LNK

METALLIZED POLYPROPYLENE D.C. LINK CAPACITORS

ICAR

Technology Looking Ahead

Issue 031027

Via Isonzo 10, 20052 Monza (Mi) Italy

Replacement of Electrolytic Capacitors by Metallized Polypropylene Film Capacitors in DC Link application.

A typical industrial drive basically consist of two parts :

- An AC / DC section which convert the AC voltage of the industrial network at fixed frequency (50 ÷ 60 Hz) into a DC voltage.

- A DC / AC section that supply a motor at variable frequency.

These two parts are connected a DC bus (*Link circuit*) and capacitors are used in this section to filter the high frequency component (*DC Link Capacitors*) . The most important requirements for these capacitors are :

- the capability in withstanding high current at frequencies above 1000 Hz,
- the high energy density (*Joule / dm³*) .

Usually Electrolytic Capacitors are used up to a voltage around 2000 V . Beside the advantage of having a very large capacitance value per can the limits for Electrolytic capacitors are :

- The maximum working voltage across each capacitor which is around 450 ÷ 500 V

- The current , especially at high frequency , is limited by their high ESR (*Equivalent Series Resistance*) .

Consequently, in most of the cases , Electrolytic Capacitors have to be connected in series/parallel to form banks to reach the requested performances in terms of Voltage and Current.

Seen the above , in order to reduce the ripple current , the banks are often designed with a very large equivalent capacitance which is normally easy to get with electrolytics capacitors. In other words the equivalent capacitance of these banks can be much lower whenever the capacitors would be able to handle an higher current . Another important point to keep into account in assembling Electrolytic Capacitor banks is to pay attention at the connection in order to keep the inductance as low as possible.

In many cases it is possible to replace favourably Electrolytic Capacitors with Metallized film capacitors.

Under certain conditions the saving become evident already at 500 V and it is more and more important as well as the voltage increase.
As commented , there is no availability of Electrolytic Capacitors above 450 ÷ 500 V, on the opposite it is quite normal to manufacture Metallized Film Capacitors which can work at several thousands of Volts .
Moreover, since Metallized Film Capacitors can handle, with the same capacitance, much higher current than Electrolytic , it is possible , and also convenient, to reduce the total equivalent capacitance of the bank.

Here are the main reasons to choice a Metallized Film Capacitors :

- Much higher current per capacitance (A/µF) i.e. possibility of using a lower capacitance bank.

- Higher voltage per element i.e. there is no need of series connection.

- Higher capability to wistand to overvoltages , up to 2 times the rated voltage.

- More than 10 years lifetime in the temperature range -25 ÷ +70 ºC .

- Non polar dielectric.

Beside the above mentioned advantages typical of all the Metallized Film Capacitors ***ICAR,*** exploiting the 50 years experience in capacitor manufacturing , has developed this new range of DC Link capacitors **LNK series** with further advantages.

- By using a new metallizing process (patented) on polypropylene film ***ICAR*** can offer capacitors which size is less than one half if compared with the traditionally Metallized capacitors .

- The use of polypropylene make the dielectric losses extremely low at any frequency ,(i.e. very low ESR) this make this kind of capacitor extremely valid at the very high frequency typical of the last generation of IGBT inverters.

LNK construction consist of a completely dry resin filled capacitor, plastic casing , self extinguish. No more leakage problems, no more dangerous electrolytes.

Issue 031027

Via Isonzo 10, 20052 Monza (Mi) Italy

LNK SERIES ICAR CAPACITORS

General Technical Characteristics

Environmental:

Operating temperature:

ϑ_{min} : - 25°C ϑ_{max} : + 70°C

Storage temperature

ϑ_{min} : - 40°C ϑ_{max} : + 85°C

Ratings:

Capacitance tolerance: ± 10%

Useful life (at 70°C hot-spot): 100000 hrs.

Reliability: 300 FIT.

Casing:

Self extinguishing, low smoke plastic material.

Filler / impregnant:

Self extinguishing resin.

