DN0006

SEPIC with Both Step-Up and Step-Down Capabilities (MP1542)

The Future of Analog IC Technology™

DESIGN NOTE

Introduction

Battery-powered applications and automotive distributed power often operate at voltages that are derived from a widely variable bus voltage. Frequently, the required operating voltage falls somewhere in the middle of the bus voltage range. These applications require a DC-DC converter that can perform both step-up and step-down, depending on the bus voltage. Flyback and SEPIC designs are commonly used as single-switch solutions to this problem.

In SEPIC designs, either a transformer with two coupled inductors or two separate inductors can be used. A transformer with two coupled inductors tends to be slightly taller, but saves board space.

Two separate inductors can be low profile and easier to implement in the PCB layout. The inductors are also not restricted to having the same inductance and can be individually picked for peak currents and allowable ripple.

The SEPIC coupling capacitor provides a low impedance path for the inductor currents to pass either from the input inductor through the catch diode to the output, or from the output inductor back through the power switch to ground. This coupling capacitor also offers output disconnect that is not available in non-synchronous step-up converters.

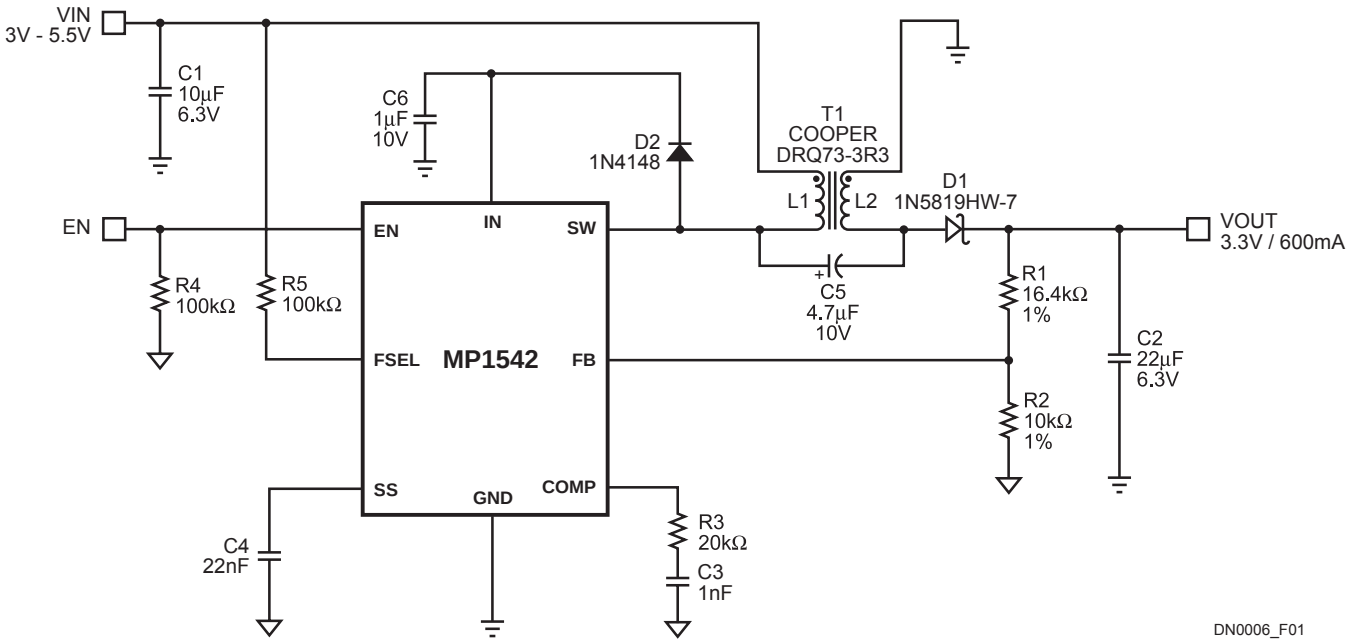

Figure 1—MP1542 SEPIC Application (1.3MHz)

