Low Start-up Synchronous Boost Converter

Features
- **94% Efficiency**
- **Device Quiescent Current: 28μA (Typ)**
- **0.9V Low Start-up Input Voltage**
- **Adjustable Output Voltage Range Up to 5.5V**
- **1.2MHz Switching Frequency**
- **Deliver 100mA at 3.3V from Single Cell 1.2V input**
- **Power Save Mode for Efficiency Improvement at Low Output Power**
- **Load Disconnection During Shutdown**
- **Thin SOT-23-6 Package**

Applications
- **All One-Cell, Two-Cell, and Three-Cell Alkaline, NiCd or NiMH or Single-Cell Li Battery-Powered Products**
- **Portable Devices**
- **Wireless Handsets**
- **Personal Medical Products**

General Description
The G5134 is a high efficiency, switch embedded boost converter with low start-up voltage. It features a current mode control for fast transient response without additional compensations. The low start up voltage makes it suitable for 1 to 3 cells battery applications. At low load currents, the converter applies power save mode to maintain high efficiency over a wide output power range. During shutdown, the load is completely disconnected from the battery.

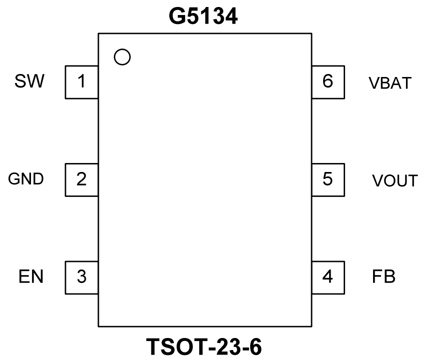
The G5134 is available in a TSOT-23-6 package.

Ordering Information

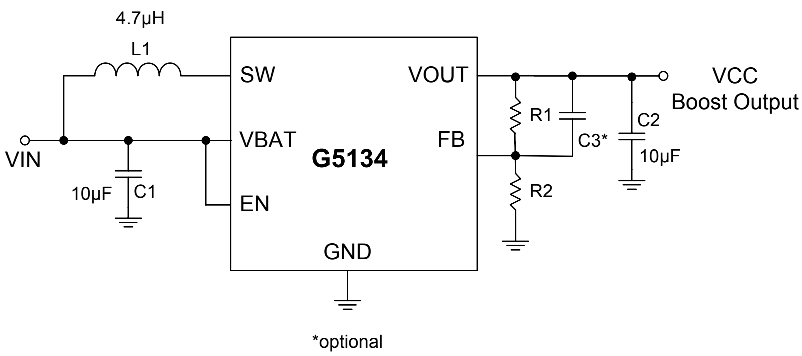
ORDER NUMBER	MARKING	TEMP. RANGE	PACKAGE (Green)
G5134TP1U	5134x	-40°C to +85°C	TSOT-23-6

Note: TP: TSOT23-6
1: Bonding Code
U: Tape & Reel

Pin Configuration



Typical Application



Absolute Maximum Ratings

SW, VOUT and VBAT to GND
. . . .-0.3V to +6V
EN and FB to GND . . . . -0.3V to VOUT+0.3V
Operating Temperature Range . . . . . .-40°C to 85°C

Junction Temperature . . . . .150°C
Storage Temperature Range . . . . . . -55°C to 150°C
Reflow Temperature (soldering, 10sec) . . . . .260°C

Stress beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device.

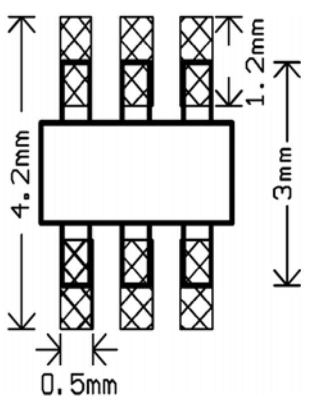
Electrical Characteristics

The device is not guaranteed outside its operating range. Parameters with MIN and/or MAX limits are 100% tested at 25°C unless otherwise noted.

