

# PMP9796 - 5V Low-Power TEC Driver Reference Design



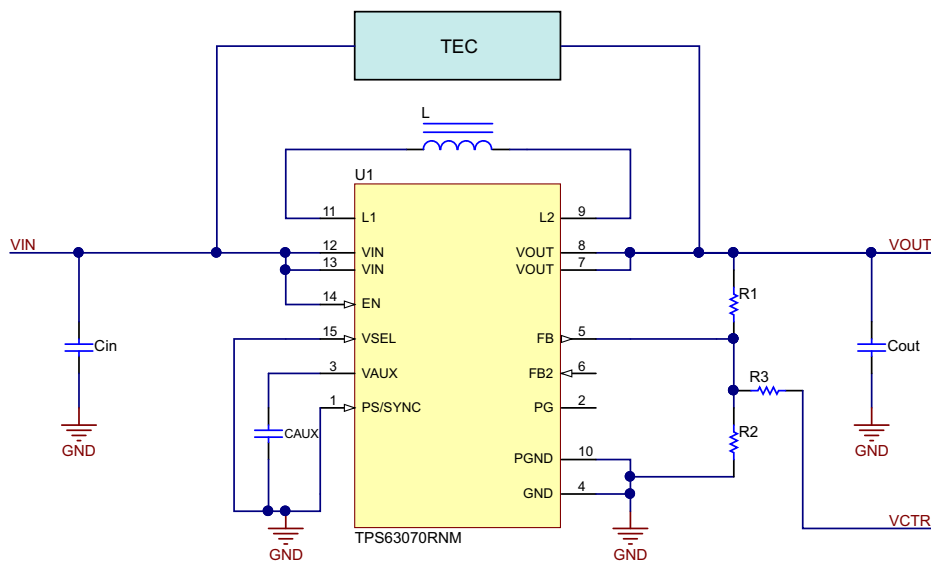
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Attaining the best performance from electronic circuits may require to tight control of the operating temperature of the circuits or at least the temperature of the critical components. Heatsinks help keep the temperature close to the ambient temperature. But if the ambient temperature is not properly controlled or components of the circuit generate heat during operation (which cannot be easily predicted as accurate as needed), active control of the temperature may be required.

Using thermoelectric coolers (TECs) may help to solve this problem. TECs are used for active cooling and heating of the attached components. To control the temperature of the components with a TEC, the current flowing through it must be controlled. Depending on the direction of the current flow they are either cooling or heating the attached components. This requires a power supply solution which can source and sink current. This application note details a circuit implementation based on TI's single inductor buck-boost converter technology which offers a simple possible solution for such a power supply.

## 1 Overview

In the example the power supply solution is implemented based on the TPS63070. The complete circuit is shown in [Figure 1](#).



**Figure 1. Simplified Circuit Schematic**

The objective of this circuit is to control the current flowing through the TEC in both directions. An example for a circuit implementation can be found in the [TI reference designs library](#).

## 2 Detailed Description

As shown in [Figure 1](#), the circuit consists of a buck-boost converter design based on the TPS63070 almost in its default configuration. The TPS63070 is supplied by a regulated voltage rail of 5 V. The TEC is connected between the output of the TPS63070 based DCDC converter and its input supply voltage rail of 5 V. For this application the minimum input voltage of the TPS63070 is 5V.

According to the TPS63070 datasheet ([SLVSC58](#)), its output voltage can be varied between 2.5 V and 9 V. Using this voltage range at the output of the buck-boost converter allows the voltage to vary across the TEC between  $V_{TECmax}$  of 2.5 V and  $V_{TECmin}$  of -4 V.

Use [Equation 1](#) and [Equation 2](#) to calculate those values.

$$V_{TECmax} = V_{OUTmax} - V_{IN} \quad (1)$$

$$V_{TECmin} = V_{OUTmin} - V_{IN} \quad (2)$$

In these equations,  $V_{IN}$  is the regulated supply voltage of the buck-boost converter,  $V_{OUTmax}$  is the maximum, and  $V_{OUTmin}$  is the minimum output voltage of the buck-boost converter.

