

AN60

Designing with Shunt Regulators - Fixed voltage regulators and opto isolation

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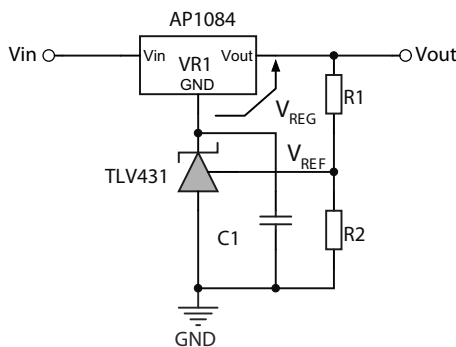
Introduction

An often used application of the 3-terminal shunt regulators or references is taking advantage of their precision function to turn otherwise medium accuracy linear regulators into precision ones. Figure 1 and Figure 2 show how this is done.

A major benefit is that the series regulator maintains all its in-built functions whilst behaving like a precision device by virtue of the reference taking over the primary control function.

Improved accuracy and extended voltage range

The circuits are very simple and the output voltage, V_{OUT} , is computed exactly as in other examples (see references at the end of this document).



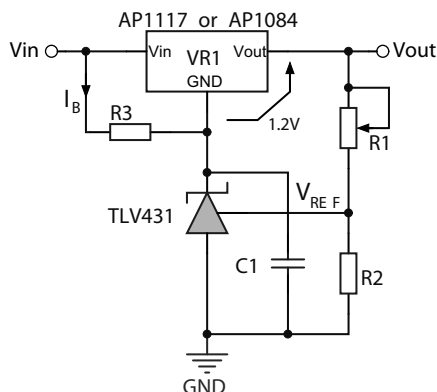
$$V_{OUT} = V_{REF} \left(1 + \frac{R1}{R2} \right)$$

$$V_{OUT} \geq (V_{REG} + V_{REF})$$

(All features of the regulator such as output current, short circuit protection, thermal shutdown, etc, are maintained.)

Figure 1 Increasing output voltage of a fixed linear regulator

One such application of references is in using it to improve the accuracy and/or extend the range and flexibility of fixed voltage regulators. In the circuit in Figure 1 above, both the output voltage and its accuracy are entirely determined by the TLV431, R1 and R2. However the rest of the features of the regulator (up to 5A output current, output current limiting and thermal shutdown) are all still available thus combining the best of both devices.



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

$$V_{OUT} \geq (V_{REG} + V_{REF})$$

$$R3 = \frac{V_{IN} - (V_{OUT} - V_{REG})}{I_B}$$

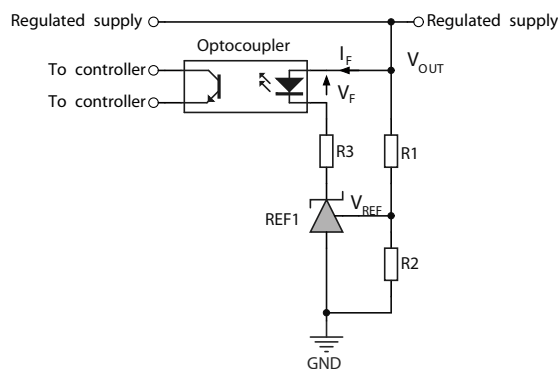
$$0.1mA \leq I_B \leq 18mA$$

(All features of the regulator such as short circuit protection, thermal shutdown, etc, are maintained.)

Figure 2 Adjustable linear voltage regulator

Figure 2 is similar to Figure 1 with adjustability added. Note the addition of R3, which is only required for the AP1117 due to the fact that its ground or adjustment pin can only supply a few micro-Amps of current at best. R3 is therefore needed to provide sufficient bias current for the TLV431.

Opto-isolated control



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

$$\frac{V_{OUT(min)} - (V_F + V_{KA(min)})}{I_{F(min)}} \geq R3 \geq \frac{V_{OUT(max)} - (V_F + V_{KA(min)})}{15mA}$$

Figure 3 Using a reference as the regulating element in an isolated PSU

A frequent application of three-terminal references is in isolated power supplies where the regulated output is galvanically isolated from the controller. In this case, an isolated feedback to the controller is implemented as shown in Figure 3.

REF1 drives current, I_F , through the optocoupler's LED which in turn drives the isolated transistor which is connected to the controller on the primary side of the power supply. The opto-isolated transistor is configured to suit the requirements of the controller on the primary side. An equilibrium state is only achieved when REF1 has achieved V_{REF} across its feedback pin.

This loop completes the feedback path that ensures that a stable isolated supply given by the expression in Figure 3 above is maintained and the reference helps to "trim" out the non-linear transfer function of the opto-isolator. In this way, the reference functions as a high gain amplifier, and, as part of the feedback loop, ensures that variations in the opto-coupler over time and temperature are not significant.

As an example, the Vishay SFH610 series opto-coupler requires an input current of between 1mA and 15mA to achieve a useful current transfer ratio for control purposes. This range of current is well within the capability of the TLV431. For the SFH610, V_F is about 1.2V, and I_{Fmin} is taken to be 1mA. For the TLV431, V_{KAmin} is taken to be 1.24V, though it can be slightly lower in practice. If for example a 5V output is required, then suitable values of R1 and R2 are easily found to be:

$$R1 = 30.5k\Omega$$

$$R2 = 10k\Omega$$

The value of R3 determines the normal regulating input current I_F of the opto-isolator. Assuming 10mA:

$$\frac{V_{OUT(min)} - (V_F + V_{KA(min)})}{I_F} = \frac{5 - (1.2 + 1.24)}{0.01}$$

$$= 256 \text{ ohms}$$

This value is not critical and R3 could be set to 240 or 270 Ω .

Conclusion

The above examples show how the superior parameters of the Diodes' 3-terminal references can be used to improve COTS voltage regulators. It also shows how they can be used in an isolated power supply application.

Recommended further reading

AN58 - Designing with Shunt Regulators - *Shunt Regulation*

AN59 - Designing with Shunt Regulators - *Series Regulation*

AN61 - Designing with Shunt Regulators - *Extending the operating voltage range*

AN62 - Designing with Shunt Regulators - *Other Applications*

AN63 - Designing with Shunt Regulators - *ZXRE060 Low Voltage Regulator*

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