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
DC/DC CONVERTER						
Minimum input range for oscillation	V_I		---	0.8	0.9	V
Minimum input range for startup		R_{OUT}=360Ω	---	0.9	1.1	
Input voltage range after startup			0.75	---	5.5	
Output voltage range	V_O		1.8	---	5.5	V
Feedback voltage	V_{FB}		490	500	510	mV
Error amplifier transconductance	G_M		---	45	---	µS
Oscillator frequency	F_{OSC}		960	1200	1440	kHz
Maximum duty	D_{MAX}		---	90	---	%
Switch current limit	I_{LIM}		700	850	1000	mA
PMOS switch on resistance	$R_{DS(ON)}$-P	V_{OUT}=3.3V, I_{SW}=500mA	---	250	---	mΩ
NMOS switch on resistance	$R_{DS(ON)}$-N	V_{OUT}=3.3V, I_{SW}=500mA	---	125	---	
Line regulation			---	1	---	%
Load regulation			---	1	---	%
Quiescent current (no switching)	I_Q	Io=0mA, V_{EN}=VBAT=1.2V VOUT=3.3V, T_A = 25°C (From VOUT)	---	28	---	µA
Shutdown Current	I_{OFF}	V_{EN}=0V, VBAT=1.2V, T_A = 25°C	---	---	0.5	µA
CONTROL STAGE						
Undervoltage lockout threshold	V_{UVLO}	VBAT falling	---	0.65	0.75	V
EN input low voltage	V_{IL}		---	---	0.3	V
EN input high voltage	V_{IH}	VBAT<1.2V	VBAT	---	---	V
		VBAT>=1.2V	1.2			
EN input current	I_{EN}	V_{EN}=GND or VBAT	---	---	0.1	µA
Overtemperature protection			---	145	---	°C
Overtemperature hysteresis			---	15	---	°C

