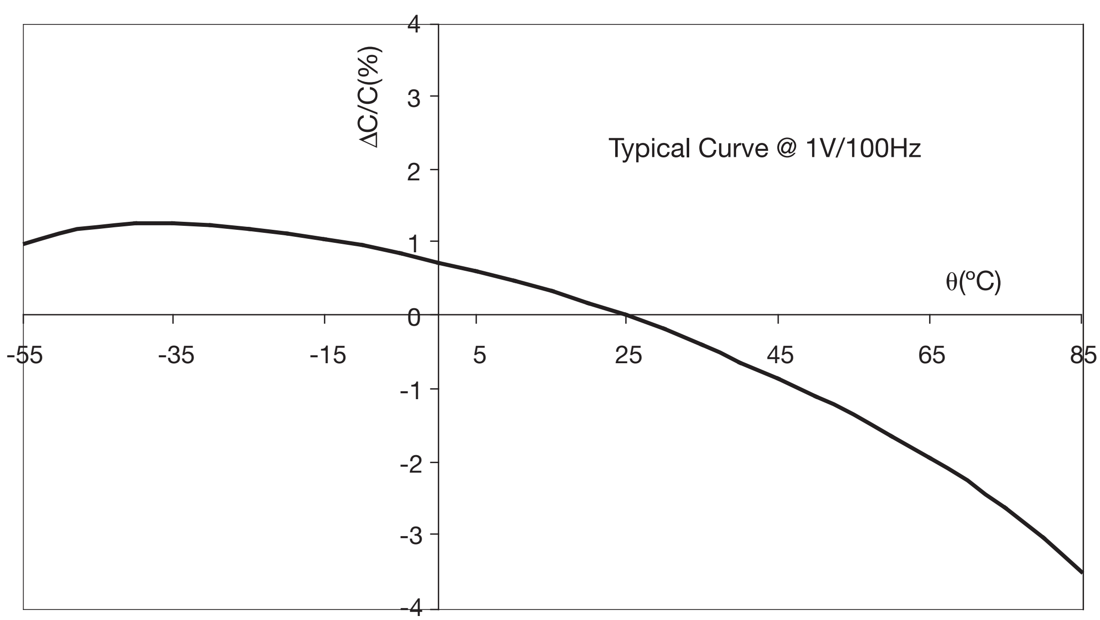
TANGENT OF LOSS ANGLE VS FREQUENCY



TANGENT OF LOSS ANGLE VS TEMPERATURE



ΔC/C VS HOT SPOT TEMPERATURE



General Description

DIMENSIONS

Dimensions are indicated in the value tables as well as the weight.

Dimensional tolerances are:

H ± 3mm, W ± 3mm

Initially, the large faces of the capacitor may be slightly convex. At delivery the maximum width is:

W'max = W +15mm

Standard material is stainless steel. Aluminum is available for specific requirement to reduce the weight or induction effect.

MOUNTING

Vertical mounting is the preferred and horizontal is acceptable. Please contact AVX for up-side down mounting configuration.

HANDLING

When unpacking, it is important that no mechanical shocks occur that might deform the cans and damage the output connection.

The capacitors include, unless otherwise specified, one or several gripping elements (mass screws, jack rings or other hoisting devices); they should be exclusively handled by means of these elements.

In no case should the electrical output terminals be used to lift the capacitor.

The grounding wire should be kept in place until the capacitor is mounted.

ASSEMBLY AND INSTALLATION

To check for the absence of excessive mechanical stresses.

The mechanical stresses in assembly should remain compatible with the characteristics of the capacitor.

The method of mounting should not lead to the deformation of the capacitor case.

Tightening torques are given below:

Output through threaded connections:

max = 25 N-m

Mechanical mounting

Moreover vertical position is the preferential one and horizontal is accepted.

In order to enable air convection, it is necessary to maintain at least 40mm between the large faces of adjacent capacitors.

Connections

They should not induce any force on the output terminals. Flexible connections should be used (braided or thin metal).

The cross section should not be less than:

$S = 0.2 \times I_{max}$ where S (mm^2) and I_{max} (A)

The skin effect, which occurs vs frequency, must also be taken into account.

MARKING

The label is usually located 50mm from the top of the case and centered to the length:

- TPC or AVX Logo
- Part number
- Capacitance and tolerance
- Rated voltage in clear
- Test voltage between terminals and case
- Batch and serial number
- Date of manufacture

SAFETY

The FIM technology provides excellent safety; there is no risk of explosion in case of defect throughout the life of the capacitor. This explains why there is no need to equip these capacitors with pressure switch. Rapeseed oil is not explosive or flammable at normal conditions, therefore capacitors can be transported without being subjected to safety rules. Rapeseed oil flash point is about 317°C and the polypropylene flash point is near 300°C, so the melting certifies a temperature of security above 300°C.

In case of fire above this temperature, it is recommended to use dust or CO_2. The use of water is contra-indicated. The possible rejected products during fire are CO_2, H_2O, CO (in case of non-complete combustion), Hydrocarbons and some other gases. Carrying mask is required for protection.