The output voltage of the buck-boost converter is programmed with the feedback divider consisting of  $R_1$  and  $R_2$ . To be able to vary the output voltage, an additional resistor  $R_3$  is connected to the feedback divider to enable feeding current into the feedback node. The feedback voltage  $V_{FB}$  is regulated to a constant value of 0.8 V (TPS63070 datasheet, [SLVSC58](#)), so the control voltage  $V_{CTRL}$  defines this current flowing through  $R_3$ .

To calculate an appropriate value for the resistance of  $R_3$ , use [Equation 3](#).

$$R_3 = R_1 \cdot \left( \frac{V_{CTRLmax} - V_{CTRLmin}}{V_{OUTmax} - V_{OUTmin}} \right) \quad (3)$$

In [Equation 3](#),  $V_{CTRLmax}$  is the maximum level of the control voltage and  $V_{CTRLmin}$  is the minimum value of the control voltage.

Finally  $R_2$  is calculated using [Equation 4](#):

$$R_2 = \frac{V_{FB} \cdot R_1 \cdot R_3}{R_3 \cdot V_{OUTmax} + R_1 \cdot V_{CTRLmin} - V_{FB} \cdot (R_1 + R_3)} \quad (4)$$

To drive the TEC properly, the buck-boost converter must source and sink current. When using the TPS63070, this is achieved by forcing the converter in fixed frequency operation. This is done by disabling the built-in power-save mode. Since the TPS63070 can source more current than it can sink, it is important how the TEC is connected to the circuit. In general, the devices which should be kept at a controlled temperature generates heat. For this reason, cooling typically requires more power than heating. So in most cases, the TEC is best connected in a way that it is cooling the device while the TPS63070 is sourcing current.

## 3 Example

In this example the input voltage  $V_{IN}$  is 5 V,  $V_{OUTmin}$  is 2.5 V and  $V_{OUTmax}$  is 7.5 V. The control voltage  $V_{CTRL}$  should be between 0.2 V to 1.4 V. With a given resistance value for  $R_1$  of 680 k $\Omega$ , and the voltages for  $V_{CTRLmax}$  (1.4 V) and  $V_{CTRLmin}$  (0.2 V) the resistance for  $R_3$  is calculated to be 163 k $\Omega$ . With the values for the parameters previously used, the resistance of  $R_2$  is calculated as 130 k $\Omega$ .

#### 4 Test Results

The following tests were performed at room temperature with the same conditions and values as shown in the example. Figure 2 shows the current flowing through the TEC depending on the control voltage. The predicted asymmetry of the maximum currents for sourcing and sinking are observed there.

