APPLICATION NOTE 1123
600mA STEP-DOWN DC/DC CONVERTER WITH SYNCHRONOUS RECTIFIER

General Description

The AP3403 is a 2.0MHz fixed frequency, current mode, PWM synchronous buck (step-down) DC-DC converter, capable of driving a 600mA load with high efficiency, excellent line and load regulation. The high efficiency is easily configured by using an inductor, resistors and capacitors as the external components. Current mode control provides fast transient response and cycle-by-cycle current limit.

The AP3403 employs complete protection to ensure system security, including input Over Voltage Protection, input Under Voltage Lock Out, programmable Soft Start, Over Temperature Protection and hiccup mode Short Circuit Protection.

The AP3403 supports a range of input voltage from 2.3V to 5.5V, allowing the use of a single Li+/Li-polymer cell, USB and other standard power sources. The output voltage is adjustable from 0.7V to input voltage.

This IC is available in U-DFN1616-6 package.

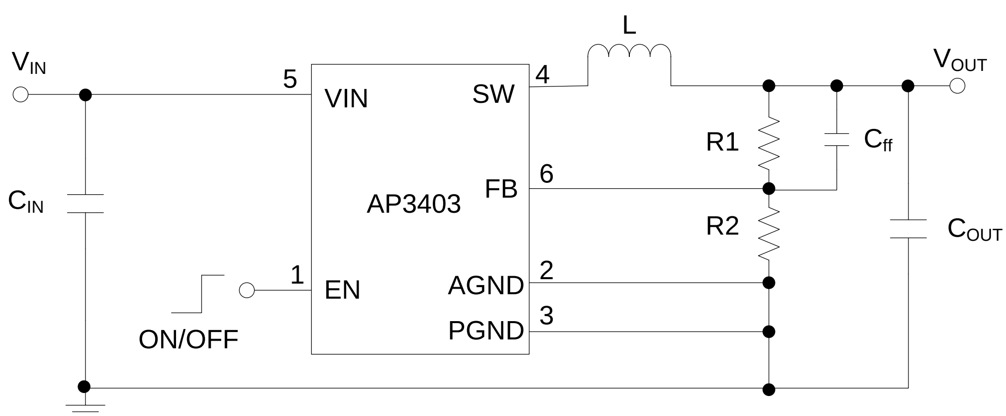
Features

- High Efficiency Buck Power Converter
- Input Voltage Range: 2.3V to 5.5V
- Output Voltage Range: 0.7V to 5.5V
- Fixed 2.0MHz Oscillator Frequency
- Built-in Soft-start Time
- Built-in Over Current Protection
- Built-in Thermal Shutdown Function
- Built-in UVLO Function
- Hiccup Mode SCP
- Output Current: 600mA
- Package: U-DFN1616-6

Applications

- Post DC-DC Voltage Regulation
- PDA and Notebook Computer

Typical Application Schematic



Application Information

Setting the Output Voltage

The output voltage is set using a resister voltage divider from the output to FB pin. The output voltage is calculated as below:

$$V_{OUT} = 0.6 \times \left(\frac{R_1 + R_2}{R_2} \right)$$

First, select a value for R2, then, R1 is determined. The output voltage is given by Table 1.

V_{OUT}	R1	R2	C_{ff}
1.0V	120KΩ	180KΩ	22pF
1.2V	180KΩ	180KΩ	22pF
1.5V	270KΩ	180KΩ	22pF
1.8V	240KΩ	120KΩ	22pF
2.5V	380KΩ	120KΩ	15pF
2.8V	275KΩ	75KΩ	15pF
3.3V	270KΩ	60KΩ	15pF

Table 1: Resistor Selection for Output Voltage Setting

Inductor Selection

The inductor is used to supply smooth current to output when it is driven by a switching voltage. Its value is determined based on the operating frequency, load current, ripple current, and duty cycle. For most application, the value of the inductor will fall in the range of 1.5µH to 4.7µH. Choose an inductor that has small DC resistance, has enough current rating and is hard to cause magnetic saturation.

V_{OUT}	1.0V	1.2V	1.5V	1.8V	2.5V	2.8V	3.3V
L	2.2µH	2.2µH	2.2µH	2.2µH	2.2µH	4.7µH	4.7µH

Table 2: Inductance Selection

Input Capacitor

Good quality input capacitor is necessary to filter noise at input voltage source and limit the ripple voltage of input while supplying most of the switch current during the on-time. For input capacitor selection, ceramic capacitor is recommended because they provide both low impedance and small footprint. But tantalum or low electrolytic capacitor is also sufficed.

