

### General Description

The KA2708 is a step-up DC/DC converter specifically designed for driving white LEDs with a constant current. The internal MOSFET can support up to 10 White LEDs for backlighting and OLED power application, and the internal soft start function can reduce the inrush current. The KA2708 uses current mode, fixed frequency of approximately 1.0MHz architecture to regulate the LED current through an external current sense resistor. The low feedback voltage of 300mV can minimize power dissipation.

Other features include current limit protection, thermal shutdown protection, under-voltage lockout (UVLO), and over-voltage function.

The KA2708 is available in space saving SOT-23-6L packages.

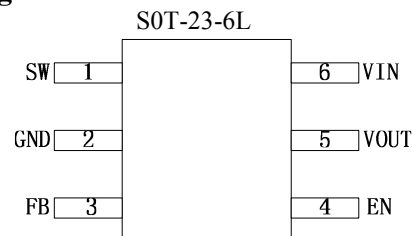
### Applications

Cellular Phones and Digital Cameras  
PDAs and Smart Phones and MP3 and OLED  
Portable Instruments  
LCD Display Power  
High-light LED Flash

### Features

VIN Operating Range : 2.5V to 5.5V  
Internal Power N-MOSFET Switch  
Wide Range for PWM Dimming (100Hz to 200kHz)  
1.0MHz Switch Frequency  
300mV Feedback Voltage  
1.2A SW Current Limit  
Minimize the External Component Counts  
Internal Compensation  
Over Voltage Protection

### Package



### Typical Application Circuit

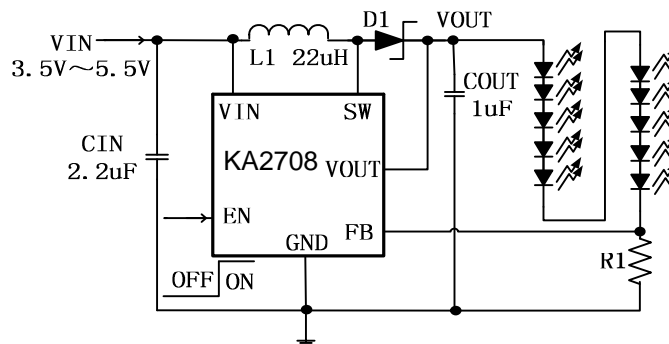


Figure 1. Basic Application Circuit with KA2708

Pin No.	Pin Name	Pin Function
SOT-23-6L		
1	SW	Switching Pin.
2	GND	Ground Pin. The exposed pad must be soldered to a large PCB and connected to GND for maximum power dissipation.
3	FB	Feedback Pin. Feedback voltage is 0.3V.
4	EN	Chip Enable(Active High).
5	VOUT	Output Voltage Pin.
6	VIN	Input Supply.

