

Voltage Dividers in Power Supplies

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In the design of power supplies, the desired output voltages can be set manually. This is accomplished in most integrated power supply circuits, as well as switching and linear regulator ICs, with the help of voltage dividers. The ratio of the two resistance values must be suitable to enable the desired output voltage to be set. Figure 1 shows a voltage divider. The internal reference voltage (V_{REF}) and the desired output voltage determine the ratio of the resistance values, as seen in Equation 1:

$$\frac{V_{REF}}{V_{OUT}} = \frac{R_2}{R_1 + R_2} \quad (1)$$

The reference voltage V_{REF} is defined by the switching regulator or linear regular IC, and is usually 1.2 V, 0.8 V, or even 0.6 V. This voltage represents the lowest voltage that the output voltage (V_{OUT}) can be set to. With the reference voltage and output voltage known, there are still two unknowns in the equation: R_1 and R_2 . One of the two resistance values can now be selected relatively freely, as usual values lie below 100 k Ω .

If the resistance values are too low, the power loss due to the constantly flowing current $V_{OUT}/(R_1 + R_2)$ during operation is extremely high. If R_1 and R_2 each had a value of 1 k Ω , then a continuous leakage current of 1.2 mA would flow at an output voltage of 2.4 V. This corresponds to a power loss of 2.88 mW generated by the voltage divider alone.

Depending on how precisely the output voltage should be set and how high the current in the power supply error amplifier at the FB pin is, Equation 1 can be specified more precisely through consideration of this current.

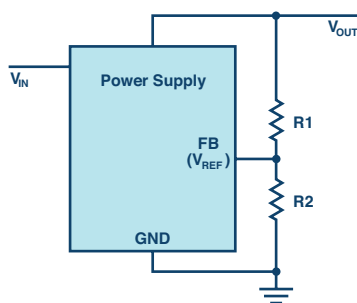


Figure 1. Voltage divider in a voltage regulator for adjustment of output voltage.

However, the resistance values should not be too high. If the resistance values were each 1 M Ω , we would only have a power loss of 2.88 μ W. A major disadvantage of this resistor dimensioning with very high values is the fact that it results in a very high feedback node impedance. The current flowing into the feedback node can be very low depending on the voltage regulator. As a result, noise can couple to the feedback node and directly affect the control loop of the power supply. This can stop the regulation of the output voltage and lead to control loop instability.

Especially in switching regulators, this behavior is critical, because noise arises due to the rapid switching of currents and can couple to the feedback node.

Useful resistance values for $R_1 + R_2$ lie between 50 k Ω and 500 k Ω depending on the noise expected from other circuit segments, the value of the output voltage, and the need to reduce the power loss.

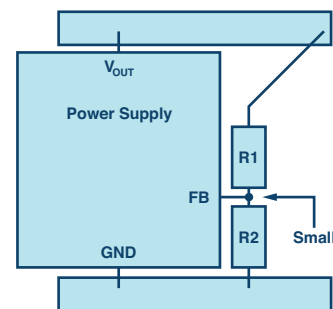


Figure 2. Example of a well-placed voltage divider in a power supply.

Another important aspect is the placement of the voltage divider on the board layout. The feedback node should be designed to be as small as possible so that very little noise can couple to this high impedance node. Resistors R_1 and R_2 should also lie very close to the feedback pin of the power supply IC. The connection between R_1 and the load is usually not a high impedance node and can hence be designed to have a longer trace. Figure 2 shows an example of resistors placed close to the feedback node.

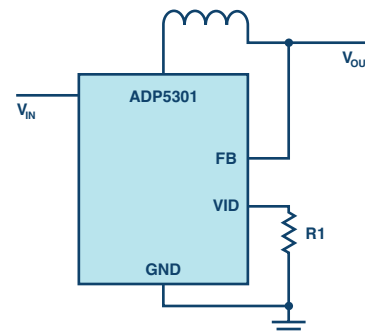


Figure 3. Adjustment of the output voltage without a continuous power loss in the voltage divider.

To reduce the power loss of a voltage divider, especially in ultra low power applications such as energy harvesting, some ICs, like the **ADP5301** step-down regulator, feature an output voltage setting function in which the value of a variable resistor at the VID pin is only checked

once during startup. This value is then stored for ongoing operation without current constantly flowing through a voltage divider. A very sensible solution for highly efficient applications.

About the Author

Frederik Dostal studied microelectronics at the University of Erlangen-Nuremberg, Germany. Starting work in the power management business in 2001, he has been active in various applications positions including four years in Phoenix, Arizona, working on switch mode power supplies. He joined Analog Devices in 2009 and works as a power management technical expert for Europe. He can be reached at frederik.dostal@analog.com.

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