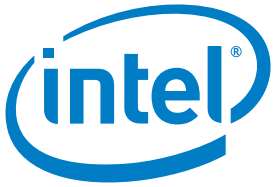

Application Note AN-840:

Generating Negative Output Voltages Using Intel® Enpirion® Power Solutions

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1. Introduction

Intel® Enpirion® power system on chip (SoCs) are fully integrated step-down DC-DC power modules with available output currents ranging from 400 mA to 60A+. They include the controller, inductor, power MOSFETs, and supporting circuitry in a single surface mount package. The standard operation for these devices is to step down a positive DC input voltage to provide lower positive DC output voltage; however, these modules can be easily configured to provide solutions for applications requiring negative output voltages as well.

This application note will show how to use an example Intel Enpirion PowerSoC, an EN6337QI 3A integrated PowerSoC, to supply a negative output voltage. For more information on the EN6337QI, please visit https://www.altera.com/products/power/devices/powersoc-dc-dc-step-down-converters/en6337qi.html.

2. Positive Output Circuit Configuration

The standard EN6337QI configuration is to provide a positive output voltage. Figure 1 shows the typical application circuit for the EN6337QI configured to provide up to 3A of output current, as shown in the EN6337QI datasheet. This circuit can be easily modified to generate a negative output voltage. Let's take a look at the process of how to do so.

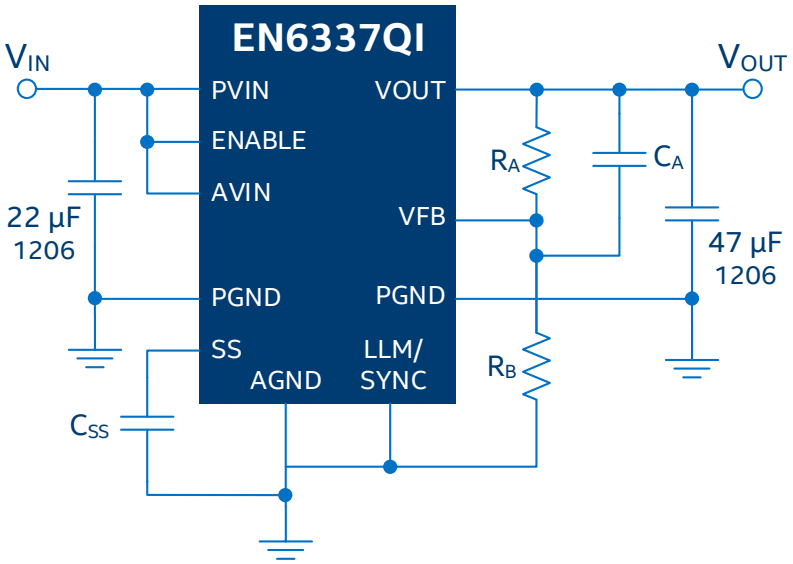


Figure 1: Standard Positive Output Circuit Configuration

3. Negative Output Circuit Configuration

To configure the EN6337QI, or any other Intel Enpirion power module, for a negative output, a few modifications to the schematic must be made. The negative terminal of the input voltage supply must be tied to the output pin of the module at the VOUT pin. The previous ground connections and all components tied to them must now be reconfigured to reference -$V_{OUT.}$ The modified circuit for a negative output is shown in Figure 2.

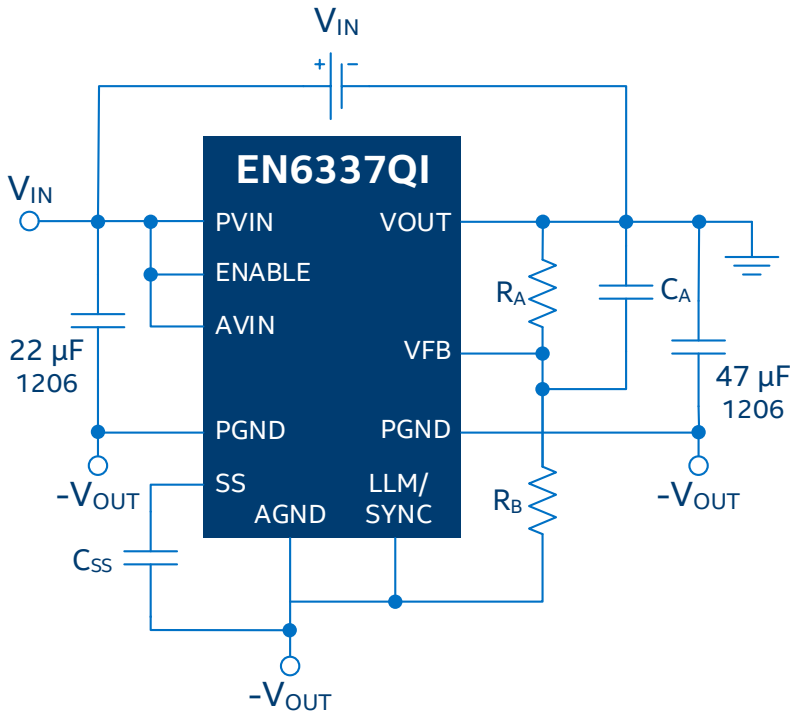


Figure 2: Negative Output Circuit Configuration

3.1 Design Considerations

There are a couple of key considerations to keep in mind while designing for negative output voltages. The first thing to remember is that the lowest potential in the circuit is no longer ground (0V) but is now -V_{OUT}, and all signals in the circuit are now referred to -V_{OUT}.