### Function Block Diagram

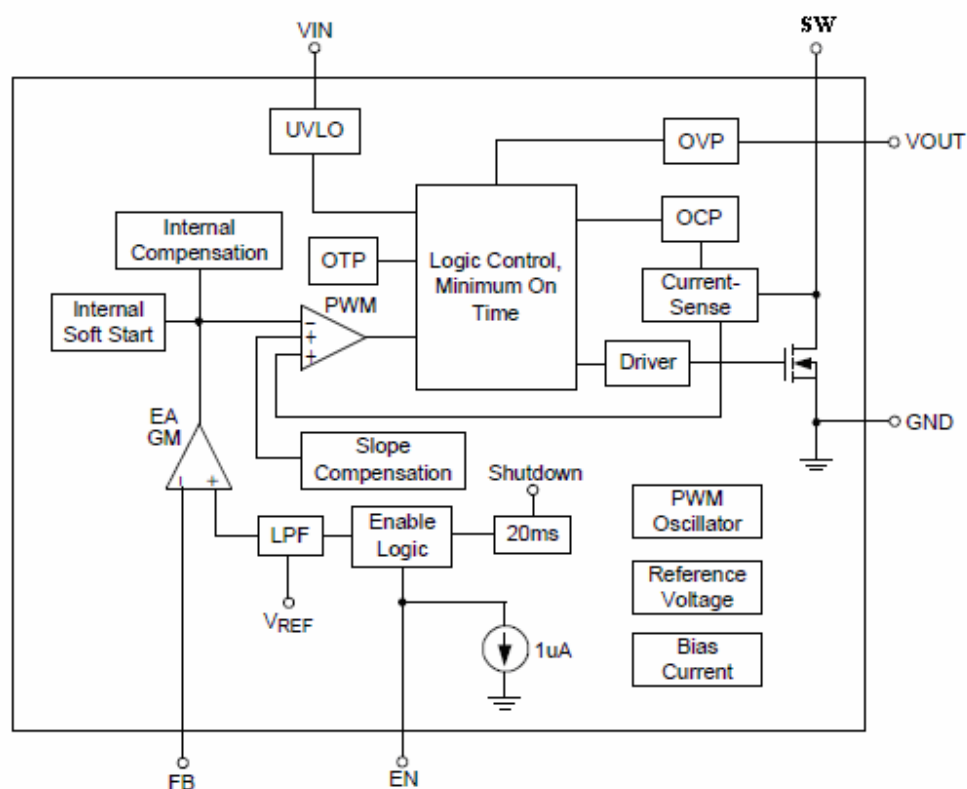


Figure 2 Function Block Diagram

**Absolute Maximum Ratings** (Note 1)

Supply Input Voltage, VIN	-----	-0.3V to 6V
Switching Pin, SW	-----	-0.3V to 40V
VOUT	-----	-0.3V to 40V
Other Pins	-----	-0.3V to 6V
Power Dissipation, PD @ TA = 25°C		
SOT-23-6L	-----	0.392W
Package Thermal Resistance (Note 3)		
SOT-23-6L, $\theta_{JA}$	-----	255°C/W
Lead Temperature (Soldering, 10 sec.)	-----	260°C
Junction Temperature	-----	150°C
Storage Temperature Range	-----	-65°C to 150°C

**Recommended Operating Conditions** (Note 2)

Junction Temperature Range	-----	-40°C to 125°C
Ambient Temperature Range	-----	-40°C to 85°C

**Electrical Characteristics**

Parameter	Conditions	Min	Typ	Max	Unit
Input Voltage		2.5		5.5	V
Feedback Reference Voltage	10 LEDs ILED=20mA	285	300	315	mV
Under Voltage Lock Out		2	2.2	2.45	V
UVLO Hysteresis			0.1		V
Line Regulation	VIN=2.5~5.5V, VOUT=12V, IOUT=20mA		1		%
Load Regulation	VIN=3.3V, VOUT=12V IOUT=0~20mA		1		%
Feedback Current	VFB=0.1		-300		nA
Supply Current	VFB=0.1V (switching)		1.2	2	mA
	VFB=0.4V (No switching)		400	600	μA
	VEN=0V		4		μA
Operation Frequency		0.75	1.0	1.25	MHz
Maximum Duty Cycle		90	92		%
SW Current Limit			1.2		A
On Resistance			0.7	1.2	?
Switch Leakage Current	VEN=0V VSW=5V		0.1	1	μA
EN High Voltage		1.4			V
EN Low Voltage				0.4	V
Dimming Frequency		0.1		50	KHz
Over-Voltage Threshold		34	36	38	V
OTP			160		°C

OTP Hysteresis			10		°C
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**Note 1.** Stresses listed as the above “Absolute Maximum Ratings” may cause permanent damage to the device. These are for stress ratings. Functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may remain possibility to affect device reliability.

**Note 2.** The device is not guaranteed to function outside its operating conditions.

**Note 3.**  $\theta_{JA}$  is measured in the natural convection at  $T_A = 25^{\circ}\text{C}$  on a low effective single layer thermal conductivity test board of JEDEC 51-3 thermal measurement standard. The case point of  $\theta_{JC}$  is on the expose pad for the W DFN package.

## Ordering Information

Pd-Free Package	Temperature	Order Part Number	Quantity/Reel	Marking
SOT23-6	$-40^{\circ}\text{C}$ to $85^{\circ}\text{C}$	KA2708 (OVP=36V)	3000PCS	In kind, whichever

## Applications Information

### LED Current Setting

The loop of Boost structure will keep the FB pin voltage equal to the reference voltage VREF. Therefore, when RSET connects FB pin and GND, the current flows from VOUT through LED and RSET to GND will be decided by the current on RSET, which is equal to following equation.

$$I_{LED} = \frac{V_{REF}}{R_{SET}}$$

### Dimming Control

#### a. Using a PWM Signal to EN Pin

For the brightness dimming control of the KA2708, the IC provides typically 300mV feedback voltage when the EN pin is pulled constantly high. However, EN pin allows a PWM signal to reduce this regulation voltage by changing the PWM duty cycle to achieve LED brightness dimming control. The relationship between the duty cycle and FB voltage can be calculated as following equation.

$$V_{FB} = \text{Duty} \times 300\text{mV}$$

Where

Duty = duty cycle of the PWM signal

300mV = internal reference voltage

used to cut the internal 300mV reference voltage. An internal low pass filter is used to filter the pulse signal. And then the reference voltage can be made by connecting the output of the filter to the error amplifier for the FB pin voltage regulation.