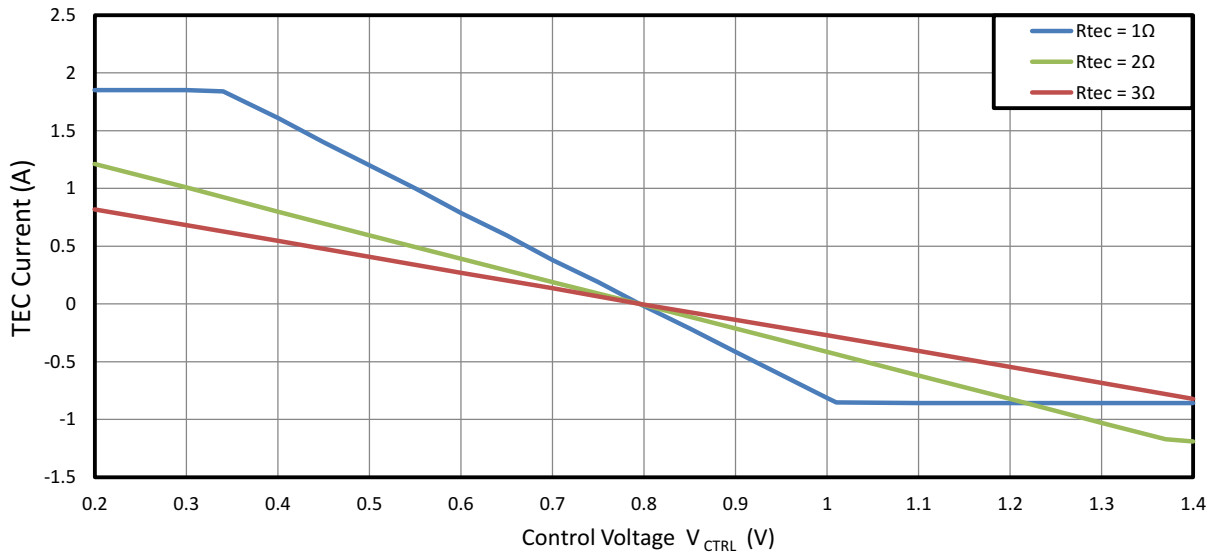


Figure 2. TEC Current vs. Control Voltage

Figure 3 and Figure 4 show the efficiency of the system in sourcing ( $V_{out} > V_{in}$ ) and sinking ( $V_{out} < V_{in}$ ) operation.

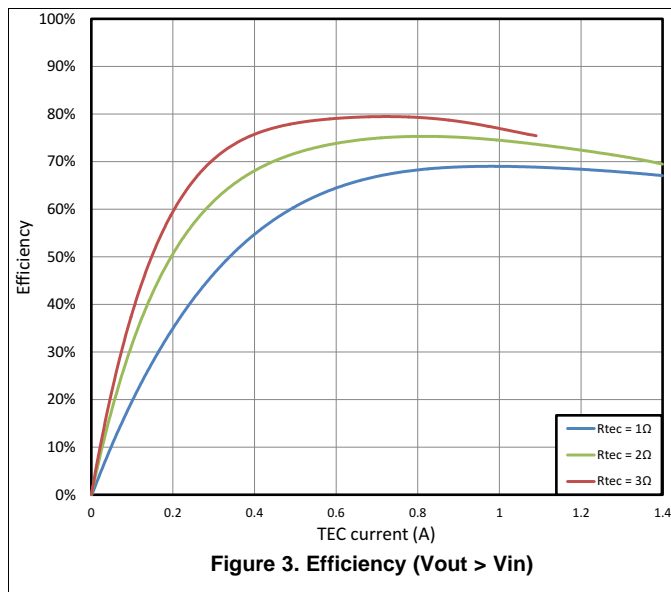


Figure 3. Efficiency ( $V_{out} > V_{in}$ )

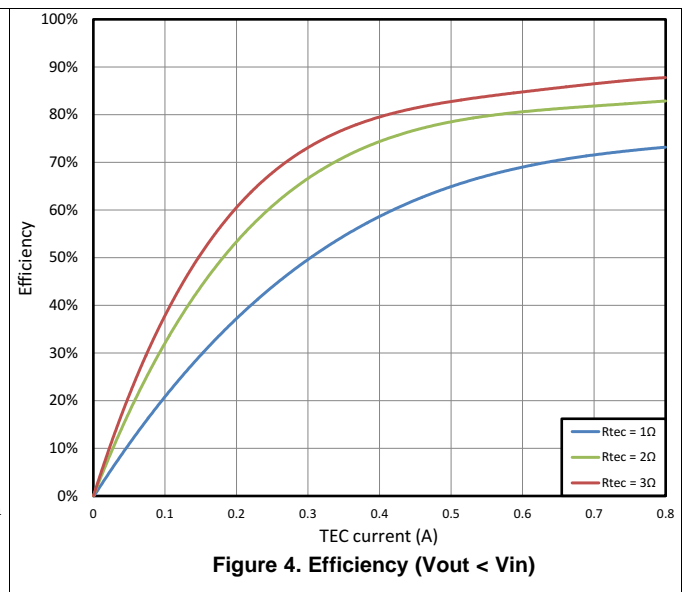


Figure 4. Efficiency ( $V_{out} < V_{in}$ )

This power supply solution can be used in a control system to control the temperature of the device. For example, if  $V_{CTRL}$  is generated by a PWM signal on a GPIO of a microcontroller which is running a temperature control algorithm, a closed loop system is built to control the temperature of the components attached to the TEC.

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