Minimum Footprint PCB Layout Section

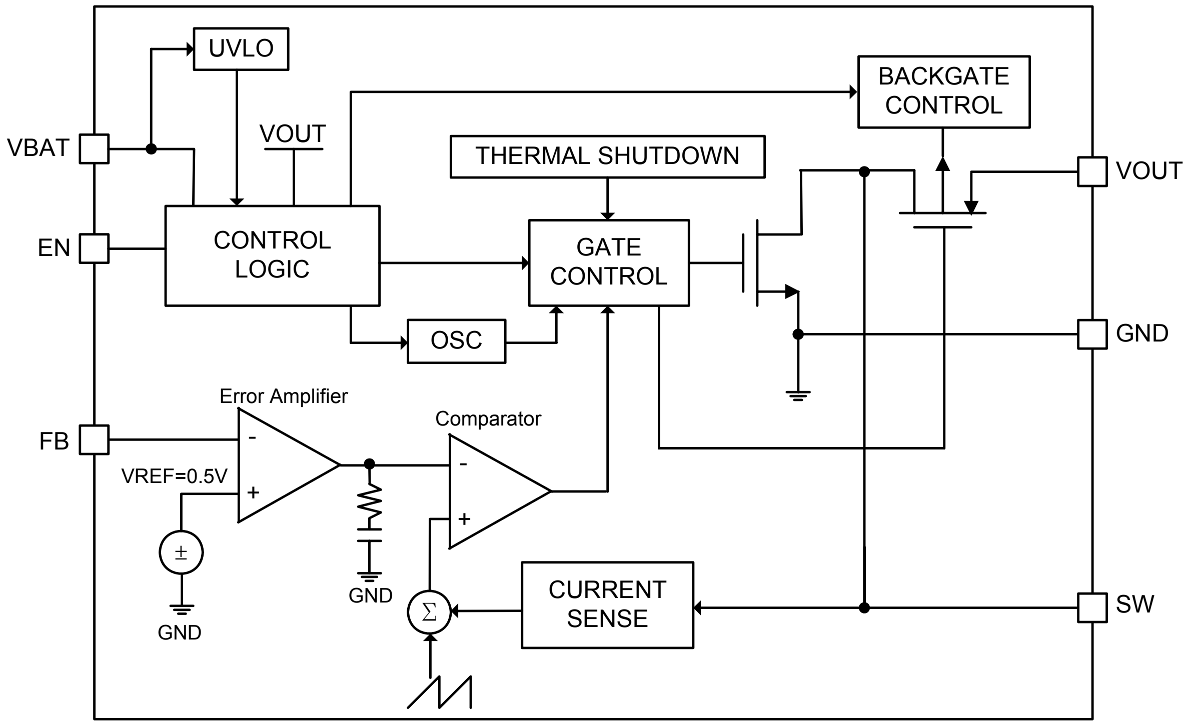
TSOT-23-6



Pin Descriptions

Number	NAME	DESCRIPTION
1	SW	Switch input pin, which is connected to the inductor
2	GND	Ground
3	EN	Chip enable pin, logic high for enable and logic low for disable.
4	FB	Voltage feedback input for programming output voltage
5	VOUT	Boost output voltage
6	VBAT	Supply voltage

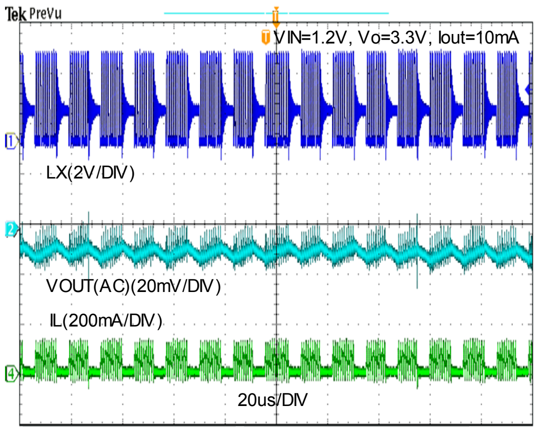
Block Diagram



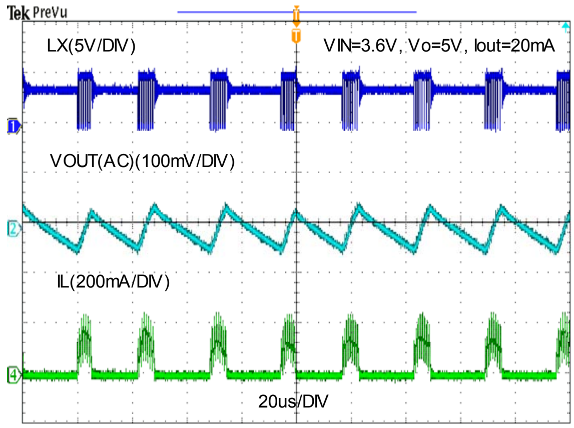
Typical Performance Characteristics

(Condition as Application Circuit, V_{IN}=1.2V, V_{OUT}=3.3V, T_A=25°C, unless otherwise noted.)

