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Power IC Shrinks Input Bulk Capacitor, Reduces Inrush Current

Power Integrations' MinE-CAP IC is a new type of power IC with a rather long description—it's a bulk capacitor miniaturization and inrush management IC for very high power density ac-dc converters. Targeting power adapters with universal input, the IC switches low-voltage bulk capacitors into the power supply circuit at low line input voltage, and switches them out of the circuit at high line input voltage. Fig. 1 illustrates the circuit concept.

This change leads to a halving the size of the high-voltage bulk electrolytic capacitors required in offline power supplies, and enables a reduction in adapter size by up to 40%. The MinE-CAP device, which itself occupies very little pc board space, also dramatically reduces in-rush current making NTC thermistors unnecessary, increasing system efficiency and reducing heat dissipation (see Fig. 2).

Comments Power Integrations' product marketing director, Chris Lee. "The MinE-CAP will be a game-changer for compact chargers and adapters. Electrolytic capacitors are physically large, occupy a significant fraction of the internal volume and often constrain form factor options—particularly minimum thickness—of adapter designs. The MinE-CAP IC allows the designer to use predominantly low-voltage-rated capacitors for a large portion of the energy storage, which shrinks the volume of those components linearly with voltage."

As Fig. 3 explains the energy stored in the capacitor is $1/2CV^2$. For a given amount of energy storage, more capacitance is required at low voltage than high voltage. Hence, with a wide input voltage range, it's the low-line condition that determines the capacitance value required. However, when a single bulk cap is used in the conventional way, the need to support the high-line condition determines the size of this capacitor since capacitor size increases with its voltage rating.

"USB PD has driven a major market push towards small 65-W chargers and many companies have concentrated on increasing switching frequency to reduce the size of the flyback transformer. MinE-CAP provides more volume saving than doubling the switching frequency, while actually increasing system efficiency by eliminating the inrush circuit components," adds Lee.

The MinE-CAP leverages the small size and low $R_{DS(ON)}$ of PowiGaN gallium nitride transistors to actively and automatically connect and disconnect segments of the bulk capacitor network depending on ac line voltage conditions. Designers using MinE-CAP select the smallest high-line rated bulk capacitor required for high ac line voltages, and allocate most of the capacitance to lower voltage capacitors that are protected by the MinE-CAP until needed at low ac line. This approach dramatically shrinks the size of input bulk capacitors (see Fig 4.) without compromising output ripple, operating efficiency, or requiring redesign of the transformer.

Conventional power conversion solutions reduce power supply size by increasing switching frequency to allow the use of a smaller transformer. The innovative MinE-CAP IC achieves just as significant overall power supply size reduction while using fewer components and avoiding the challenges of higher EMI and the increased transformer/clamp dissipation challenges associated with high-frequency designs. Applications include smart mobile chargers, appliances, power tools, lighting and automotive.

Said Bhaskar Thiagaragan, director of Power Integrations India, "MinE-CAP ICs are excellent for all locations with wide ranging input voltages. In India we often design for voltages from 90 Vac to 350 Vac, with a generous surge derating above that. Engineers here often complain about the forest of expensive high-voltage capacitors required. MinE-CAP dramatically reduces the number of high-voltage storage components, and shields lower voltage capacitors from the wild mains voltage swings, substantially enhancing robustness while reducing system maintenance and product returns.

Housed in the miniature MinSOP-16A package, the new devices work seamlessly with Power Integrations' InnoSwitch3 family of power supply ICs with minimal external components. According to Lee, the chip is particularly suited for use with InnoSwitch3 because it works with the input voltage protection features of the InnoSwitch3/Pro devices, but in theory, it could be used with other ac-dc controllers. He also notes that it's optimized for 25-W to 75-W applications. Above that power factor correction becomes a requirement, which MiniE-CAP does not support since it doesn't work with dc input.