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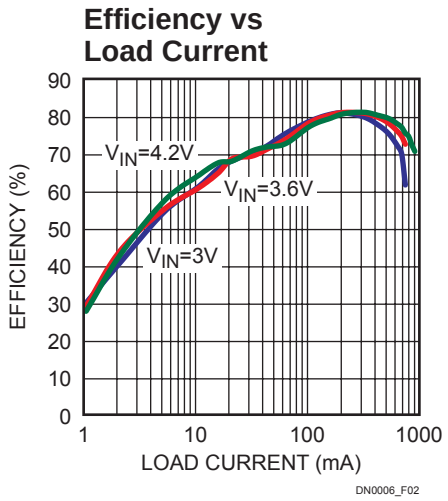

Figure 2—Efficiency Curve for Circuit of Figure 1

Figure 1 shows a 3V to 5.5V input, 3.3V output, 3mm maximum height SEPIC using the MP1542. The MP1542 is a 700KHz/1.3MHz current-mode step-up converter with a 2A, 0.18Ω internal switch.

The output current capability of this circuit varies with the input voltage (See Figure 3). The switch current during the switch on-time is the sum of the two inductor currents. The DC current of the input inductor L1 is equal to the input current. And the DC current of the output inductor L2 is equal to the load current.

The converter can typically supply up to 675mA of load current at 3V input and as high as 1A of load current at 5.5V input. As the input voltage rises, the current going into the input inductor decreases and the current going into the output inductor and the load current both increase.

The 4.7μF, 10V coupling capacitor is used to handle the RMS ripple current transferring between the input and output sides of the circuit and to maintain a voltage equal to the input voltage in order to provide good regulation and maximum output power.

The current-mode control topology of the MP1542 provides excellent transient response over the wide input voltage range. To enhance the gate drive of the internal power switch for lower $R_{DS(ON)}$ and better efficiency, a peak detector circuit consisting of D2 and C6 is used on the chip's IN pin.