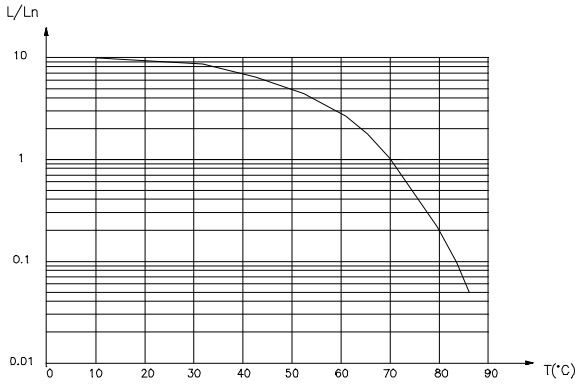
Standard of reference:

IEC 61071 – 60068 - 61881

With the new LNK series a new level of safety for the DC capacitors has been reached:

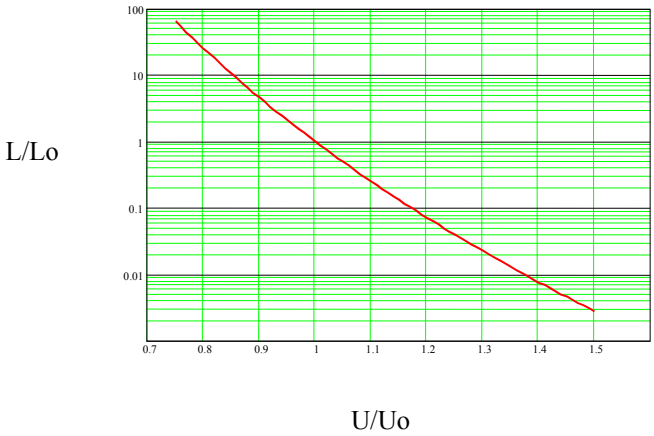
- ***Active safety:*** When the capacitor is stressed within the specifications, Icar patented metalization is designed to bring capacitor to an open circuit at the end of life.
- ***Passive safety:*** In case of failure the gas generated in not trapped in a sealed aluminium case but has a safe way out given by breaking of the casting resin. The risk of explosion is then dramatically reduced.
- ***Fire prevention:*** Casting resin and case material are flame retardant

Expected life versus hot spot temperature at rated voltage



Ln = expected life with hot spot temperature of 70°C
L = expected life with hot spot temperature T

Useful life versus voltage



Ln = expected life at rated voltage Un
L = expected life at U

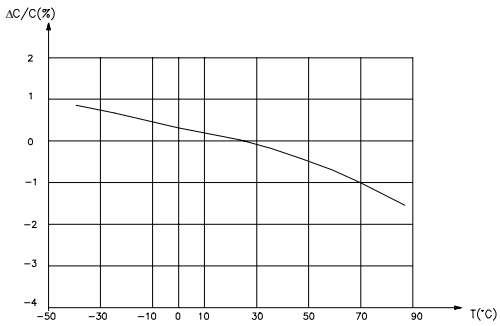
LNK SERIES

METALLIZED POLYPROPYLENE D.C. LINK CAPACITORS

Replacing Electrolitycs Capacitors by Metallized Polypropylene Film Capacitors.

- **No series connections for higher Voltage (Up to 4000 Vdc).**
- **Extremely low losses even at very high frequencies.**
- **Higher ripple current.**
- **Plastic case**
- **Lower E.S.R.**
- **Dry , environmental friendly construction.**

Capacitance variation versus temperature



Issue 031027

Via Isonzo 10, 20052 Monza (Mi) Italy

SELECTING THE CORRECT CAPACITOR

VOLTAGE

The first check should be done on the working voltage: The surge voltage U_S, the rated voltages U_N and U_{rms} should be not higher than the operating values.
Also the sum of the ripple and the dc component of the voltage should not be beyond the rated voltage U_N.
Although it is possible to work above the rated voltage, this will mean a reduction of the expected life; this can be evaluated through the correspondent graph.

CURRENT LIMITATION

The I_{rms} current must not exceed the maximum current I_{max}. The current must also be compatible with the maximum power that can be dissipated.
The I_{mxx} values in the schedules was been calculated supposing irrelevant the dielectric losses (Q" tan δ_0)and they correspond with a difference of temperature ($\theta_n - \theta_0$)of about 20°C. As a consequence, to have an expected life of 100.000 at the maximum current, the ambient temperature has not to exceed of 50°C.
If not the expected life will be calculated again using the graph on the following page.
The thermal check, here indicated, will be done in any case.
In case of forced air cooling the thermal resistance will be reduced of 30%.