As noted previously, MiniE-CAP takes advantage of the small size and low $R_{DS(ON)}$ of PowiGaN gallium nitride power switch. The GaN transistor is actually an enabler of this device because MiniE-CAP needs to support the same level of current as the InnoSwitch controller. Since the PowiGaN switch is required for the highest power rated versions of InnoSwitch, that means it's needed also in the MiniE-CAP. In addition, the PowiGaN technology results in a switch with very low leakage current, which is critical in managing the voltage developed across the low-voltage bulk capacitors.

MinE-CAP MIN1072M ICs are available immediately from PI offices and franchised distributors and are priced at $1.75 each in quantities of 10,000. Two initial design example reports (DERs) pair the MinE-CAP IC with Power Integrations' InnoSwitch3-Pro PowiGaN IC, INN3370C-H302. A 65-W USB PD 3.0 power supply with 3.3-V to 21-V PPS output for mobile phone and laptop chargers is described in DER-626, and DER-822 describes a 60-W USB PD 3.0 power supply for USB PD/PPS power adapters using INN3379C-H302.

Learn more about the family and download the reference designs at the Power Integrations website.

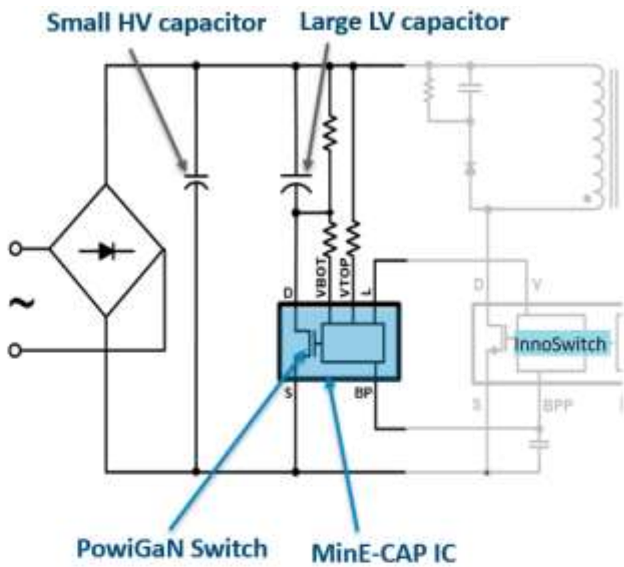
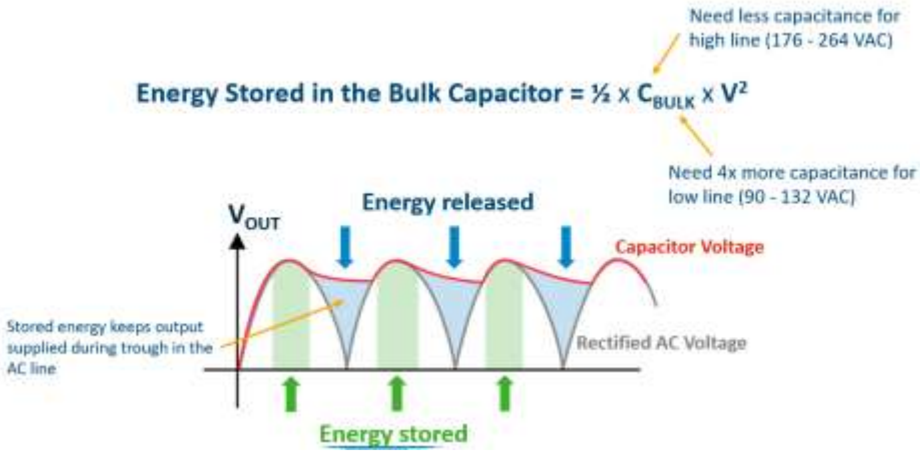
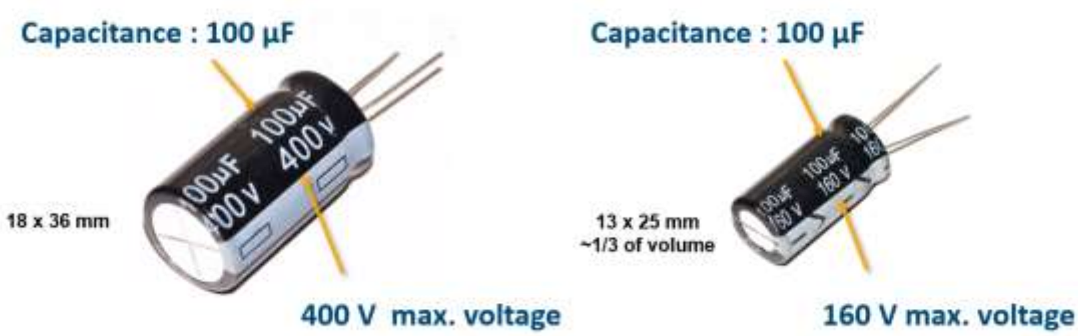


