Ballast Resistors Allow Load Sharing Between Two Paralleled DC/DC Converters

Jeff Falin *PMP Portable Power*

ABSTRACT

This application report explains one method for minimizing the size of the ballast resistors between two identical dc/dc converters that are tied, through these resistors, to the same load.

In some applications, it may be more cost effective or thermally beneficial to parallel two lower current dc/dc converters to drive a single high-current load instead of using a single higher current-rated converter. However, all dc/dc converters regulate their output voltage to a dc set point (V_{DCx}) plus and minus a tolerance percentage (TOL_{DCDC}) up to their maximum-rated current. Therefore, simply tying the outputs of the two converters to the same load does not always result in equal current sharing below each converter's maximum-rated current because the converter that is regulating high at V_{DCx} x (1+TOL_{DCDC}) attempts to provide all of the load current until reaching its current limit. As shown in Figure 1, load-sharing (ballast) resistors, R_{SHARE}, located between each converter's regulated output and the load are necessary in order to accommodate the difference in each converter's regulated output voltage. This application report explains one method for minimizing the size of the ballast resistors between two identical dc/dc converters that are tied, through these resistors, to the same load. Minimizing the ballast resistors is important for minimizing power lost in the resistors as well as minimizing $V_{DROP} = I_{DCx} \times R_{SHARE}$ which reduces the voltage seen by the load, V_O. The following assumptions were used to develop the design equations:

1. Both dc/dc converters are the same and are set to the same nominal output voltage. Due to internal voltage reference tolerances and external feedback resistor tolerances for adjustable devices, each converter's regulated output voltage is different.
2. Both dc/dc converters only source current, i.e., neither dc/dc converter can sink current, less than or equal to their maximum-rated currents.
3. Both R_{SHARE} resistors are the same value.

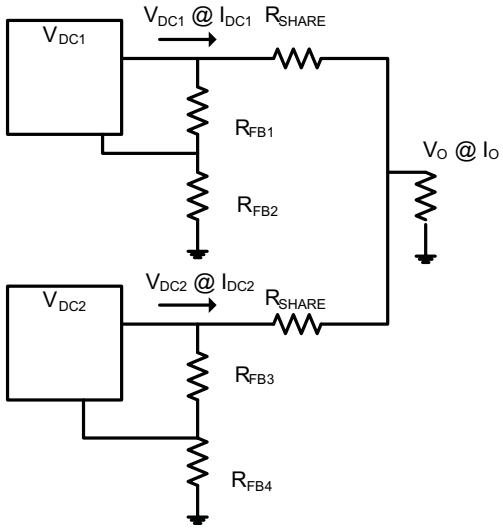

Figure 1. Using Load-Sharing Resistors

If it is assumed that dc/dc converter 1 regulates at the high end of its tolerance while dc/dc converter 2 regulates at the low end of its tolerance, then Equation 1 gives the minimum share resistor value to ensure that neither converter exceeds its maximum-rated current.

$$R_{SHARE} = \frac{V_{DC} \times (2 \times TOL_{DCDC})}{2 \times I_{DCMAX} - I_{OMAX}} \quad (1)$$

Where

V_{DC} = the nominal output of each converter

$$TOL_{DCDC} = TOL_{VREF} + 2 \times \left(1 - \frac{V_{REF}}{V_{DC}}\right) \times TOL_{RFB}$$

TOL_{VREF} = the tolerance of the dc/dc converter's internal reference

V_{REF} = the nominal value of the dc/dc converter's internal reference

TOL_{RFB} = the tolerance of the external feedback resistors

I_{DCMAX} = the maximum-rated current of the dc/dc converter

I_{OMAX} = the maximum load current to be shared

The absolute minimum output voltage occurs in the unlikely event that both converters are regulating at the low end of their tolerance and therefore are equally sharing the output load current. The equation below computes this value:

$$V_{OABSMIN} = V_{DC} \times (1 - TOL_{DCDC}) - \frac{I_{OMAX}}{2} \times R_{SHARE} \times \left(1 + TOL_{RSHARE}\right) \quad (2)$$

Where TOL_{RSHARE} = the tolerance of the R_{SHARE}.

Choosing a value for R_{SHARE} is an iterative process in which V_{DC} is selected then $V_{OABSMIN}$ is computed. If $V_{OABSMIN}$ is too low, V_{DC} is incremented and R_{SHARE} recomputed until $V_{OABSMIN}$ is above the minimum regulated voltage required by the application. Choosing converters and resistors with tighter tolerances reduce the value of R_{SHARE} and increase $V_{OABSMIN}$.

Due to the various combinations of the tolerances of each component, the actual output voltage varies from board to board. Using the preceding equations to compute R_{SHARE} ensures that V_O is between $V_{DC} \times (1+TOL_{DCDC})$ at no load and $V_{OABSMIN}$ at full load.

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