OIL

The only impregnant used in TRAFIM capacitors is rapeseed oil (otherwise known as Canola oil) and then is fully environmentally compatible. It does not emit toxic or carcinogenic gases, nor is it harmful to soil, water or humans in the event of accidental spillages. As a natural product derived from foodstuff, it is even edible.

Of all the vegetable oils, rapeseed oil has one of the best thermal stabilities and lowest acidity levels.

NON-TOXIC COMPOSITION

Our capacitors are free of:
Arsenic, Asbestos, Beryllium, Brominated flame retardants (PBB and PBDE), Cadmium, CFC, HCFC, Cobalt, Formaldehyde, Halon, Isocyanatos, Mercury, Nickel PCB, PCT, Polyaromatic Hydrocarbons (PAH), Phtalates, PVC, PTFE and Thirams.

Lead is only found in soldering (for approximately 0.3% of the capacitor weight).

Free of SF6.

CALORIFIC VALUE

A formula that gives the calorific value of a standard TRAFIM capacitor is:

$CV\ (MJ) = L \times [4 \times 10^{-5} \times W \times H - 1.3 \times 10^{-5} \times H + 8 \times 10^{-4} \times W + 4.55 \times 10^{-2}] + 3.75 \times N$

where H, L, W, are Height, Length and Width in millimeters, and N is the number of terminals.

DESTROYING CAPACITORS

The destruction of the capacitors are subject to the laws in force in each country.

In practice, today, please contact AVX for a list of companies who can take charge of the products to be destroyed.

CAPACITOR DESIGN

The capacitor lifetime depends on the working voltage and the hot spot temperature.

Our caps are designed for 100000 hours lifetime at nominal voltage and 70°C hot spot temperature. According to your operating conditions, you will need to calculate the hot spot temperature, and deduce from this calculation if the lifetime obtained can suit your application.

1 According to the tables, you should find a capacitor with required capacitance C_n and voltage V_n with $V_n > V_w$.

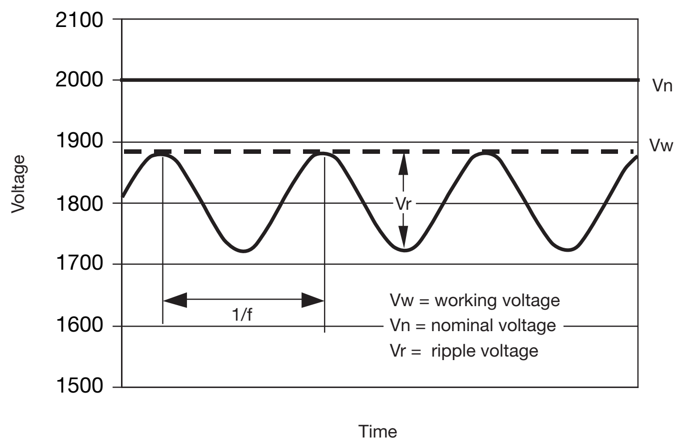
Calculate the maximum ripple voltage allowed for the chosen cap and check if $V_r < 0.45V_n$.

Copy out:

Serial resistance (R_S): see table of values

Thermal resistances Rth1 and Rth2 (depending on cooling conditions):

See page 13 for CAPAFIM
page 16 for TRAFIM
page 24 for FILFIM



2 Hot spot temperature calculation

Total losses are calculated as follow: Pt = Pj + Pd

Joule losses: $Pj = Rs \times I_{rms}^2$

Dielectric losses:

$Pd = Q \times tg\delta_0$ with

- Q = reactive power; $I_{rms}^2 / (C \times 2 \times \pi \times f)$ for a sinusoidal waveform
- $tg\delta_0$ = dielectric losses of polypropylene + rapeseed oil ($tg\delta_0 = 3 \times 10^{-4}$)

Hot spot temperature will be:

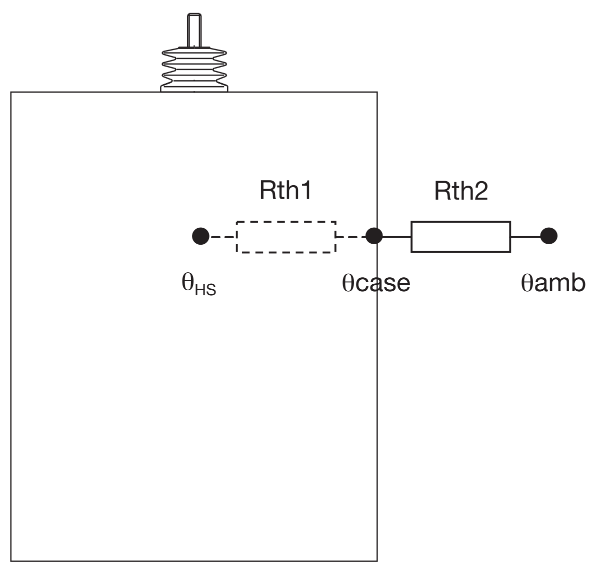
$\theta_{HS} = \theta_{amb} + (Pj + Pd) \times (Rth1 + Rth2)$

θ_{HS} absolute maximum is 85°C

If temperature is higher than 85°C, choose a bigger cap.