Fig 1. MinE-CAP offsets the need for large values of high-voltage capacitors by switching low-voltage capacitors into the power supply circuit at low line voltage, and then switching them out when the line voltage increases. This partial schematic depicts the concept, but shows only one low-voltage capacitor—in practice there may be two.

Fig. 2. In this example power supply design, MinE-CAP, replaces one 400-V 100-µF bulk capacitor with one 400-V 22-µF capacitor and two 160-V 47-µF capacitors, saving space as illustrated here. In addition to reducing the total volume of the capacitors required for bulk energy storage by 50%, this technique reduces inrush current and increases the total capacitance by 16%, enabling more peak power.



(a)



(b)

Fig 3. The bulk capacitor stores then releases energy during each ac line cycle. As the energy storage equation indicates, more capacitance is required to store a given amount of energy at low-line voltage than at high-line voltage. Hence it's the low input voltage that generally determines the bulk cap's capacitance value (a). However, the need to support to support the high-line voltage condition, requires a higher voltage rating on the capacitor. And since capacitor size increases with voltage rating, as illustrated in (b) and in Fig. 4 below, it's the high line condition that determines bulk cap size in existing power supply designs. MinE-CAP essentially disrupts this relationship between the required capacitance value and voltage rating by splitting the bulk cap into low-voltage and high-voltage caps.

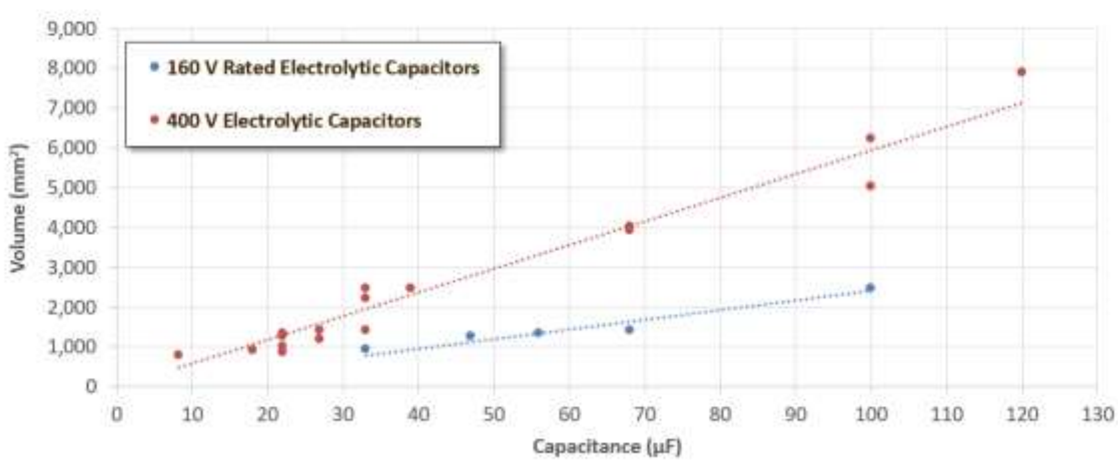


Fig. 4. 400-V rated electrolytics are significantly larger than 160-V rated devices with the same capacitance.