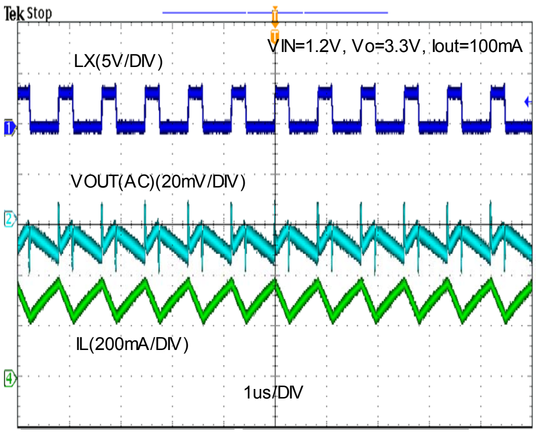
Output Voltage in Power-save mode



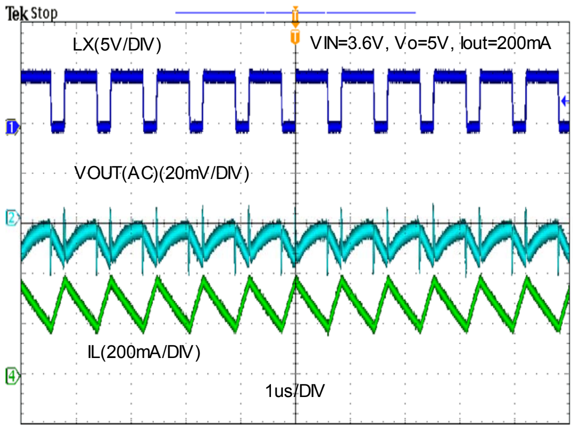
Output Voltage in Power-save mode



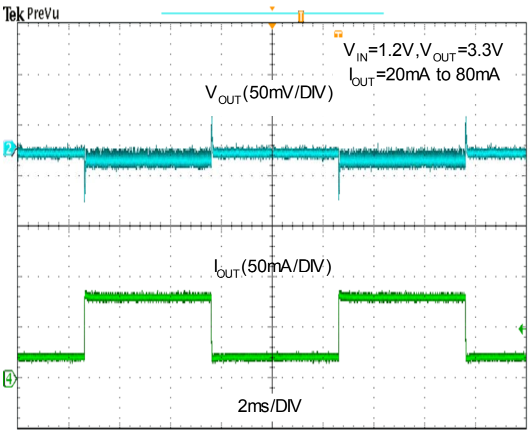
Output Voltage in Continuous mode



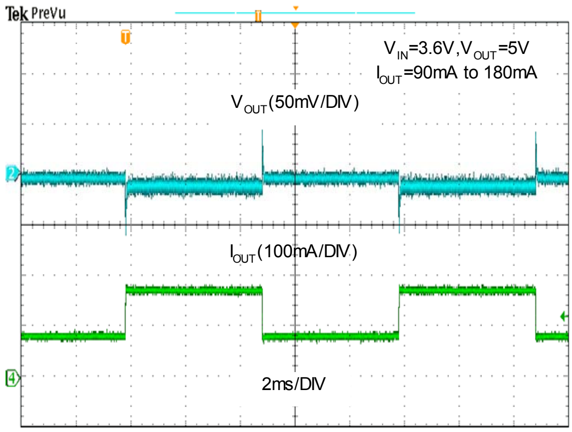
Output Voltage in Continuous mode



Load transient response

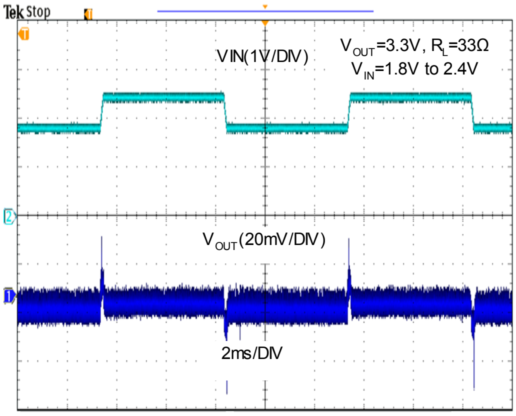


Load transient response

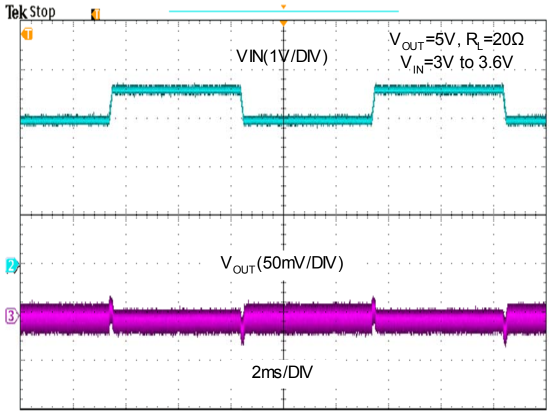


Electrical Characteristics (continued)

