White LED Driver

General Description

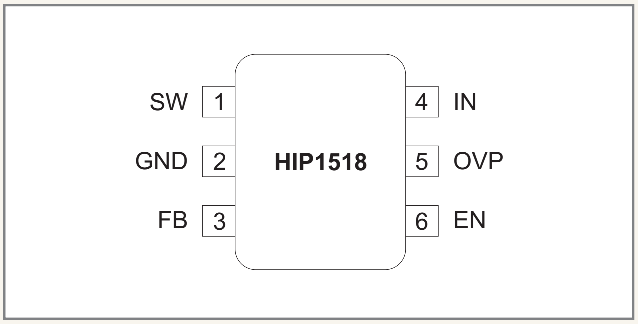
The HIP1518 is a step up converter designed for driving up to 6 white LEDs in series from a single cell Lithium Ion battery. The HIP1518 uses the current mode, fixed frequency architecture to regulate the LED current, which is measured through an external current sense resistor. Its low 110mV feedback voltage reduces the power loss and improves the efficiency. The OVP pin monitors the output voltage and turns off the converter if an over-voltage condition is present due to an open circuit condition.

The HIP1518 includes under-voltage lockout, current limiting and thermal overload protection to prevent the circuitry, working inside, from malfunctioning and being damaged due to unusual phenomena. The HIP1518 is available in small 6-pin SOT23-6 package.

Applications

- Cell phones
- Hand-held computers and PDAs
- Digital cameras
- Small LCD displays

Pin Assignment



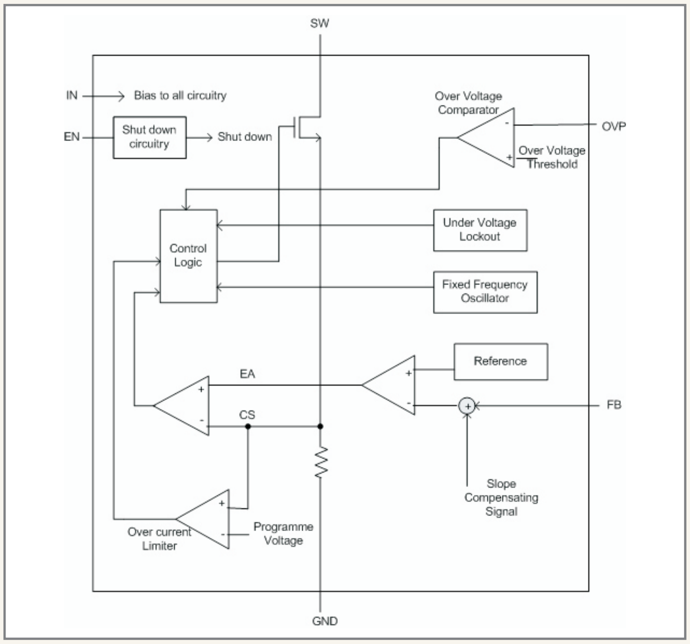
Pin Description

Name	Pin	Type	Function
SW	1	Switch	Connects inductor between SW and IN
GND	2	Ground	Ground pin
FB	3	Feedback	Adjustable feedback input, connects to resistor voltage divider
EN	4	Enable input	EN = High: normal operation (Supports both TTL and CMOS logic)
OVP	5	Over voltage input	Measures the output voltage for over voltage protection
IN	6	Battery input	Boost regulator input

Features

- On board power MOSFET
- Drives up to 6 white LEDs in series
- Up to 87% efficiency
- Over 600KHz / 1MHz fixed switching frequency
- Open load shutdown
- Low 110mV feedback voltage
- Soft start / PWM dimming
- UVLO, thermal shutdown
- Internal current limit
- Available in SOT23-6 and QFN-8 package

Block Diagram



Absolute Maximum Ratings*

DC Voltage at Pin 1 ....-0.5 to +28.0V
Enable Input Voltage at Pin 4 ....-0.3 to +6.0V
Continuous Power Dissipation ....Internally limited
Storage Temperature Range ....-65 to +150°C
Thermal Resistance, Junction-To-Air ....+235°C/W
Operating Junction Temperature ....-40 to +125°C
Lead Temperature (Soldering, 5sec) ....+260°C
ESD Capability, HBM model ....+2.0KV

Recommended Operating Conditions

Symbol	Parameter	Value	Unit
V_{IN}	DC Supply Voltage at Pin 6	+2.5 to +6.0	V
V_{EN}	Enable Input Voltage at Pin 4	0 to V_{IN}	V
T_J	Operating Junction Temperature	-40 to +125	C

Electrical Characteristics

(All specifications are at T_A = +25°C. V_{IN} = 5.0V, unless otherwise specified.)