The important parameters for the input capacitor are the voltage rating and the RMS current rating. The voltage rating should be at least 1.25 times greater than the maximum input voltage, while a voltage rating of 1.5 times is conservative. The RMS of input capacitor current is calculated as:

$$I_{CIN\_RMS} = I_{OUT(MAX)} \times \sqrt{\frac{V_{OUT}}{V_{IN}} \left(1 - \frac{V_{OUT}}{V_{IN}} \right)}$$

I_{CIN_RMS}: The RMS of input capacitor current.

As indicated by the RSM ripple current equation, highest requirement for RMS current rating occurs at 50% duty cycle. So the RMS ripple current rating of input capacitor should be greater than half the output current under this worse case. For reliable operation and best performance, ceramic capacitors are preferred for input capacitor because of their low ESR and high ripple current rating. And X5R or X7R type dielectric ceramic capacitors are preferred for their better temperature and voltage characteristic. Additional, when selecting ceramic capacitor, make sure it has enough capacitance to provide sufficient charge to prevent excessive voltage ripple at input.

The capacitance of C_{IN} should be more than or equal to 4.7µF.

Application Information (Cont.)

Output Capacitor

The output capacitor is selected based upon the desired output ripple and transient response. The output voltage ripple depends directly on the ripple current and it is affected by two parameters from the output capacitor: total capacitance and the equivalent series resistance (ESR). The output ripple voltage can be found from:

$$\Delta V_{OUT} = \Delta I_L \times \left[R_{ESR} + \left(\frac{1}{8 \times C_{OUT} \times f_{SW}} \right) \right]$$

ΔV_{OUT} : The output ripple voltage.

R_{ESR} : The equivalent series resistance of output capacitor.

For lower output ripple voltage across the entire operating temperature range, X5R or X7R dielectric type of ceramic, or other low ESR tantalum capacitor or aluminum electrolytic capacitor are recommended. The capacitance of C_{OUT} should be more than or equal to 10µF and the output capacitor voltage rating should be greater than 1.5 times of maximum output voltage.

PCB Layout Guideline

PCB layout is an important part of DC-DC converter design. Poor board layout can disrupt the performance of the converter and surrounding circuitry by contributing to EMI.

Power Path Length

The power path of AP3403 includes an input capacitor, output inductor and output capacitor. Place them on the same side of PCB. The GND trace, the SW trance and the VIN trance should be kept short, direct and wide. AGND and PGND must be wired to the GND plane when mounting on boards.

Feedback Net

Special attention should be paid to the route of the feedback ring. The feedback trace should be routed far away from the inductor and noisy power trace. Try to minimize trace length to the FB pin and connect feedback network behind the output capacitors.

Via Hole

Be careful with the via hole. Via will result high resistance and inductance to the power path. If heavy switching currents must be routed through vias and/or internal planes, use multiple vias parallel to reduce their resistance and inductance.

Figures 1 and 2 are examples of AP3403 PCB layer.

Application Information (Cont.)

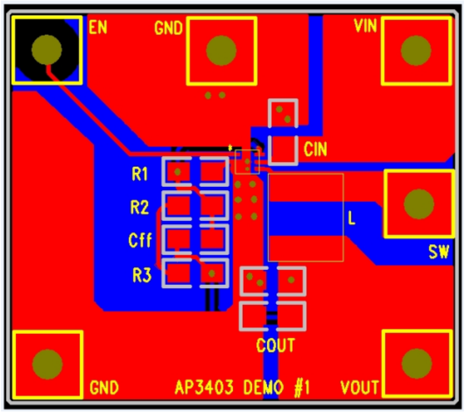


Figure 1: Top Layer

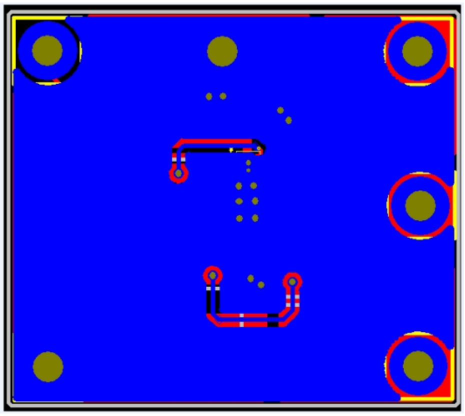


Figure 2: Bottom Layer

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