THERMAL CHECK

First of all the power due to the internal losses of the capacitor should be calculated.
These power losses consist of the dielectric losses and series losses ($R_S * I^2_{rms}$) i.e. those due to the resistance of the armatures and the connections.
The total power can be calculated as follows:
$P = Q \tan \delta_0 + R_S I^2_{rms}$
It is now possible to calculate the hot spot temperature as:
$\vartheta_h = R_{th} * P + \vartheta_0$.
The expected life for these capacitors is actually calculated with the assumption the hot spot temperature is 70°C. In these conditions, at rated voltage the expected life is calculated as 100000 hours, with a failure rate of 300 FIT.
Using the enclosed graphs and other data here given the designer can calculate the expected life of the in the actual working conditions.

WARNING

This thermal check supposes that only the heat generated into the capacitor is transmitted to the environment through the case surface. Eventual localised overheating (poor connections, hot components in the nearby etc.) would then likely bring the capacitor to a dramatic reduction of the expected life.

DEFINITIONS

C_N	Rated Capacitance.
U_N	Rated (repetitive peak) voltage.
U_{rms}	Rated rms. voltage.
U_S	Surge (not repetitive) peak voltage.
I_{max}	Maximum rms. current value for continuous operation.
Q	Reactive power = $2 * \pi * F * C * U^2rms$
F	Fundamental frequency.
R_S	Series resistance i.e. the resistance responsible for the current heat losses ($I^2 R_S$) in the capacitor.
ESR	Equivalent Series Resistance defined as $ESR = R_S + \tan \delta_0 / 2*\pi*f*C$
tan δ_0	Dielectric dissipation factor. It can be considered as constant in the normal working frequency range. Typical value for polypropylene is $2*10^{-4}$.
tan δ	Dissipation factor calculated as: $\tan \delta_0 + 2*\pi*C*F*R_S$.
dv/dt	Maximum slope of the voltage waveshape.
I_{PK}	Peak current $I_{PK} = C * dv/dt$.
P	Total power dissipated in the capacitor.
R_{th}	Thermal resistance between the hot-spot in the winding and the environment (natural cooling), so that: $P = (\vartheta_h - \vartheta_0) / R_{th}$
ϑ_h	Hottest point in the capacitor winding.
ϑ_0	Operating ambient temperature. It is the air temperature measured under steady conditions, measured at 0,1 m from capacitor case.
L_0	Expected life at rated voltage U_0 and hot-spot temperature of 70°C
L	Expected life at the actual working conditions, obtained from the enclosed graph.
L_S	Self inductance of the capacitor. It is due to the internal connections, terminals, winding characteristics and physical dimensions.

Issue 031027

Via Isonzo 10, 20052 Monza (Mi) Italy

WARNING

DO NOT MISAPPLY CAPACITORS FOR POWER ELECTRONICS

Icar spa is not responsible for any kind of possible damages to persons or things, derived from the improper installation and application of Power Electronics capacitors.

Most common misapplication forms:

- Ripple current beyond specification or not according with the maximum power that can be dissipated.
- Surge or working voltage beyond specified value.
- Hot spot or storage temperature beyond the specified limits or not according with the maximum power that can be dissipated.
- Incorrect mounting or wrong installation
  - installation nearby hot components or heat sources
  - not suitable connections (not adequate cable or busbars cross section)
  - nuts and washers material, shape or size not suitable for the application
  - tightening torque not according to the specification
- Unusual service conditions as :
  - mechanical shock and vibrations,
  - corrosive or abrasive conductive parts in cooling air,
  - oil or water vapour or corrosive substances,
  - explosive gas or dust,
  - radioactivity,
  - excessive and fast variations of ambient conditions,
  - service areas higher than 2000 m above sea level.

Periodic check of the connection conditions and tightening torque is strongly recommended.

In case of doubt in choice or in performances of the capacitors Icar technical service **MUST** be contacted.

Personal Safety :

Electrical or mechanical misapplication of Power Electronics Capacitors may become hazardous. Personal injury or property damage may result from disruption of the capacitor and consequent expulsion of melted material.
Before using the capacitors in any application, please read carefully the technical information contained in this catalogue.
The energy stored in a capacitor may become lethal, to prevent any chance of shock the capacitor should be discharged before handling.
Special attention must be taken to make sure the capacitors are correctly used for each application and that warnings and instructions are followed

Issue 031027