# Design Consideration with AP3012

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## 1. Introduction

The AP3012 is a general purpose DC/DC converter. To save space and reduce cost, this AP3012 operates at 1.5MHz switching frequency normally, which means that the tiny periphery components are acceptable. In fact, 1mm tall inductors and 1μF output capacitors for typical applications are very appropriate. To achieve flexible maneuverability, a disable terminal is designed to turn on or turn off this device.

The main application of the AP3012 consists of handheld devices, including digital cameras, PDAs, MP3 players, cellular phones, etc. The main feature of these handheld devices is compactness. To satisfy this specific requirement for handheld devices, the AP3012 is available in a small 5-lead SOT-23 package to save space.

## 2. Functional Block Description

The pin configuration of the AP3012 and the representative block diagram are respectively shown in Figure 1 and Figure 2:

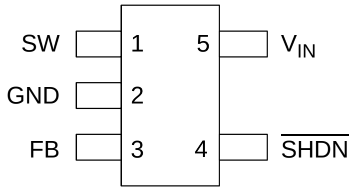


Figure 1. Pin Configuration of AP3012

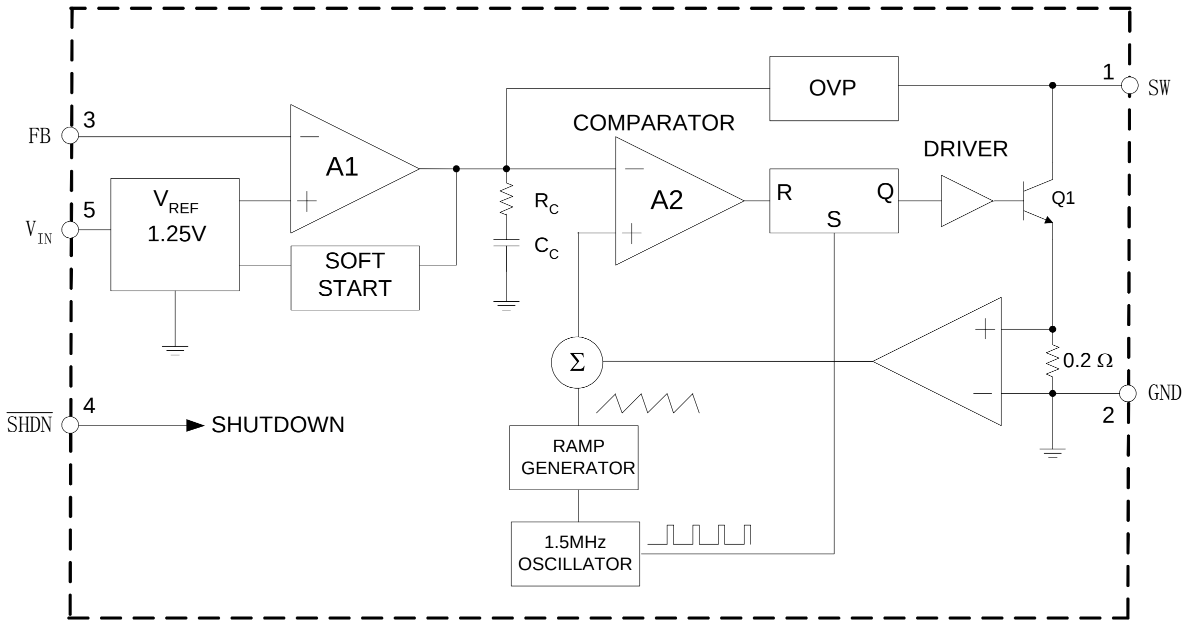


Figure 2. Functional Block Diagram of AP3012

## 3. Typical Application

Figure 3 shows a typical application of AP3012 in an LCD bias supply:

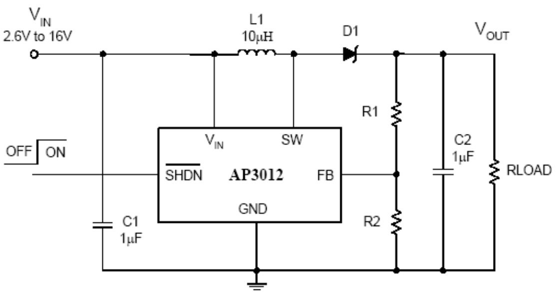


Figure 3. Typical Application Diagram

In this circuit, the inductor L1, diode D1 and the switch integrated in the AP3012 build a typical boost converter. C1 and C2 are input bypass and output capacitors respectively. R1 and R2 are the feedback resistors, which determine the output voltage. In this application, the $\overline{\text{SHDN}}$ pin should be connected to Pin 5 to enable this device.

## 4. Operation

The AP3012 uses a constant frequency, current mode control scheme to provide excellent line and load regulation. The operation can be best understood by referring to Figure 2 and Figure 3. Each switching cycle can be divided into two time subintervals.