This shift in potential has effects on the input voltage seen at the PVIN pins of the power module; let's call this new value $V_{IN(EFFECTIVE)}$. The input pin PVIN now sees a $V_{IN(EFFECTIVE)}$ of:

$$V_{IN(EFFECTIVE)} = V_{IN} + |-V_{OUT}|$$

This higher input voltage $V_{IN(EFFECTIVE)}$ must remain below the power module's maximum operating input voltage range. In the case of the EN6337QI, the maximum operating input voltage is 6.6V.

In addition to higher relative voltage observed at the PVIN pin, one must also take into account the input capacitor voltage ratings. To avoid DC bias effects of lower effective capacitance, the input capacitors must be rated for at least twice the voltage (2 x $V_{IN(EFFECTIVE)}$) seen at the PVIN pin of the power module.

It is also important to note that the duty cycle of a negative output regulator is as follows:

$$D = \frac{|-V_{OUT}|}{V_{IN} + |-V_{OUT}|}$$

3.2 Design Example

This section demonstrates a design example using an EN6337QI to generate a -2.25V output from a 3.3V input supply voltage:

- V_{IN} = 3.3V
- $-V_{OUT}$ = -2.25V
- EN6337QI maximum operating voltage (from the device datasheet): 6.6V

The input voltage seen at the PVIN pin of the EN6337QI PowerSoC is therefore:

$$V_{IN(EFFECTIVE)} = V_{IN} + |-V_{OUT}| = 3.3V + |-2.25V| = 5.55V$$

This is below the maximum operating voltage of 6.6V. To limit the effects of DC bias, the input capacitors should be rated for at least 10V or greater and have an X5R or X7R dielectric rating.

The duty cycle is:

$$D = \frac{|-V_{OUT}|}{V_{IN} + |-V_{OUT}|} = \frac{|-2.25V|}{3.3V + |-2.25V|} = 0.405 \; or \; 40.5\%$$

The waveforms for 3.3V input voltage, enable, and -2.25V output voltage are shown below in Figure 3 and Figure 4.

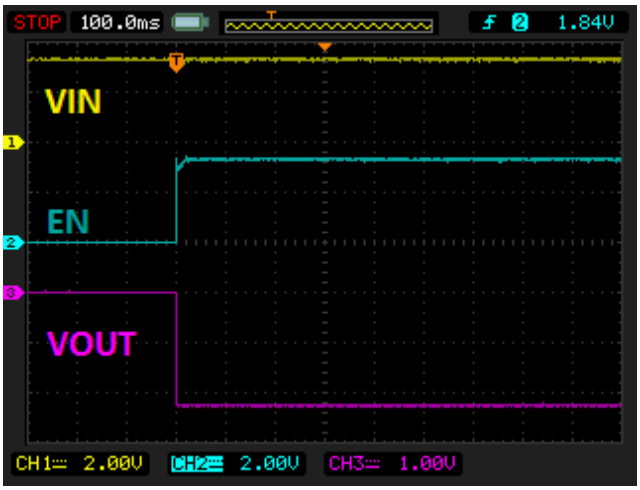


Figure 3: Waveform for V_{IN}, Enable (EN), and V_{OUT}, where V_{IN} = 3.3V and V_{OUT} = -2.25V

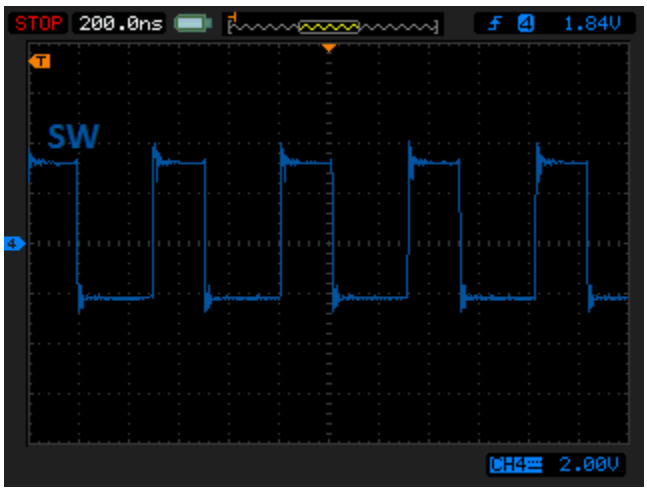
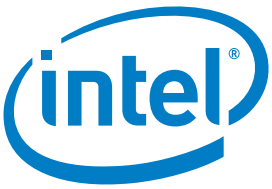


Figure 4: Switch Node (SW), where V_{IN} = 3.3V and V_{OUT} = -2.25V

4. Conclusion

Intel's Enpirion integrated PowerSoC modules provide a fast and easy means to power devices over a wide varying range of output currents. In a standard configuration, these modules provide a positive DC output voltage from a positive DC input voltage; but, with some minor modifications, they can also provide negative DC outputs.



5. Revision History

Revision Number	Description	Revision Date
1.0	Initial release.	December 2017