Symbol	Parameter	Test Condition	Min	Typ	Max	Units
V_{IN}	Operating Input Voltage		2.5		6.0	V
UVLO	Under Voltage Lockout		2.02	2.13	2.24	V
	UVLO Hysteresis			50		mV
V_{OUTMAX}	Maximum Output Voltage			25		V
I_G	Supply Current (Quiescent)	No switching (V_{IN} = 5.0V, V_{FB} = 125mV)		162	230	μA
		Continuously switching (V_{IN} = 5.0V)		946	1330	μA
I_{SH}	Supply Current (Shut-down)	V_{EN} = 0		0.006	1	μA
F_{OSC}	Operation Frequency		0.47	0.78	1.1	MHz
D_{MAX}	Maximum Duty Cycle		80	85	90	%
V_{FB}	Feedback Voltage		99	110	120	mV
	Feedback Input Bias Current	V_{FB} = 125mV		-12		nA
$R_{DS(ON)}$	MOSFET ON Resistance			0.8		Ω
I_{LIM}	Current Limit		430	650	975	mA
V_{EN}	Enable Threshold	Turn ON	0.95			V
		Turn OFF			0.35	V
I_{EN}	Enable Input Bias Current	V_{EN} = 0, 5.0V			1	μA
	Thermal Shut-down			160		°C
V_{OV}	Over Voltage	V_{OV} rising		26		V

Operation Description

The HIP1518 is a high efficiency, fixed frequency, peak current mode boost regulator. It has the architecture to regulate the voltage at the feedback pin, so that a regulated fixed current is achieved to drive white LEDs. The power MOS is turned ON through the control circuitry, at the start of each oscillator cycle and thus the charging phase is initiated. The error amplifier, consisting of a voltage comparator and current sense amplifier, is basically, a PWM comparator. The voltage comparator, amplifies the difference between the reference and feed back voltage. When the output of the current sense amplifier, reaches the output of the voltage comparator, the POWER MOS is turned OFF and thus the charging phase is terminated. To prevent sub-harmonic oscillations at duty cycles greater than 50 percent, a stabilizing ramp is added to the current sense signal. In this way the peak current level keeps the output in regulation. The HIP1518 has internal soft start mechanism, to limit the inrush current at startup and to limit the amount of overshoot on the output, also. An internal blanking time is provided during start up, to prevent the start of switching before all the circuitry become ready for operation. The current limit is increased by a fourth every 60μs giving a total soft start time of 240μS.

Setting the LED current

The LED current can be set, according to the requirement, by feedback resistor, R1. The current through the LEDs is selected by the following equation:

$$I_{LED} = 110\,mV/R1$$

Current Limit

The HIP1518 includes a pulse-by-pulse current limiter. It monitors the peak current through the inductor and controls the gate of the power device.

Enable Input

The HIP1518 features an active-high Enable input (EN) pin that allows on/off control of the regulator. The HIP1518 bias current reduces to less than microampere when the it is shutdown. The output remains at a schottky forward voltage lower than the SW pin, if a schottky diode is connected between SW and OV pin, at shut. The Enable input is TTL/CMOS compatible.

Under Voltage Lockout

When the input supply goes too low (below 2.3V), the HIP1518 produces an internal UVLO (Under Voltage Lockout) signal that generates a fault signal and shuts down the chip. This mechanism protects the chip from producing false logic due to low input supply.

Thermal Overload Protection

Thermal-overload protection limits total power dissipation in the HIP1518. When the junction temperature exceeds $T_J = +160°C$, the thermal sensor signals the shutdown logic and turning off most of the internal circuitry. The thermal sensor turns internal circuitry on again after the IC's junction temperature drops by 20°C. The regulator then starts functioning in the required mode based on the supply voltage.

Thermal-Overload protection is designed to protect the HIP1518 in the event of a fault condition. For continual operation, do not exceed the absolute maximum junction temperature rating of $T_J = +150°C$.

Open Load Protection

Open load protection in HIP1518, protects the chip from destruction, due to excessive high voltage. When, in any case, one or more LEDs in the LED string fails, the feedback pin is pulled down to zero. As a result, the chip runs at maximum duty cycle, boosting the output voltage higher and higher. The open load protection mechanism, checks this condition, if OV pin is tied to the top of the LED string. If the output voltage exceeds the OV threshold (28V) and persists there for a certain span of time (15μS) (Fig - open load protection), the switching stops, allowing the output to discharge. The open load protection mechanism includes a hysteretic comparator. The switching is enabled again, when the output voltage has fallen to a certain level. Because the chip doesn't turn OFF fully, no power recycling is necessary, when this condition takes place. But it's highly recommended, not to use the chip in that mode of operation for longer span of time.