At the start of each switching cycle, the oscillator will reset the SR latch, which turns on the power switch Q1. The input voltage will be applied to the boost inductor L1 and the current through this inductor and the switch will increase linearly. The voltage is added to a stabilizing ramp and the resulting sum is fed into the positive terminal of comparator A2. When this voltage exceeds the level at the negative input of A2, the output of A2 is changed and the SR latch is reset to turn off the switch. In this time subinterval, the output energy is provided by the output capacitor and the output voltage drops slightly.

After the switch turns off, the inductor provide current to the white LEDs and charge output capacitor. The current through the inductor is decreased linearly since the diode is on and a negative voltage applies to this inductor. The switch will turn on until the oscillator reset the SR latch again. The oscillator frequency is set at 1.5MHz at normal conditions.

It is clear that the level at negative input of A2 sets the peak current level to keep the output in regulation. This voltage level is the output signal of A1. A1 is a simple error amplifier, and the positive input of A1 is a reference voltage of 1.25V; the negative input of A1 is the feedback voltage. In other words, the peak current level through switch is determined by the feedback voltage. So a constant output current can be provided by this operation mode.

To achieve a higher efficiency with light load, the device will enter a pulse skipping state. At this state, the device operates at a low frequency and discontinuous current mode (DCM).

## 5. Components Selection

**Inductor Selection**

To obtain stable output current and greater current capability, the 22µH inductor manufactured by SUMIDA is recommended.

**Diode Selection**

For this typical application, a low forward voltage drop and fast reverse recovery diode is suggested to achieve higher efficiency and reliable stability. Besides, the diode capacitance is an important factor when choosing the diode. Considering the higher frequency, the smaller the capacitance, the higher the efficiency. For this application, a schottky diode rated at 100mA to 200mA is sufficient.

**Capacitor Selection**

The small size of ceramic capacitors makes them ideal in this application. Compared with other types of capacitors, X5R and X7R types feature wider voltage and temperature ranges. So, ceramic capacitors are recommended. Considering the operation frequency is 1.5MHz, a 1µF input capacitor and 1µF output capacitor are acceptable.

**Resistor Selection**

In order to obtain an accurate output voltage, a precision resistor is preferred. The correlation between the values of R1 and R2 should be chosen applying the following equation.

$$R2 = R1 \times V_{ref} / (V_o - V_{ref})$$

## 6. Application Hints

**Over Voltage Protection**

The output voltage should be less than 29V at any case; otherwise, the device will be shut down by the OVP function. In the case of the feedback voltage going to zero, when the feedback resistor R2 is shorted or R1 is opened, this circuit will operate at maximum duty, which may cause the output voltage to reach the same level as at the OVP voltage. At that time, the device will enter shut down mode. So, the output voltage will not reach a destructive voltage.

**Current limit**

AP3012 has an internal switch current limit. Figure 4 shows the relationship between the current limit and the duty cycle. In a boost circuit, when the input voltage and the output voltage are fixed, the duty cycle is also fixed in continuous current mode. So the current limit can be calculated at this duty cycle from Figure 4. The switch peak current should not surpass the current limit; otherwise, the output voltage will decrease.

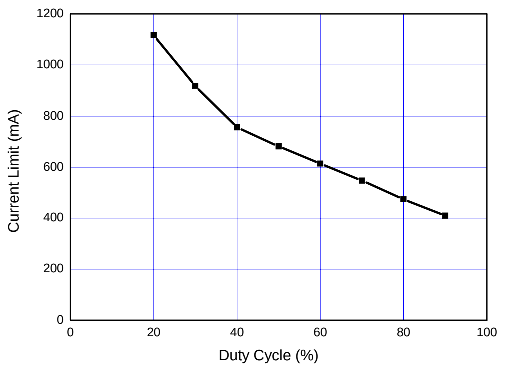


Figure 4. Current Limit vs. Duty Cycle

**Soft Start**

The AP3012 has an internal soft start circuit to limit the inrush current during startup. The time of startup is determined by the internal soft start capacitor.

Figure 5 shows the start up current waveform for the circuit in Figure 3. The inrush current is limited by the built-in soft start function of the AP3012.

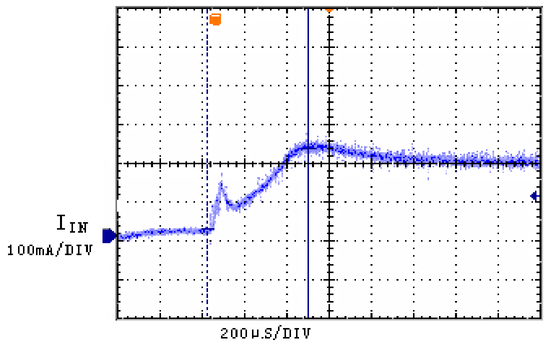


Figure 5. Input Current Diagram