Generate an Output Below the Reference Voltage

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Applications sometimes require the generation of a voltage that is below the reference rail. Many design engineers would just use a second regulator to generate this voltage. However, a simple change in the feedback path of a switching regulator allows a single regulator to perform this task.

In switching power converters, a pulse-width modulation (PWM) IC regulates the output voltage by comparing a fraction of the output voltage with a reference voltage using the chip's error amplifier. The signal representing the output voltage is developed by connecting a voltage divider between the output-voltage rail and ground.

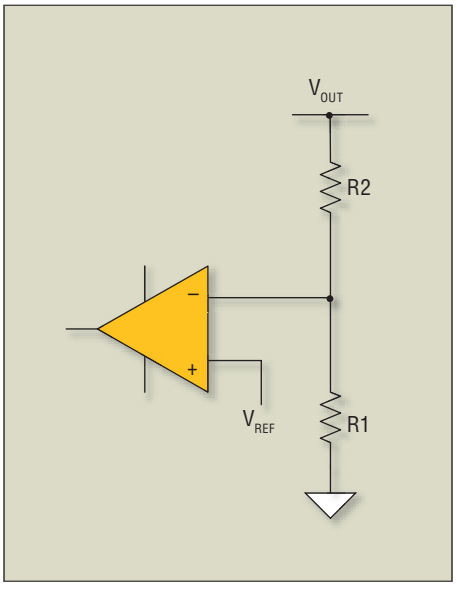

Fig. 1. *When the output voltage is greater than the reference voltage of the error amplifier, this circuit is used to set the output voltage of a converter.*

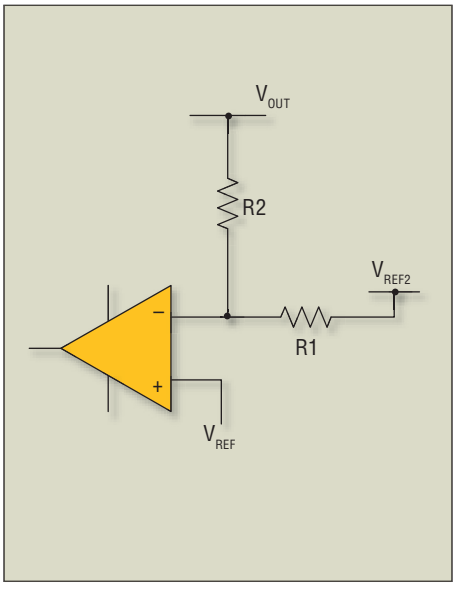

Fig. 2. *With a slight modification in the voltage divider, the error-amplifier circuit can be used to set an output voltage that is less than the reference voltage.*

Any deviations from the output-voltage set point are corrected by the converter's feedback network. With this arrangement, shown in **Fig. 1**, the output voltage can be arbitrarily high but cannot be lower than the error amplifier's reference voltage (V_{REF}). The output voltage of this configuration is given by the equation:

$$V_{OUT} = V_{REF}\left(\frac{R1+R2}{R1}\right). \quad \text{(Eq. 1)}$$

However, there are cases when the output voltage required is lower than the reference voltage. At first sight, this might imply the need to change to a PWM controller with a lower reference voltage. But, in fact, such instances can be easily accommodated with the original PWM controller and the same voltage divider circuit.

By making a slight modification in the way the divider is connected in the circuit, the second lower source can be developed. Its bottom leg is now connected not to ground but to a second reference voltage, which is higher than the PWM controller's reference (**Fig. 2**).

Using the principle of superposition, the output voltage of this configuration is found to be:

$$V_{OUT} = V_{REF}\left(\frac{R1+R2}{R1}\right) - V_{REF2}\frac{R2}{R1}, \quad \text{(Eq. 2)}$$

where $V_{REF} < V_{REF2}$ in order to ensure that $V_{OUT} < V_{REF}$. It is clear that Eq. 1 is a particular case of the more general Eq. 2. In other words, Eq. 2 is exactly equal to Eq. 1 when $V_{REF2} = 0$.

To illustrate the application of this scheme, take a typical example where the desired output voltage is V_{OUT} =1.20 V and the PWM IC's V_{REF} = 1.24 V. The second reference is typically in the 3-V to 5-V range. Let it be V_{REF2} = 5 V. Now pick R2 = 1 kΩ. Then from Eq.2, R1 = 94 kΩ.

V_{REF} contributes 1.253 V to the 1.2-V output voltage and V_{REF2} contributes only –0.053 V. This lopsidedness between the two references in contributing to the output voltage will be the case in all instances where the output voltage is only slightly lower than V_{REF}, which will be the majority of cases. Therefore, V_{REF2} will not have to be tightly specified and can come from, say, the output of a linear regulator or from another switching power supply. **PETech**