Dimming Control

LED is a current driven device. Hence, current through the LED needs to be controlled to have dimming control. Different ways are there to control dimming for PS0020, in the normal mode of operation. In the first way, the feedback voltage is controlled using an external voltage source. As shown in the figure-A, current starts flowing down R1, R2 and R3, as the external voltage increases. The loop will continue to regulate the feedback voltage to 110mV, and as a result, the current through the LEDs has to decrease as the same amount of that being injected from the external source. With the external voltage from 0 to 2V, the resistor values shown for R2 and R3 can control LED current from 0 to 20mA.

Dimming can also be achieved using logic signal to EN pin. As shown in Figure-B, the PWM signal can be applied to the EN pin of PS0020. The LEDs will switch between full load to completely shut down state. The average current through the LEDs will be proportional to the duty cycle of PWM. The PWM signal in figure-B, should be of 1 KHz or less , because of the presence of the soft-start mechanism.

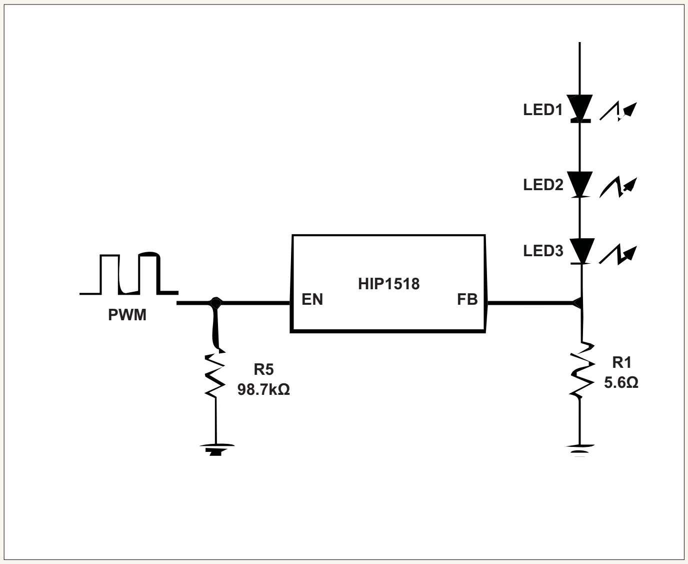


Figure-B: PWM dimming control using Logic signal

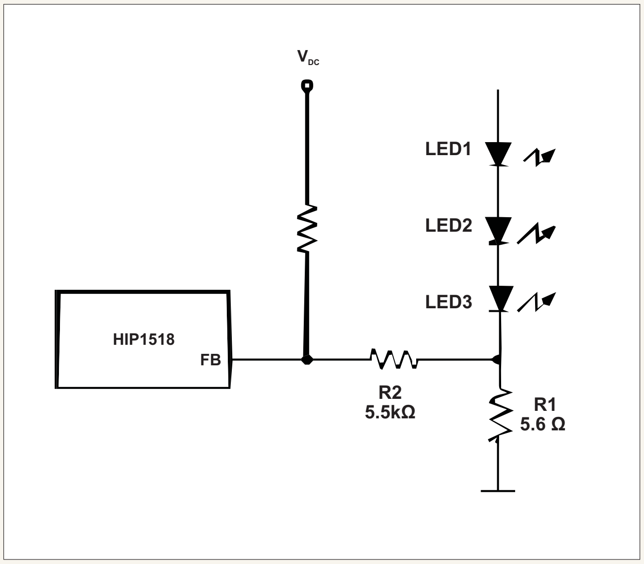


Figure-A : Dimming control using a DC voltage

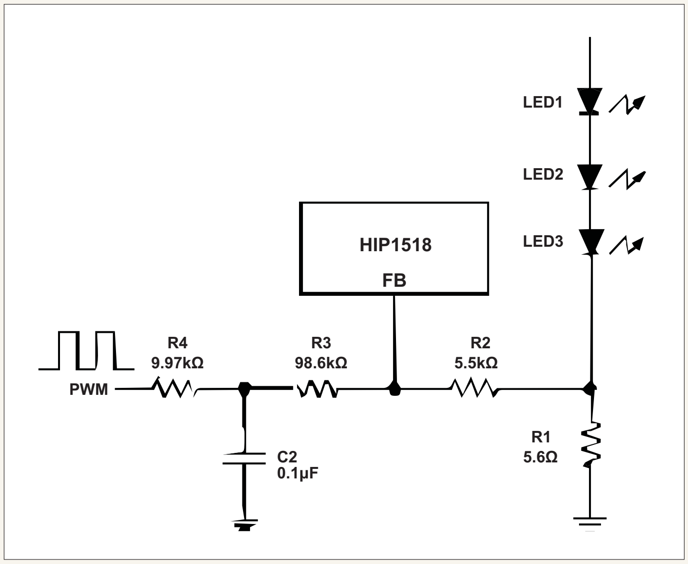


Figure-C: Dimming control using a filtered PWM signal

Typical Operating Characterstics

(All specifications are at T_A = +25°C, unless otherwise specified.)

