Paralleling CAPACITORS

Differences in maximum ripple current and ESR can lead to a shift in the ripple current – and premature failure. **by MARK WOOLLEY and JAE CHOI**

During the design of a power supply, careful consideration must be given to the equivalent series resistance and ripple current, as well as the total output capacitance. The capacitors should be as identical as possible, with the same ESR and ripple current capacity.

Early life failures can occur as a result of using two different capacitors. In the case below, the capacitance value and working voltage rating of each were the same. However, the maximum ripple current and ESR were substantially different. This causes a shift in the ripple current through the capacitors and caused the supply to fail prematurely.

The design of the power supply called for the following:

- Maximum ripple current: 1400mA.
- Maximum allowable ESR: 50mΩ.
- Total capacitance: 940µF.

This design used two different capacitors in parallel to meet these requirements. One capacitor was a Series A capacitor, while the second parallel capacitor was a Series B capacitor. TABLE 1 compares the two capacitors. The capacitors were well matched, except in two areas: the maximum allowable ripple current and the ESR.

The ESR of a capacitor acts as a resistance in series with the capacitance (FIGURE 1). The difference in ESR meant that the ripple current did not split evenly between the two capacitors. Equation 1 shows the calculation of current through the resistors (and hence the capacitors).

TABLE 1. Capacitor Specifications

	SERIES A	SERIES B
Capacitance	470µF	470µF
Temperature Range	-40° to 105°C	-40° to 105°C
Capacitance Tolerance	±20%	±20%
Load Life	5000 hr. @ 105°C	6000 hr. @ 105°C
Rated Ripple Current	760mA	640mA
ESR	0.072W	0.130W

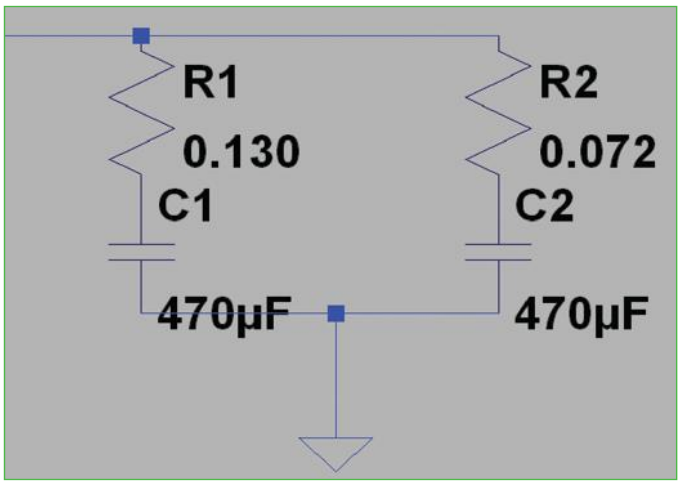

FIGURE 1. A simplified schematic of the circuit.

Eq. 1 $$I_{R1} = \left(\frac{R_2}{R_1 + R_2}\right) I_T$$

Given the values shown above and the estimated total ripple current of 1400mA, I_{R1} is ~500mA (640mA max), while I_{R2} is ~900mA (760mA Max). The ripple current through C2 is about 20% greater than allowed. This excessive ripple current caused C2 to overheat and lose its electrolyte. C2 then acted as an open circuit, forcing all ripple current through C1, quickly causing its failure as well.

The standard practice of using parallel capacitors to increase the ripple current capacity and reduce the total output resistance must be used with caution. The capacitors must be identical in ESR and ripple current, as well as in capacitance. Otherwise, the ripple current will not be split evenly and will cause early life failures. PCD&F

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