Applications and Technical Consideration for Metallized Film Capacitors

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Metallized film capacitors satisfy a large variety of electronic applications, because available dielectrics have excellent fundamental electrical characteristics, high stability and longevity. Capacitor manufacturers are constantly improving the breed to deliver greater capacitance within smaller package dimensions. Engineers need to be aware of current technologies in order to select the optimal device quickly. This allows them to focus on aspects of design that will differentiate their product in the market for maximum value. If there are special requirements relating to capacitor performance, help from the device manufacturer can minimize time needed to complete a design.

Film Technologies

Capacitor manufacturers can optimize the characteristics of metallized film capacitors for specific applications by selecting a suitable dielectric. For example, polyester films display good properties for general-purpose applications. These include high dielectric constant (allowing them to achieve the highest capacitance per unit volume of metallized film-type capacitors), high dielectric strength, self-healing properties and good temperature stability. Polyester capacitors display the best volumetric efficiency of all film capacitors at moderate cost and are a popular choice for DC applications like decoupling, blocking, bypassing and noise suppression. Figure 1 shows the cross section of a generic metallized film capacitor, illustrating the dielectric, connection to electrodes and flame-retardant packaging.

Figure 1

Capacitors made from metallized polypropylene film display low dielectric losses, high insulation resistance, low dielectric absorption, high dielectric strength and deliver a robust, space-efficient solution. Long-term stability is also good. These characteristics make metallized polypropylene film capacitors a strong choice for mains-attached applications like AC input filters, electronic ballasts and snubber circuits. Polypropylene film capacitors are available rated to 400VAC and beyond for industrial 3-phase applications and specialist equipment. They are also used in switch mode power supplies, frequency discrimination and filter circuits, as well as in energy storage and sample-and-hold applications.

AC and pulse capacitors are optimized for applications where steep pulses occur, like electronic ballasts, motor controllers, SMPS, CRT televisions and monitors or snubbers. These applications feature double-metallized polypropylene film construction with low-loss dielectric, capable of withstanding high voltage and high-pulse load applications at high operating frequencies. One example is the MKP383 series [Figure 2].

Figure 2

Designing with film capacitors is usually straightforward. For example, an EMI filter for a main-powered product follows a well-established topology and capacitance values are easily selected. X-capacitors, placed between the main and neutral phases, have no theoretical upper limit but are usually selected between 0.1µF and 1.0µF. Y-capacitors, placed between the main or neutral and chassis ground, are chosen as small as possible to minimize AC leakage to ground. For most designs, 4700pF is optimal. These devices must meet safety and performance standards applicable to mains-connected components, including UL 94 V-0, European ENEC standards and EN 132400. The American UL1414, Canadian CSA C22.2 No.1. IEC 60384-14, IEC 60384-14 (2nd edition), and IEC 60065 have been proposed as international guidelines concerning mains-connected filtering capacitors.

Often, the most significant design activity is to select appropriate capacitor technology and ensure package dimensions and styles meet the application's needs. Stability of capacitance includes adequate self-healing capabilities, a key performance criterion. After satisfying these criteria, special test requirements, supply and logistical issues become chief concerns.

Packaging

Miniaturization (including achieving higher capacitance, maintaining insulation and isolation characteristics, voltage rating and other key electrical parameters within smaller package dimensions) gives greater design freedom to engineers facing board space and mounting height limitations. With reduced package dimensions, development of lead-free packages has become a prime concern. Suitable devices are emerging, enabling new products to meet forthcoming guidelines. As an example, new compact, lead-free EMI suppression film capacitors such as the 339 X2 series (Figure 3) fulfill these requirements, with values from 1.0nF to 4.7µF in smaller case sizes and pitches down to 7.5mm. In addition, 339x2 capacitors below 100nF are between 1mm and 2mm lower in height and thickness.

Figure 3

Alternative Packages

As a rule, engineers need to complete designs like EMI filters, ballasts, snubbers and power supplies quickly, with little reference to the capacitor manufacturer. Typically, added value lies at a higher level, and designers need to focus on perfecting differentiating features of the product; including special modes, capabilities, stylish appearance or long battery life.

Sometimes it is necessary for the product designer and capacitor manufacturer to customize a solution to a particular set of challenges like application requirements or compliance issues in specialist markets or particular tests. These may include specified capacitance values in alternative package sizes, reduced packaging for space-efficient applications (like filtering an automotive AC supply), or incorporation into a filter or system functional block using integrated passive device (IPD) technology. IPDs save space and per-unit cost if the expected production volume is high enough to make the technology viable.

The trend toward metallized film capacitors in surface-mount packages is already established. X- and Y- type suppression devices are likely to adopt this technology in the future. While through-hole remains the dominant format for these types of capacitor, some vendors are able to offer cutting-to-length or pre-forming services for component leads, reducing assembly time and complexity for customers.

Custom Tests

The vendor may also carry out custom tests during manufacturing, if required. This may be necessary if the device must withstand particularly high peak rated voltage or current. End product designers may also require vendors to guarantee performance under varying temperature or other special conditions. For an EMI filter, for example, this may include disturbances in the main supply. When special requirements like these exist, the manufacturer's expertise can significantly shorten the product design and approval processes.

Conclusion

Film capacitors are the workhorses of the electronics industry. Even though associated construction and composition technologies are continually evolving to deliver higher capacitance and better electrical performance, these devices are rarely connected with differentiating features in new product design. This being the case, designers need to complete design and component selection quickly with minimum complications. When special requirements apply, one-on-one service from the capacitor vendor can help resolve design issues and ensure smooth completion of fundamental functional blocks like interference filters, basic signal conditioning circuits and electronic ballasts. ❑