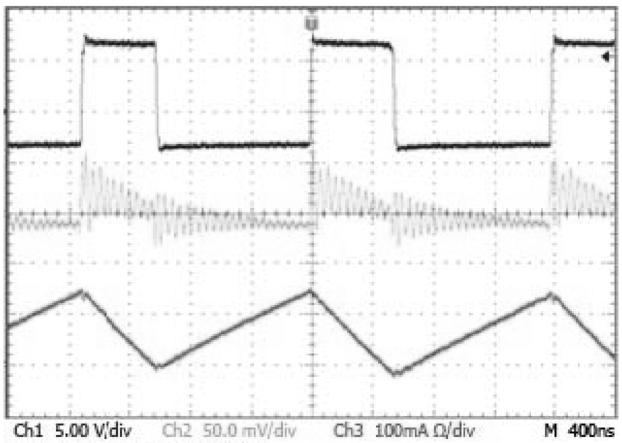


Fig : Steady-State Operation
VIN = 3.6V, 3 LEDs, 20mA
CH1 : V(SW), CH2: V(OV), AC coupled .CH3 : I(INDUCTOR), input current

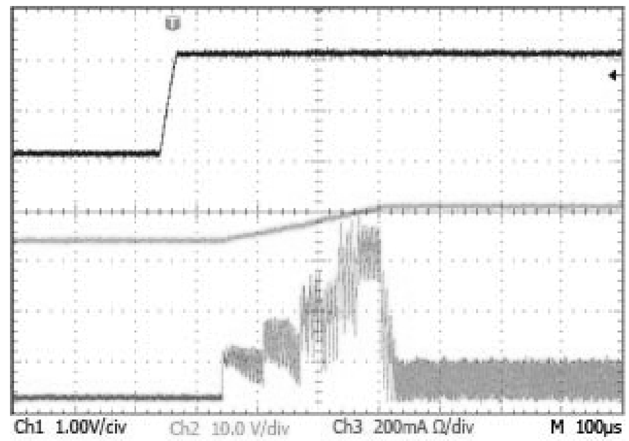


Fig: Startup Waveforms
VIN= 3.6V, 3 LEDs, 20mA,CH1: V(EN)
CH2: V(OV), DC coupled CH3: I(INDUCTOR), input current

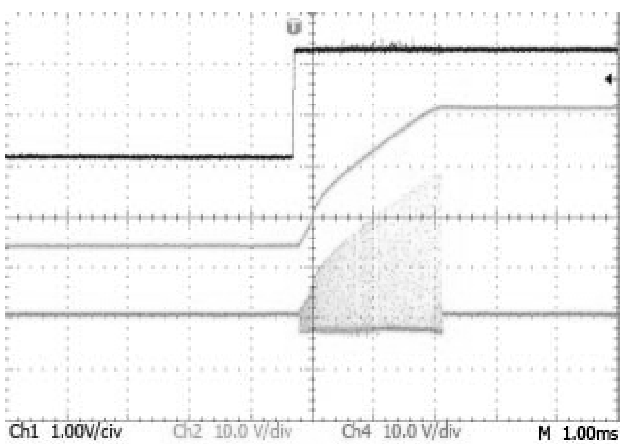


Fig: Startup Waveforms into an Open Load
VIN = 3.6V, CH1: V(EN)
CH2: V(OV), DC coupled, CH4: V(SW)

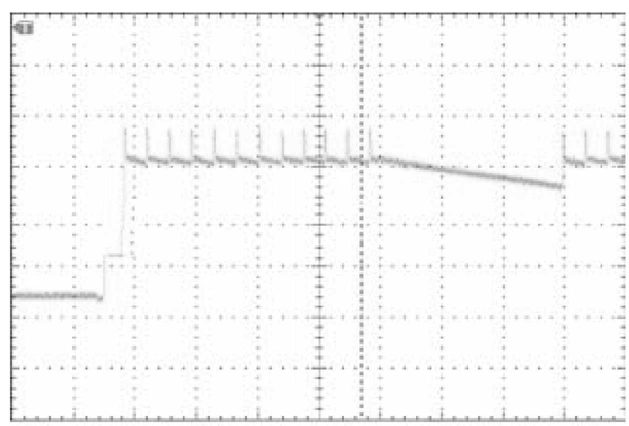


Fig: Open Load Protection
CH2 : V(OV) (10V/DIV)
X-Axis : TIME (4 uS/ DIV)