# THV6511

Boost converter

## Description

THV6511 is a 1 channel boost converter IC.
Soft start / Over current protection / Under voltage lock out protection / Thermal shut down are built in.
Mounted area is reducible by MSOP-8.

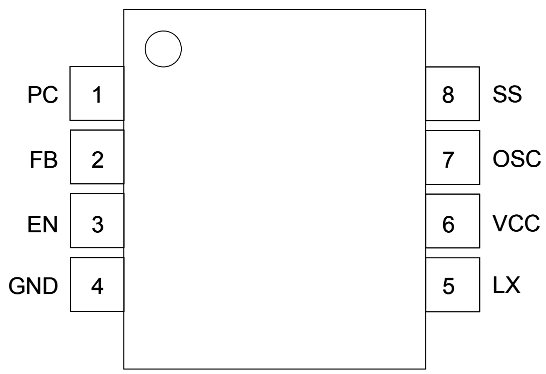
## Application

・Mobile phone display
・Car Navigator display
・Laptop/Netbook/Tablet PC display

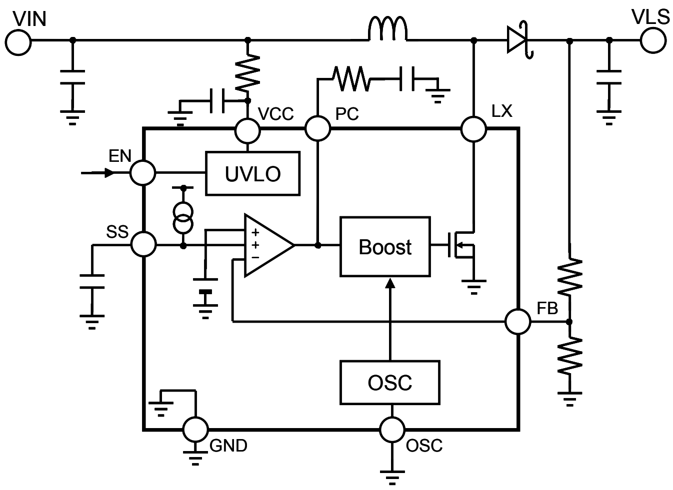
## Features

・Input voltage range : 2.5V – 5.5V
・Boost converter
  Maximum output voltage : 18V
  Switching limit current : 1.2A
  Feedback voltage accuracy : +/-1.5%
  Switching frequency : 640kHz / 1.2MHz
・Protection circuit
  Soft start
  Over current protection
  Under voltage lock out protection
  Thermal shut down
・MSOP-8pin package

## Pin Configuration




## Block Diagram



## Absolute Maximum Ratings

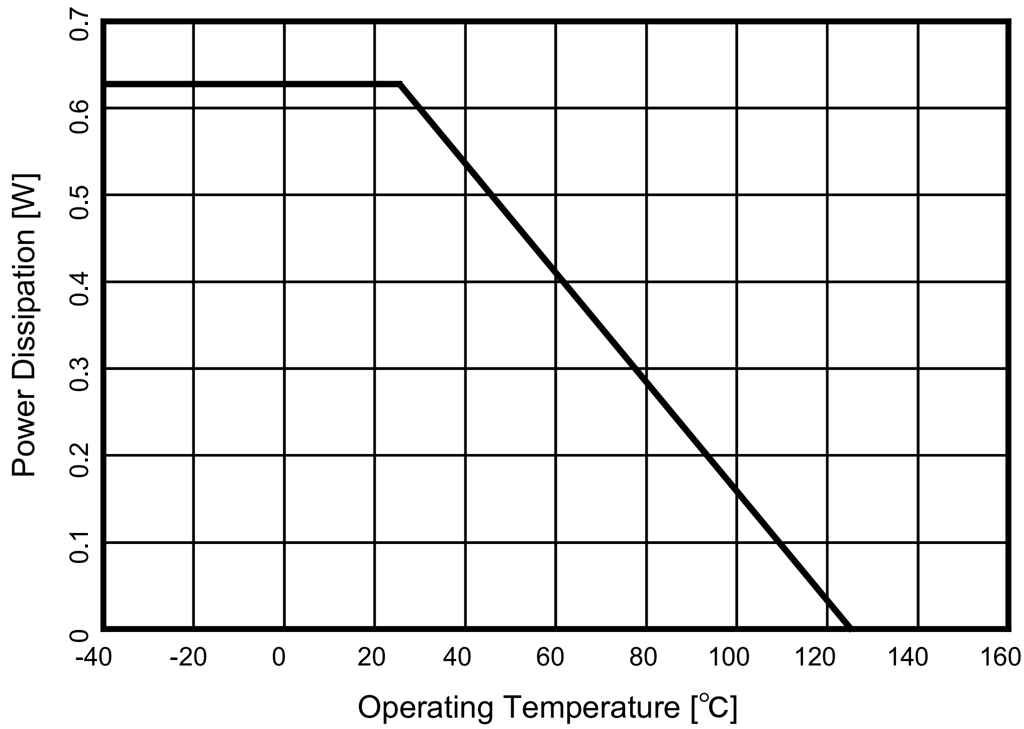
| Parameter | Symbol | Rating | Units |
|---|---|---|---|
| VCC voltage | VCC | 6.5 | V |
| LX voltage | VH | 26 | V |
| Power dissipation | Pd | 625 | mW |
| Junction temperature (*1) | Tj | -40 to 125 | ℃ |
| Storage temperature range | Tstg | -55 to +150 | ℃ |