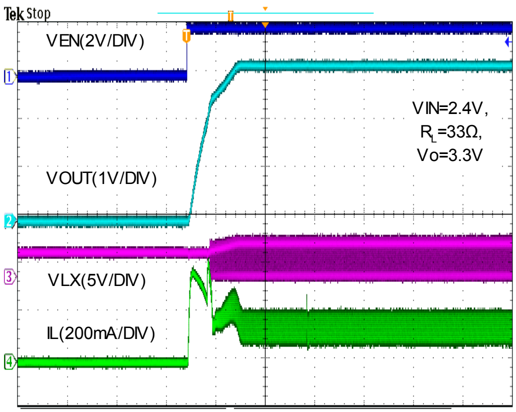
Line transient response



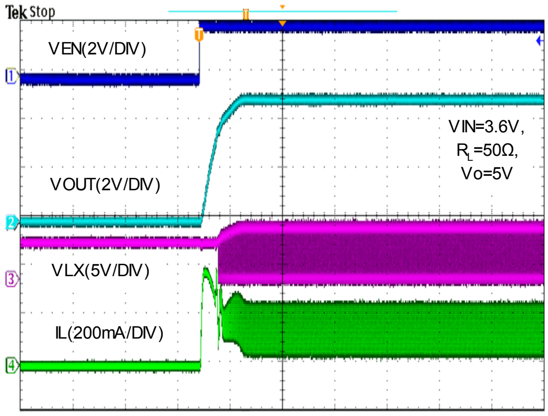
Line transient response



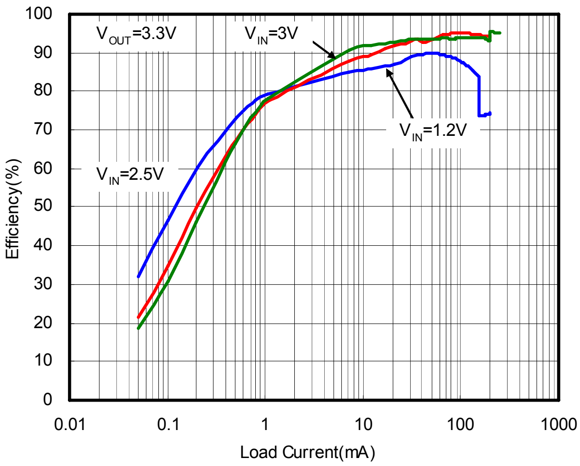
Start-up after Enable



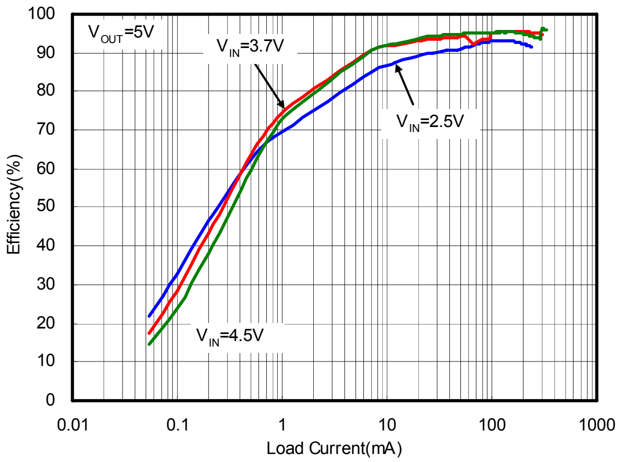
Start-up after Enable



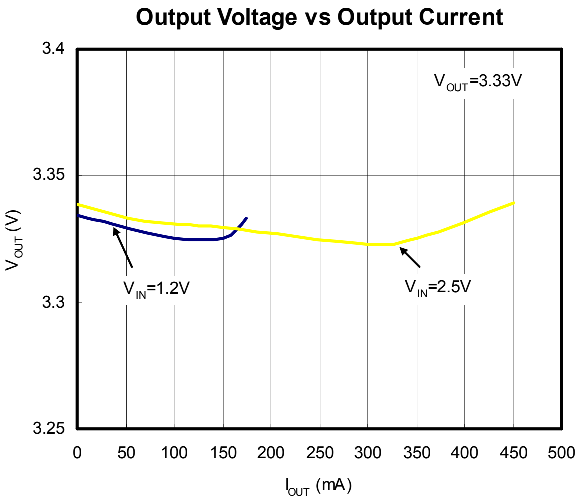
Efficiency vs Output Current

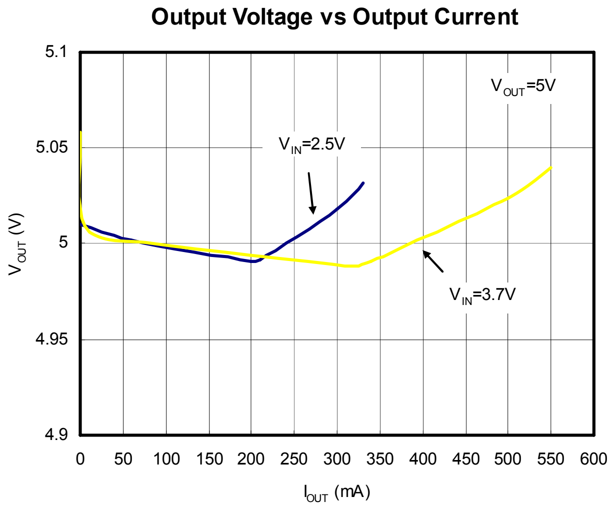


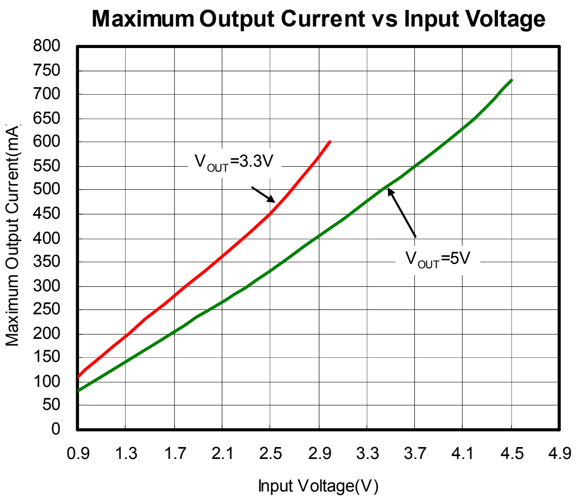
Efficiency vs Output Current



Electrical Characteristics (continued)







Function Description

Controller Circuit

The device is based on a current-mode control topology with a fixed frequency pulse-width-modulator. The controller senses the current during the boost switch on, limits the maximum current flowing through the inductor and generates the current control loop. The small signal error in output is determined by the error amplifier on the FB pin, it is compared with an internal reference voltage for regulation. The control loop is internally compensated. Therefore no additional R-C network is required.

Synchronous Rectifier

The device integrated an N-channel and a P-channel MOSFET to realize a synchronous rectifier. Because the commonly used Schottky diode is replaced with the internal PMOS switch, the power conversion efficiency reaches above 90%. A special function is applied to disconnect the direct path from the battery to the output during shutdown, which is realized by switching the bulk of the high-side PMOS. The benefit of this feature is that the battery is not depleted during shutdown, and therefore the battery life is extended.

Device Enable

The device is put into operation when EN is set high. It is put into shutdown when EN is set to GND. During shutdown, all internal circuitry is switched off, and the load is isolated from the input (as described in the ***Synchronous Rectifier Section***).

Undervoltage Lockout

In order to prevent the malfunctioning of the device, the undervoltage lockout function is applied if the supply voltage on VBAT is lower than approximately 0.8V. When in operations, the battery is being discharged, the device enters shutdown once the VBAT voltage drops below approximately 0.8V.

Startup Cycle

When the device enables, it enters the first step of the startup cycle, the precharge phase. During precharge, the high-side PMOS switch is turned on until the output capacitor is charged to a value close to the input voltage. After precharge, the device starts switching with a fixed frequency of 60% duty until the output voltage reaches 1.8V. Once the output reaches 1.8V, the error amplifier controls the loop. Therefore the output goes to its nominal value.

Power-Save Mode

The device enters power-save mode at loads for efficiency improvement. In power-save mode, the converter stops switching until the output voltage drops below a set threshold voltage. It ramps up the output voltage with several pulses, and returns to power-save mode once the output exceeds the set threshold.