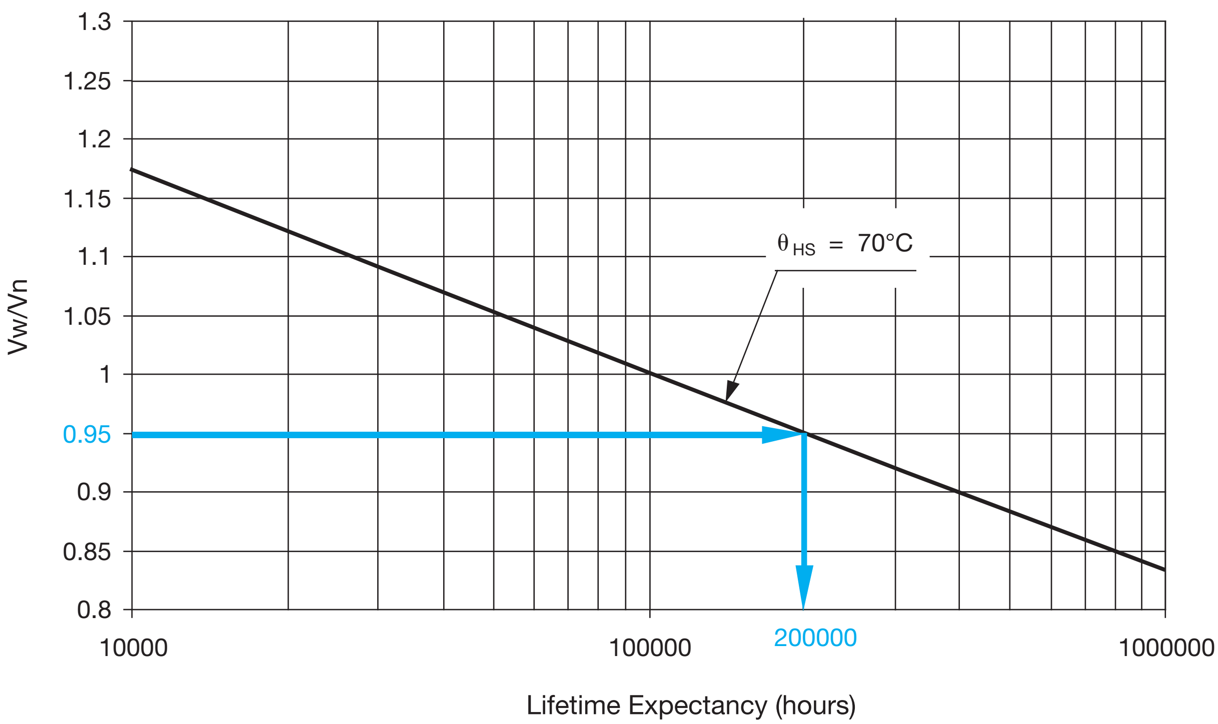
Rth1: Thermal resistance between hot spot and case

Rth2: Thermal resistance between case and ambient air



3 Refer to curve and deduce the lifetime vs V_w/V_n ratio.

LIFETIME EXPECTANCY VS HOT SPOT TEMPERATURE AND VOLTAGE



Ex: nominal voltage 2000V
working voltage 1900V
$\rho = 0.95 \Rightarrow$ lifetime 200000 hours @ 70°C hot spot temperature

You can find a calculation form on page 28 at the end of the catalog.

For any help or specific requirements, please contact your AVX local representative.

MTBF CALCULATION

Based on 20 years of test results, we have established the following relation.

The failure rate λ_B depends on the hot spot temperature θ_{HS} and the charge ratio ρ:

$$\rho = V_w/V_n$$

$$\lambda_B = 3x10^{5.861\ (\rho - 1)} \times e^{\left[3.98\left[\left(\frac{\theta_{HS}+273}{358}\right)\right]^{30.35}\right]} \times 10^{-9} \text{ in failures/hour}$$

GENERAL FAILURE RATE

$\lambda = \lambda_B \times \pi_Q \times \pi_B \times \pi_E$ failures/hour

π_Q, π_B and π_E see following tables

Qualification	Qualification factor π_Q
Product qualified on IEC 61071 and internal qualification	1
Product qualified on IEC 61071	2
Product answering on another norm	5
Product without qualification	15

Environment	Environment factor π_E
On ground (good conditions)	1
On ground (fixed materials)	2
On ground (on board)	4
On ship	9
On plane	15

Environment	Environment factor π_B
Favorable	1
Unfavorable	5

MEAN TIME BETWEEN FAILURE (MTBF)

M.T.B.F. = $1/\lambda$ hours

SURVIVAL FUNCTION

$N = N_0 \times \exp(-\lambda t)$

N is the number of pieces still working after t hours.

N_0 is the number of pieces at the origin (t=0).