However, the internal low pass filter 3db frequency is 500Hz. When the dimming frequency is lower than 500Hz, VA is also a PWM signal and the LED current is controlled directly by this signal. When the frequency is higher than 500Hz, PWM is filtered by the internal low pass filter and the VA approach a DC signal. And the LED current is a DC current which eliminate the audio noise.

But there is an offset in error amplifier which will cause the VA variation. In low PWM duty signal situation, the filtered reference voltage is low and the offset can cause bigger variation of the output current. For the KA2708, the minimum duty vs frequency is listed in following table.

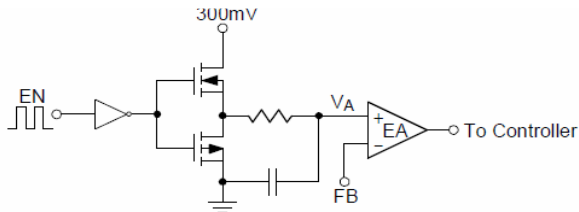


Figure 3 Block Diagram of Programmable FB Voltage Using PWM Signal

### b. Using a DC Voltage

Using a variable DC voltage to adjust the brightness is a popular method in some applications. The dimming control using a DC voltage circuit is shown in Figure 4. As the DC voltage increases, the current flows through R3 increasingly and the voltage drop on R3 increase, i.e. the LED current decreases. For example, if the V<sub>DC</sub> range is from 0V to 2.8V and V<sub>REF</sub> is equal to 0.3V, the selection of resistors in Figure 4 sets the LED current from 21mA to 0mA. The LED current can be calculated by the following equation.

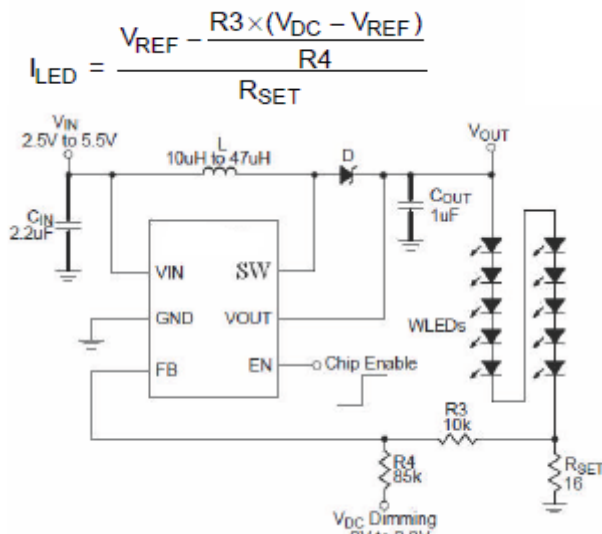


Figure 4 Dimming Control Using a DC Voltage

### c. Using a Filtered PWM signal

Another common application is using a filtered PWM signal as an adjustable DC voltage for LED dimming control. A filtered PWM signal acts as the DC voltage to regulate the output current. The recommended application circuit is shown as Figure 14. In this circuit, the output ripple depends on the frequency of PWM signal. For smaller output voltage ripple (<100mV), the recommended frequency of 2.8V PWM signal should be above 2 kHz. To fix the frequency of PWM signal and change the duty cycle of PWM signal can get different output current. The LED current can be

calculated by the following equation.

$$I_{LED} = \frac{V_{REF} - \frac{R3 \times (V_{PWM} \times Duty - V_{REF})}{R4 + R_{DC}}}{R_{SET}}$$