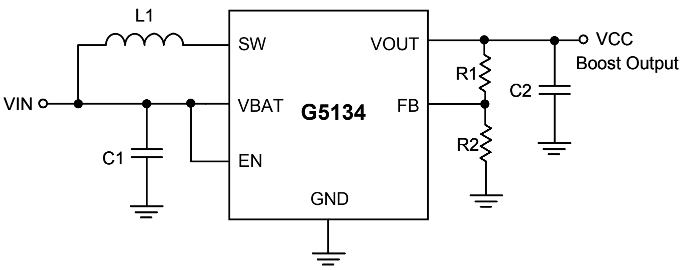
Applications Information

The G5134 boost converter is intended for systems powered by a single-cell, up to triple-cell alkaline, NiCd battery with a typical terminal voltage between 0.9V and 4.5V. It can also be used in systems powered by single-cell Li-ion or Li-polymer with a typical voltage between 2.5V and 4.2V. Additionally, a voltage source with a typical output voltage between 0.9V and 4.5V can power systems where the G5134 is used. Due to the nature of the boost converters, the output voltage regulation is maintained only if the applied input voltage is lower than it.

Programming the Output Voltage

The output voltage of the G5134 is adjusted with an external resistor divider. The typical value of the voltage at the FB pin is 500mV. The maximum recommended value for the output is 5.5V. The current through the resistive divider should be 100 times greater than the current in the FB pin. The typical current into the FB pin is 10nA, and the voltage across R2 is typically 500mV. Therefore the value for R2 is recommended lower than 500kΩ, in order to set the current flows the divider higher than 1μA. From that, the value of R1, depending on the needed output voltage, is calculated in Equation 1:

$$R1 = R2 \times \left(\frac{V_O}{V_{FB}} - 1\right) = 500k\Omega \times \left(\frac{V_O}{500mV} - 1\right) \qquad (1)$$



Inductor Selection

A boost converter requires two main passive components, a boost inductor and a storage capacitor, for storing energy during the conversion. To select the boost inductor, it is recommended to keep the peak inductor current below the current limit threshold of the power switch. The highest peak current is estimated in Equation 2:

$$I_{PEAK} = I_{OUT} \times \frac{VOUT}{VBAT \times eff.} + VBAT \times \frac{1 - \frac{VBAT}{VOUT}}{2 \times L \times f} \qquad (2)$$

Parameter f is the switching frequency and the eff. can be determined by the typical characteristics graphs.

The second parameter for choosing the inductor is the current ripple in the inductor. A smaller current ripple reduces the magnetic hysteresis losses in the inductor, the output voltage ripple and EMI. Typically, a current ripple less than 20% of the average inductance current is recommended. With these parameters, the value of the inductor is calculated in Equation 3:

$$L = \frac{VBAT \times (VOUT - VBAT)}{\Delta I_L \times f \times VOUT} \qquad (3)$$

Parameter ΔI_L is the ripple current in the inductor. The device is recommended to operate with the inductor of 2.2μH to 10μH, typically 4.7μH. Higher inductance is possible in some applications, while lower inductance may cause a sub-harmonic issue when the duty cycle>0.5. DCR (DC resistance) of the inductor has to be taken into consideration for the efficiency decreases as it increases.

Capacitor Selection

Input Capacitor

At least a 10µF input capacitor is recommended to improve transient behavior of the regulator and EMI behavior of the total power supply circuit. A ceramic capacitor or a tantalum capacitor with a 100nF ceramic capacitor in parallel, placed close to the IC, is recommended.

Output Capacitor

The major parameter to define the output capacitor is the allowed output voltage ripple of the converter. The ripple is determined by two parameters of the capacitor, the capacitance and the ESR. Supposing the ESR is zero, the minimum is estimated in Equation 4:

$$C_{min} = \frac{I_{OUT} \times (VOUT - VBAT)}{\Delta V \times f \times VOUT} \quad (4)$$

Parameter ΔV is the maximum allowed ripple of the output voltage. The ripple caused by the ESR is calculated in Equation 5:

$$\Delta V_{ESR} = I_{OUT} \times R_{ESR} \quad (5)$$

The total ripple is the sum of those caused by the capacitance and those caused by the ESR. Additional ripple is caused by load transients. With a chosen ripple of 10mV (at normal operation) and load transient considerations, a least output capacitor of 10µF is recommended.

