Application Report
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AN-11 High-Efficiency Regulator Has Low Drop-Out Voltage

ABSTRACT

Conventional regulators have a high drop-out voltage that is a function of the total output current. However, with just a regulator chip, an external transistor and a few passive components, this design forms a high output current regulator with a limited input voltage and high efficiency. The circuit presented has a drop-out of 0.7 V at 5A load current and 1.3 V at a current level of as high as 10A.

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1 Introduction

The circuit output voltage equals that of PNP regulator U1 and may be expressed as $V_{OUT} = V_{REF}$ (R1 + R2)/R1 where V_{REF} equals U1's reference voltage of 1.2 V. To compensate for bias-current errors and to keep the extra quiescent current that is induced by this resistor network to a few µA, resistor R1 is set at 28 kΩ. Thus, for a 5 V regulated output voltage, R2 is set at 88.7 kΩ. In addition, the output voltage can be adjusted between 3 V and 24 V by varying R2.

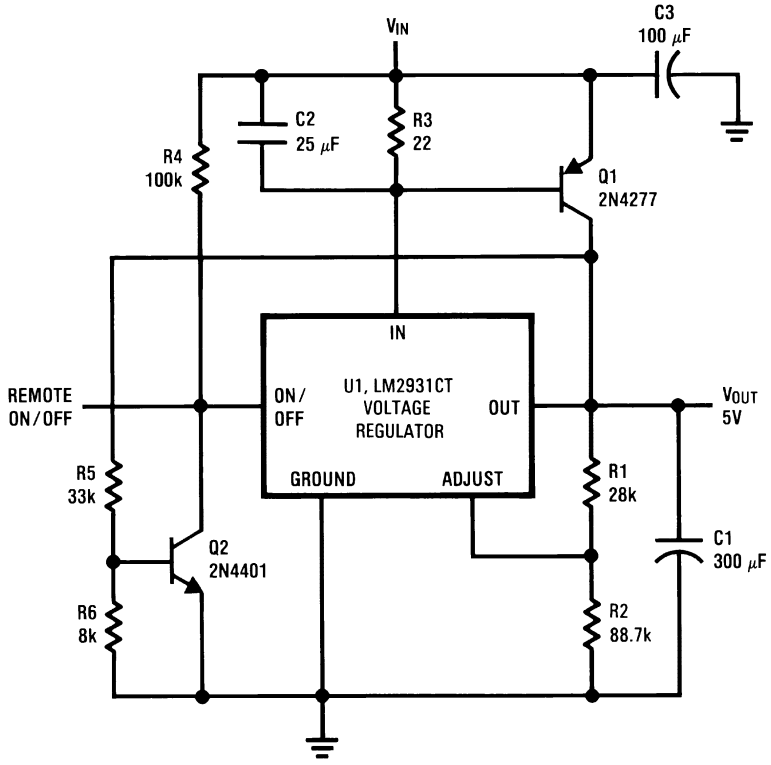
The circuit can handle a great deal of current because of external PNP transistor Q1. At high current levels, the circuit's drop-out voltage is a function of the saturation voltage of the PNP device. As a result, Q1 must have low saturation levels for V_{CE} and V_{BE} along with a high beta. In addition, the maximum output current is equal to the maximum output sink of regulator U1 multiplied by the maximum beta of Q1. A germanium transistor, such as a 2N4277 for the external pass element, satisfies the above requirements. For the components shown, the circuit gives excellent regulation at V_{IN} = 5.7V up to 5A in load current, giving a drop-out of only 0.7 V.

U1 is biased to a minimum of 30 mA by a resistor R3, which also functions as a bleeding resistor for Q1. The on-off pin of U1 permits extra remote on-off control and current-limiting functions for the circuit. Pulling this pin to ground enables the circuit, whereas keeping it open disables the circuit and leaves the regulator in the standby mode. The ratio R5:R6 limits the maximum output current. When the load current exceeds this maximum, the output voltage begins to fall and the voltage across R6 decreases. This low voltage cuts off transistor Q2, thereby disabling the circuit output. As a result, transistor Q1 and the load are protected from overdrive and damage.

2 Efficiency

Using Texas Instruments regulator LM2931CT, external transistors Q1 and Q2, and a few passive components, this circuit forms a high-current regulator having a low drop-out. For the components shown in the figure, the regulator has a drop-out of 0.7 V at 5A load current and 1.3 V at a level as high as 10A. The on-off pin of regulator U1 provides remote control, while transistor Q2 limits the maximum output current.

Figure 1. High-Current Regulator Using LM2931CT



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