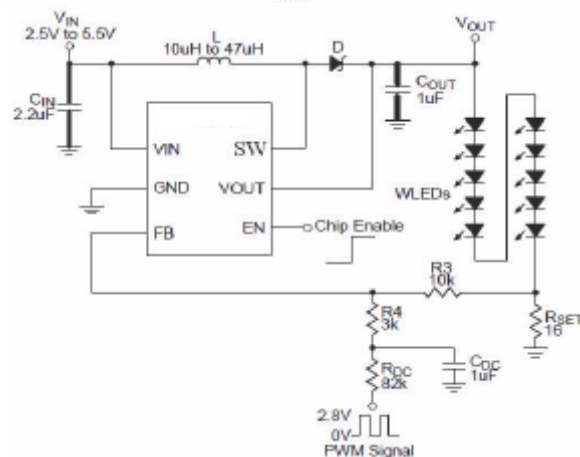


Figure 5 Dimming Control Using a Filtered PWM Signal

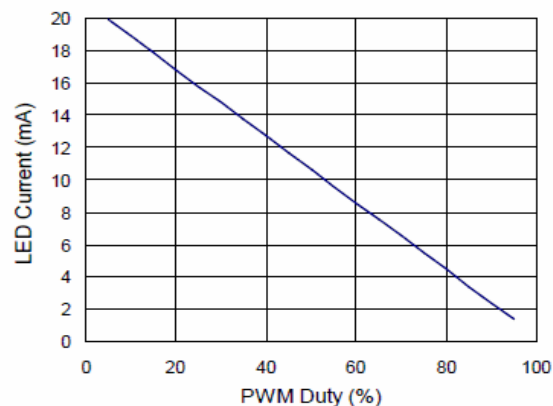


Figure 6 PWM Duty Cycle vs LED Current

By the above equation and the application circuit shown in Figure 5. Figure 6 shows the relationship between the LED current and PWM duty cycle. For example, when the PWM duty is equal to 60%, the LED current will be equal to 8.6mA. When the PWM duty is equal to 40%, the LED current will be equal to 12.7mA.

### Power Sequence

In order to assure the normal soft start function for suppressing the inrush current the input voltage should be ready before EN pulls high.

### Soft-Start

The function of soft-start is made for suppressing the inrush

current to an acceptable value at the beginning of power-on. The KA2708 provides a built-in soft-start function by clamping the output voltage of error amplifier so that the duty cycle of the PWM will be increased gradually in the soft-start period.

### Current Limiting

The current flow through inductor as charging period is detected by a current sensing circuit. As the value comes across the current limiting threshold, the N-MOSFET will be turned off so that the inductor will be forced to leave charging stage and enter discharging stage. Therefore, the inductor current will not increase over the current limiting threshold.

### OVP/UVLO/OTP

The Over Voltage Protection is detected by a junction breakdown detecting circuit. Once VOUT goes over the detecting voltage, LX pin stops switching and the power N-MOSFET will be turned off. Then, the VOUT will be clamped to be near VOVP. As the output voltage is higher than a specified value or input voltage is lower than a specified value, the chip will enter protection mode to prevent abnormal function. As the die temperature is higher than 160°C, the chip also will enter protection mode. The power MOSFET will be turned off during protection mode to prevent abnormal operation.

### Capacitor Selection

Input ceramic capacitor of 2.2uF and output ceramic capacitor of 1uF are recommended for the KA2708 applications for driving 10 series WLEDs. For better voltage filtering, ceramic capacitors with low ESR are recommended. X5R and X7R types are suitable because of their wider voltage and temperature ranges.

### Inductor Selection

The recommended value of inductor for 10 WLEDs applications is from 10uH to 47uH. Small size and better efficiency are the major concerns for portable devices, such as the KA2708 used for mobile phone. The inductor should have low core loss at 1.0MHz and low DCR for better efficiency. The inductor saturation current rating should be considered to cover the inductor peak current.

### Thermal Considerations

For continuous operation, do not exceed absolute maximum operation junction temperature. The maximum power dissipation depends on the thermal resistance of IC package, PCB layout, the rate of surroundings airflow and temperature difference between junction to ambient. The maximum power dissipation can be calculated by following formula :

$$P_{D(MAX)} = (T_{J(MAX)} - T_A) / \theta_{JA}$$

Where  $T_{J(MAX)}$  is the maximum operation junction temperature,  $T_A$  is the ambient temperature and the  $\theta_{JA}$  is the junction to ambient thermal resistance.

For the recommended operating conditions specification of KA2708, the maximum junction temperature of the die is 125°C. The junction to ambient thermal resistance  $\theta_{JA}$  is layout dependent. The junction to ambient thermal resistance for SOT-23-6L package is 255°C/W and on the standard JEDEC 51-3 single layer thermal test board. The maximum power dissipation at  $T_A = 25^\circ\text{C}$  can be calculated by following formula :

$$P_{D(MAX)} = (125^\circ\text{C} - 25^\circ\text{C}) / (255^\circ\text{C/W}) = 0.392\text{W for SOT-23-6L packages}$$

The maximum power dissipation depends on operating ambient temperature for fixed  $T_{J(MAX)}$  and thermal resistance  $\theta_{JA}$ . For KA2708 packages, the Figure 2 of derating curves allows the designer to see the effect of rising ambient temperature on the maximum power allowed.

