



Product Group: Passive electronic components

**September 2001**

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## **Low ESR capacitors come to the fore**

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There is a rapidly increasing demand for low equivalent series resistance (ESR) capacitors in a small case, surface mount format. But what exactly is ESR, why is it important and what products are on offer to satisfy the market's hunger for these devices?

### **What is ESR?**

ESR is an abbreviation for Equivalent Series Resistance, the characteristic representing the sum of resistive (ohmic) losses within a capacitor. While ESR is undesirable, all capacitors exhibit it to some degree. Materials and construction techniques used to produce the capacitor all contribute to the component's ESR value. ESR is a frequency dependent characteristic, so comparison between component types should be referenced to same frequency. Industry standard reference for ESR is 100kHz at +25°C. Power dissipation within the capacitor, and the effectiveness of the capacitor's noise suppression characteristics will be related directly to the ESR value.



### **Why do we need low ESR?**

An industry wide trend towards lower voltage, higher current circuit design, fuelled by lower voltage silicon devices is causing designers to specify capacitors with minimal ESR. Higher levels of functionality in today's designs mean that despite voltage levels falling, circuit power levels have not dropped accordingly. Ohms law tells us, in very simple fashion, that at the same power dissipation level, lower voltage operation will mean higher current levels. This greatly increases the demands on the power management circuit (power supply or DC/DC converter) to deliver energy during periods of high current load stepping. Lower voltage circuit operation also imposes greater restrictions upon the output voltage variation levels. The output capacitors or capacitor bank, used in the power management circuit, need to exhibit low ESR characteristics. Ripple voltage (noise) on the output supply voltage will be directly proportional to the ESR of the capacitors used. By considering the formula:  $V_r = I \times R$ , where  $V_r$  is the ripple voltage and  $R$  is the ESR, we can see that if the current ( $I$ ) increases from, say, 4A to 20A then the ripple voltage will also increase by a factor of five. Increased ripple voltage ( $V_r$ ) cannot be tolerated in today's and next generation designs. This is driving the demand for lower ESR capacitors.

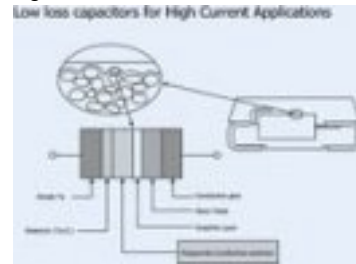
## What's on Offer?

The high capacitance values (typically greater than 100mF) that are needed to supply energy to the circuit during high load current stepping, are most often achieved through the use of multiple SMT electrolytic capacitors. Surface mount devices are often preferred to leaded parts as they simplify PCB assembly and allow closer component placement. Low ESR SMT electrolytic capacitors mainly fall into four categories. Liquid electrolyte, vertical can chip aluminium electrolytic capacitors offer the highest values of capacitance and low ESR. They tend to be low cost, but have case sizes that are large compared to other constructions.



Solid electrolyte, resin encapsulated flat chip aluminium electrolytic capacitors feature reduced ESR, very high ripple current ratings and reduced size at a higher cost. Solid 'dry' electrolyte also greatly extends the operational life of the component when used at high temperature. Solid electrolyte, resin encapsulated flat chip MnO<sub>2</sub> cathode tantalum electrolytic capacitors again offer low ESR. They are produced with a manganese dioxide cathode

construction. Solid electrolyte, resin encapsulated flat chip polymer cathode tantalum electrolytic capacitors are available as ultra-low ESR versions. These are produced using a speciality polymer cathode construction. The Standard manganese dioxide cathode ( $MnO_2$ ) being replaced by a highly conductive polymer (polypyrrole) cathode that considerably reduces ESR. Indeed, the conductivity of polypyrrole is more than 100 times that of manganese dioxide.



Circuit designs incorporating lower voltage semiconductors and ICs are driving increasing demand for better and lower ESR capacitors. SMT low ESR type electrolytic capacitors offer the combined solution of high capacitance, to supply energy during high-speed load stepping, and low ESR to reduce the output filter ripple (noise) voltage to meet the needs of today's and tomorrow's power management design challenges.

**\* More Information on Low ESR capacitors at [www.lowESR.com](http://www.lowESR.com)**