Layout considerations

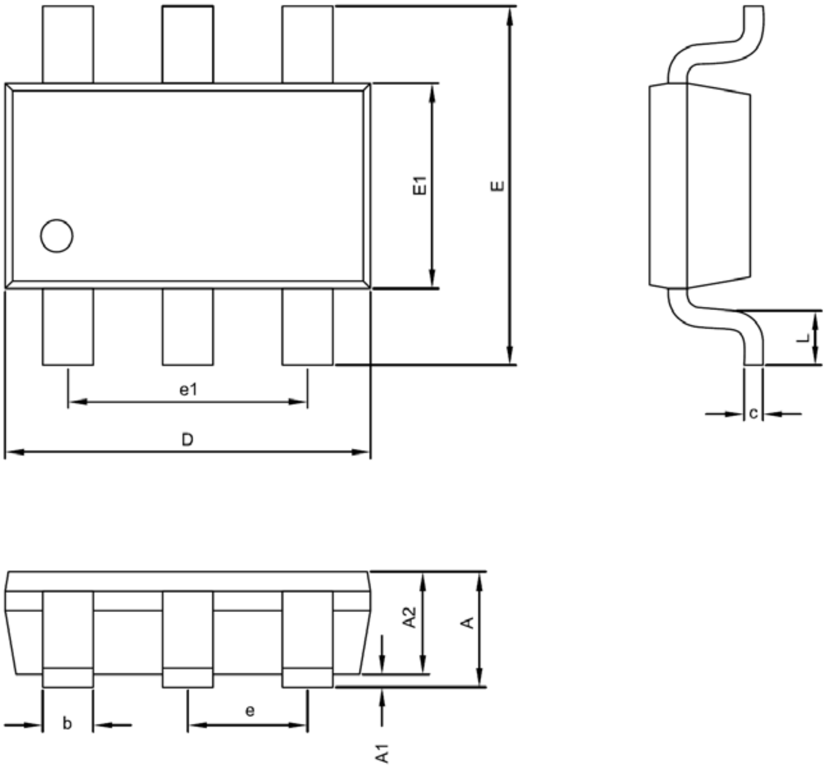
The layout is an important step in the design, especially at high-peak currents and high switching frequencies. It may cause serious problems in stability and EMI if not being carefully done. Wide and short traces are applied for the main current path and for the power ground traces. The input capacitor, the output capacitor, and the inductor should be place as close as possible to the IC. To minimize the effects of ground noise, we use a common ground node for the power ground and another for the control ground. These ground nodes are connected at any place close to the IC. To avoid ground shift problems, short traces are applied to control the ground as well.

Thermal Information

The maximum recommended junction temperature (T_J) of the G5134 is 145˚C. The thermal resistance of the TSOT-23-6 package is $R_{J\theta A}$= 240°C/W. The specified regulator operation is assured to a maximum ambient temperature T_A of 85°C. Therefore, the maximum power disspation is about 250mW according to Equation 6. More power can be disspated if the maximum ambient temperature of the application is lower.

$$P_{D(MAX)} = \frac{T_{J(MAX)} - T_A}{R_{\theta JA}} = \frac{145°C - 85°C}{240°C/W} = 250mW \quad (6)$$

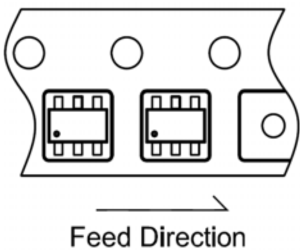
Package Information



TSOT-23-6 Package

Symble	DIMENSION IN MM			DIMENSION IN INCH		
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	- - -	- - -	0.90	- - -	- - -	0.035
A1	0.00	0.05	0.10	0.000	0.002	0.004
A2	0.70	0.75	0.80	0.028	0.030	0.031
D	2.70	2.90	3.10	0.106	0.114	0.122
E	2.60	2.80	3.00	0.102	0.110	0.118
E1	1.50	1.60	1.70	0.059	0.063	0.067
c	0.08	0.15	0.25	0.003	0.006	0.010
b	0.30	0.40	0.50	0.012	0.016	0.020
e	0.95 BSC			0.037 BSC		
e1	1.90 BSC			0.075 BSC		
L	0.30	0.45	0.60	0.012	0.018	0.024

Taping Specification



PACKAGE	Q'TY/REEL
TSOT-23-6	3,000 ea