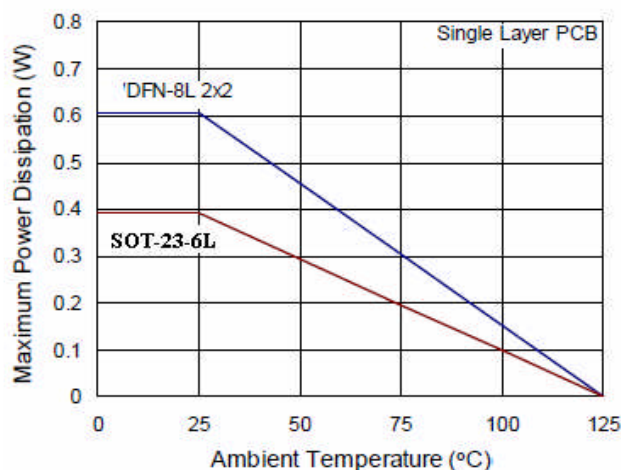


Figure 7 Derating Curves for KA2708 Packages

### Layout Consideration

For best performance of the KA2708, the following guidelines must be strictly followed.

Input and Output capacitors should be placed close to

the IC and connected to ground plane to reduce noise coupling.

The GND and Exposed Pad should be connected to a strong ground plane for heat sinking and noise protection.

Keep the main current traces as possible as short and wide.

SW node of DC-DC converter is with high frequency voltage swing. It should be kept at a small area.

Place the feedback components as close as possible to the IC and keep away from the noisy devices.

### Typical Application Circuits

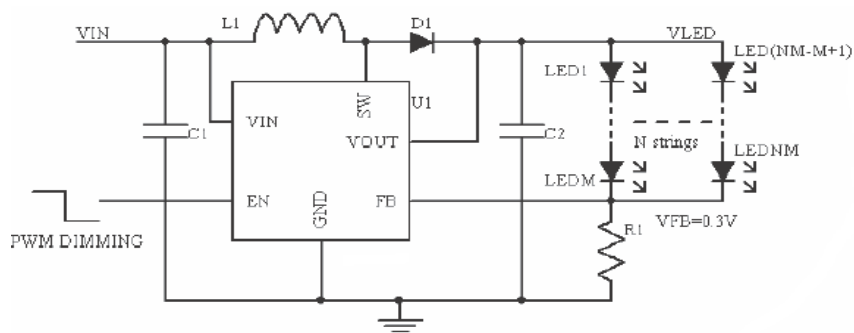


Figure 8 LED Backlighting

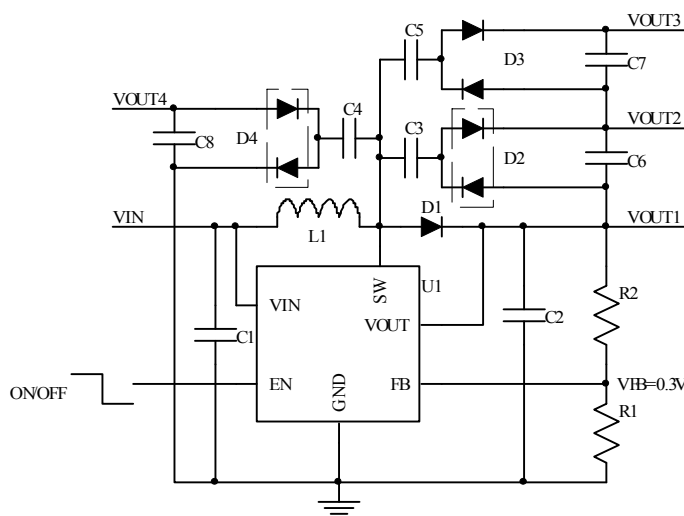


Figure 9 LCD Display Power

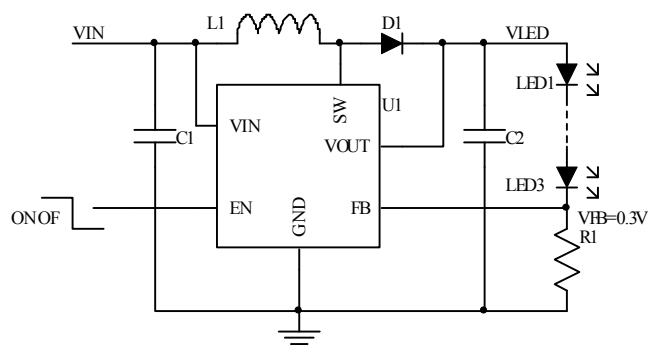


Figure 10 High-light LED Flash

### Package Information

