Application Report
SNOA607B–February 1984–Revised May 2013

# AN-12 Wide Adjustable Range PNP Voltage Regulator

**ABSTRACT**

This application note discusses the PNP voltage regulator.

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# 1 Introduction

What happens when the need arises for a regulator voltage that isn't matched by your stock of fixed voltage I/C regulators? For the standard NPN pass transistor regulators (LM340 for example) the answer may be as simple as adding a resistor (R1) in the ground pin (Figure 1). The new output voltage ($V_O$) will then be:

$$V_O = V_{REG} + I_Q \times R1 \quad (1)$$

where: $V_{REG}$ is the original regulator output voltage,

$I_Q$ is the regulator's quiescent current.

But if the need is also for a low drop across the regulator, then a PNP pass regulator is required. Simply adding a resistor in the ground pin doesn't work, since the regulator internal current varies too much because of increased base drive to compensate for lower PNP beta. However, if a zener is used instead of a resistor, the higher voltages can be accommodated (Figure 2). The new output voltage ($V_O$) is:

$$V_O = V_{REG} + V_Z \quad (2)$$

where $V_Z$ is the zener voltage.

As $V_{REG}$ is constant, the output voltage regulation will depend largely on the zener voltage ($V_Z$) and its dynamic impedance.

The zener voltage will vary slightly with the current flowing through. Let's take the popular LM2931Z PNP regulator as an example of variation of the quiescent current. When the regulator load changes from 50 mA to 150 mA, the zener current will increase by 12.5 mA. The zener voltage variation due to this current change will only be a few hundred mV. That is, the output voltage will vary slightly, but not as much (as high as a few volts) as with a resistor to ground. Thus, a much better regulated output voltage is maintained.

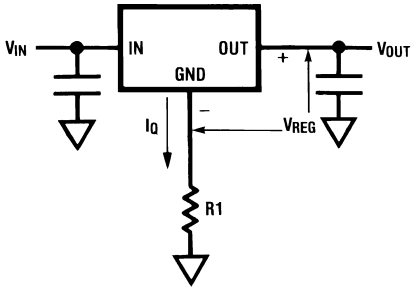


**Figure 1. NPN Regulator**

One advantage inherent to this circuit is the ability to achieve higher output voltages than the normal regulator rating. The maximum regulator output is limited by the breakdown of its internal circuitry. However, carefully selecting the zener to keep the input and ground pin differential voltage well below the breakdown, the input is allowed to exceed its maximum rating. For example, a 5V 3-terminal LM2931Z PNP regulator (maximum operating input voltage = 26V) can become a 56V regulator with a 51V zener. And the input voltage can be as low as 56.6V with a load current of 150 mA or less. Most of the PNP regulator's features are still maintained. The short circuit protection may or may not be there, depending on the output voltage and the safe operating area of the output pass PNP transistor.

Capacitors C1 and C2 should have the same values as those specified for normal operation. However, their maximum operating voltage ratings should exceed the input voltage. Capacitor C3 should be located as close as possible to the ground pin to get good decoupling and ensure stable operation. The value of C3 will depend on zener impedance and noise characteristics. The capacitor types must also be rated over the desired operating temperature range.

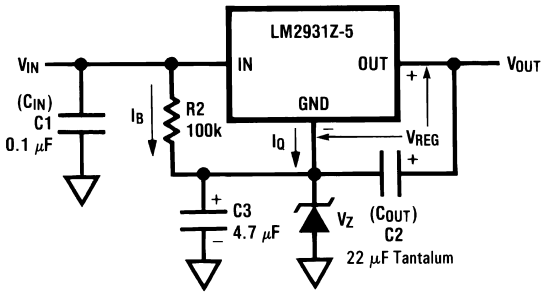


**Figure 2. PNP Regulator**

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