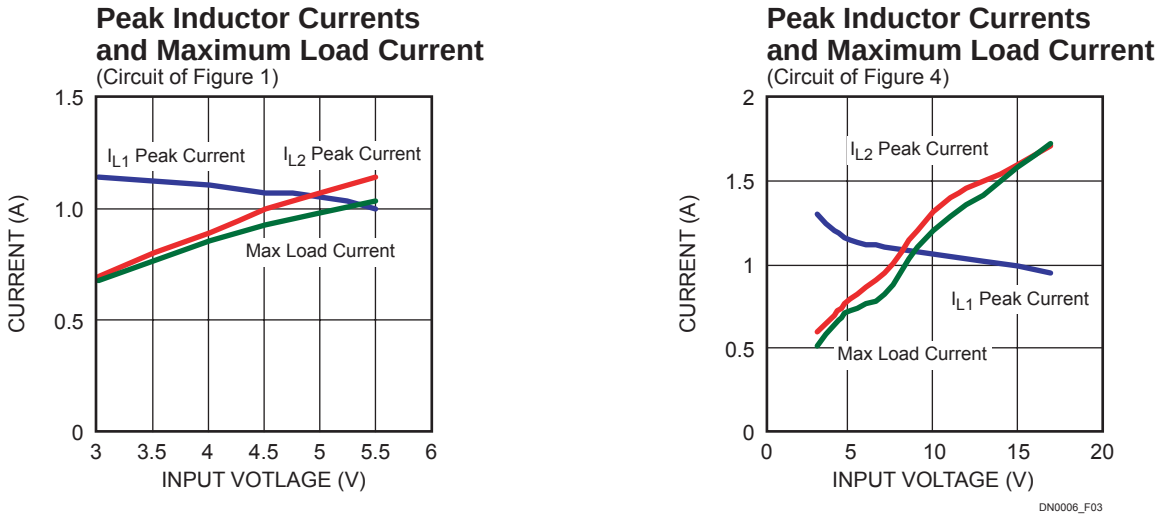

Figure 3—Peak Inductor Currents

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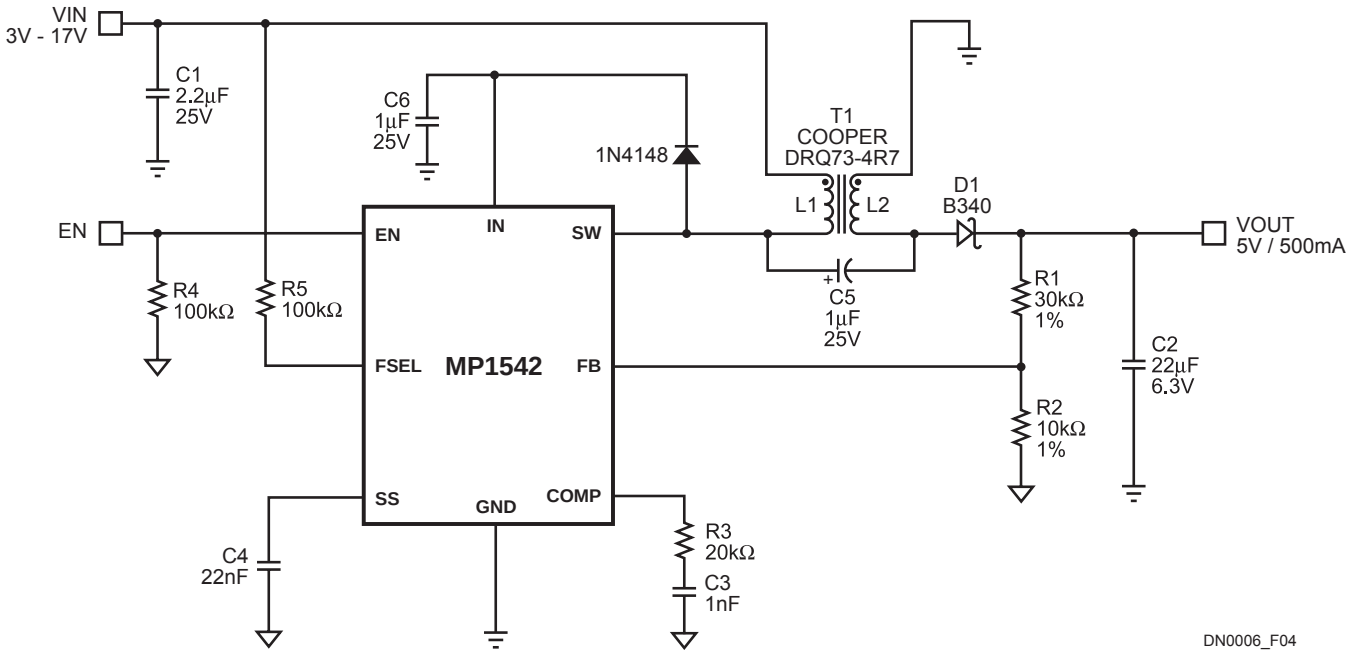

Figure 4—MP1542 SEPIC Application (1.3MHz)

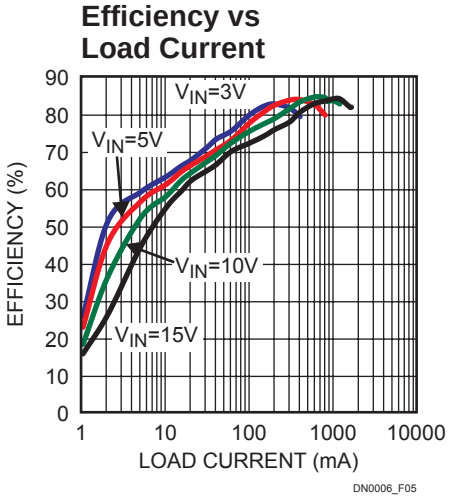

Figure 5— Efficiency Curve for Circuit of Figure 4

Figure 4 shows another example used to obtain 5V output with a SEPIC circuit using the MP1542. The catch diode D1 needs to have at least a 30V reverse breakdown voltage rating in order to handle the voltage induced across it during the switch off-time, which is equal to the output voltage plus the input voltage. The 25V maximum switch voltage rating of the MP1542 allows the input voltage to go as high as 17V.

With a DC voltage equal to the input voltage, the coupling capacitor raises the voltage at the switch node to a level equal to the input voltage plus the output voltage. The converter can typically supply the load up to 500mA at 3V input and 1.7A at 17V input.

Conclusion

The MP1542 fits into SEPIC solutions for applications with wide input voltage ranges and output disconnect. The solutions are small, simple and low profile and also offer over 80% efficiency.

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