The power density of a DC/DC converter is generally limited by bulky magnetic components, especially in applications where the input and output voltages are relatively high. Inductor/transformer size can be reduced by increasing the switching frequency, but this reduces converter efficiency because of switching-related losses. Better, eliminate the magnetics altogether with an inductorless switched capacitor converter (charge pump) topology. Charge pumps can increase power density as much as 10× over a conventional converter without sacrificing efficiency. Instead of an inductor, a “flying capacitor” stores and transfers the energy from input to output. Despite the advantages of charge pump designs, switched capacitor converters are traditionally limited to low power applications, due to the challenges presented in start-up, protection, gate drive and regulation.

Figure 1 shows a 48W output voltage divider circuit featuring the LTC7820. The input voltage is 48V and the output is 24V at up to 20A load. Sixteen 10μF ceramic capacitors (1210 size) act as a flying capacitor to deliver the power. The approximate solution size is 23mm × 16.5mm × 5mm as shown in Figure 2, and the power density is as high as 4000W/in³.
Since no inductor is used in the circuit, all four MOSFETs are soft switched, greatly reducing switching-related losses. The converter can achieve high efficiency, where the peak efficiency is 99.3% and the full load efficiency is 98.4%.

**HIGH EFFICIENCY**

Since there is no inductor used in the circuit, all four MOSFETs are soft switched, greatly reducing switching-related losses. The converter can achieve high efficiency as shown in Figure 3, where the peak efficiency is 99.3% and the full load efficiency is 98.4%. The thermograph in Figure 4 shows a balanced thermal design with a hot spot temperature about 82.3°C in an ambient environment of 25°C and no forced airflow.

**PRE-BALANCE PREVENTS INRUSH CURRENTS**

In addition to impressive efficiency and thermal performance, the LTC7820 includes a proprietary pre-balance method to minimize inrush current in voltage divider applications. The LTC7820 controller detects the V_LOW_SENSE pin voltage before switching and compares it with the V_HIGH_SENSE/2 internally. If the voltage at the V_LOW_SENSE pin is much lower than V_HIGH_SENSE/2, a current source injects 93 mA of current at the V_LOW pin to pull V_LOW up. If the voltage at V_LOW_SENSE is much higher than V_HIGH_SENSE/2, another current source sinks 50 mA from V_LOW to pull it down. If the voltage at V_LOW_SENSE is near V_HIGH_SENSE/2, that is, within the preprogrammed window, both current sources are disabled and the LTC7820 starts switching.

Figure 5 shows the enormous input inrush current that occurs at start-up without pre-charging—more than enough to damage the MOSFETs and capacitors. In
Even though the LTC7820-based voltage divider is an open-loop controlled converter, load regulation is tight due to its high efficiency, with the output voltage dropping only 1.7% at full load.

contrast, no excessive inrush current is observed after the pre-balance method is applied, as shown in Figure 6.

TIGHT LOAD REGULATION

Even though the LTC7820-based voltage divider is an open-loop controlled converter, load regulation is tight due to its high efficiency. As shown in Figure 7, the output voltage drops only 1.7% at full load.

PROTECTION FEATURES

The LTC7820 includes protection features to ensure high converter reliability. Overcurrent protection is enabled through a sensing resistor on the high voltage side. A precision rail-to-rail comparator monitors the differential voltage between the ISENSE+ pin and the ISENSE− pin, which are Kelvin connected to a sensing resistor. When the voltage at ISENSE+ is 50mV higher than the ISENSE−, an overcurrent fault is triggered, the FAULT pin is pulled down to ground, and the LTC7820 stops switching and starts retry mode based on the timer pin setup.

Further protection is available through the OV/UV window comparator. In normal operation, the voltage at VLOW_SENSE should approach half of VHIGH_SENSE. A window comparator monitors VLOW_SENSE and compares it to VHIGH_SENSE/2. The hysteresis window voltage can be programmed and is equal to the voltage at the HYS_PRGM pin. With a 10k resistor on the HYS_PRGM pin, the VHIGH_SENSE/2 voltage must be within a (VLOW_SENSE ±1V) window during start-up and normal operation. Otherwise a fault is triggered and the LTC7820 stops switching.

CONCLUSION

The LTC7820 is a fixed ratio high voltage, high power switched capacitor controller that meets the power density demands of bus converters, high power distributed power systems, communications systems and industrial applications. No inductors are needed.