*1. The operating temperature range should perform a thermal design, after consulting the thermal characteristic. Please use it in the range which does not exceed junction temperature.

## Recommended Operating Conditions

| Parameter | Min | Typ | Max | Units |
|---|---|---|---|---|
| VCC voltage | 2.5 | - | 5.5 | V |
| LX voltage | - | - | 18 | V |

## Power Dissipation



## Pin Description

| Number | Name | Function | Description |
|---|---|---|---|
| 1 | PC | Boost converter error amplifier output pin | This pin is the boost converter error amplifier output. Please connect resistance and capacitor to GND for phase compensation. |
| 2 | FB | Boost converter feedback voltage sense input pin | This pin is feedback input for boost converter. |
| 3 | EN | Enable pin. | If low level voltage is impressed, PMIC is shutdown. |
| 4 | GND | Ground pin | Ground of PMIC. |
| 5 | LX | Boost converter switching output pin | This pin is switching output of boost converter. |
| 6 | VCC | Input supply voltage pin | Power supply pin. |
| 7 | OSC | Oscillator set pin | Low level voltage is 640kHz, high level voltage is 1.2MHz. |
| 8 | SS | Soft start set pin | This pin is set by soft start for boost converter. Please connect capacitor to GND for soft start time. |

## *Electrical Characteristics* (at VCC＝3.3V , Ta=25℃, unless otherwise noted)

| Parameter | Symbol | Test Conditions | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| Input quiescent Current 1 | Icc1 | Vfb=1.34V(No switching) | - | 350 | 500 | uA |
| Input quiescent Current 2 | Icc2 | Vfb=1.14V(Switching) | - | 2 | 5 | mA |
| Standby current | Ist | Ven<(0.3xVCC) | - | 0.1 | 1 | uA |
| Oscillator and EN threshold voltage | Venh | | 0.7xVCC | - | - | V |
| | Venl | | - | - | 0.3xVCC | V |
| Oscillator and EN pull down resistance | Ren | | - | 250 | - | kΩ |
| UVLO threshold voltage | Vuvlo | VCC rising | 1.9 | 2.0 | 2.1 | V |
| UVLO hysteresis voltage | Vuvloh | | - | 0.1 | - | V |
| Boost converter switching frequency 1 | Fosc1 | Vosc<(0.3xVCC) | 540 | 640 | 740 | kHz |
| Boost converter switching frequency 2 | Fosc2 | Vosc>(0.7xVCC) | 1.0 | 1.2 | 1.4 | MHz |
| Boost converter maximum duty cycle | Dmax | | 85 | 90 | 95 | % |
| FB voltage | Vfb | | 1.222 | 1.240 | 1.258 | V |
| LX ON-resistance | Ron | | - | 200 | 500 | mΩ |
| LX current limit | Ilim | | 1.2 | 1.6 | 2.0 | A |
| LX leakage current | Ioff | Vlx=18V | - | - | 10 | uA |
| Soft start charge current | Iss | | - | 4 | - | uA |
| FB short circuit voltage | Vuvp | | - | 1 | - | V |
| FB short circuit delay time | Tuvp | | - | 54 | - | msec |

## Function

Boost converter

The LCD panel VLS supply is generated from a high-efficiency PWM boost converter operating with current mode control, and the switching frequency is selectable 640kHz or 1.2MHz. During the on-period, $T_{ON}$, the synchronous FET connects one end of the inductor to ground, therefore increasing the inductor current. After the FET turns off, the inductor switching node, LX, is charged to a positive voltage by the inductor current. The freewheeling diode turns on and the inductor current flows to the output capacitor.

The converter operates in continuous conduction mode when the load current $I_{VLS}$ is at least one-half of the inductor ripple current $\Delta I_{rip}$.

$$I_{IN} \geq \frac{\Delta I_{rip}}{2}$$

$$\Delta I_{rip} = \frac{(VLS - V_{IN}) \times V_{IN}}{L \times F_{OSC} \times VLS}$$

The output voltage (VLS) is determined by the duty cycle(D) of the power FET on-time and the input voltage, $V_{IN}$.

$$VLS = \frac{V_{IN}}{1-D}$$

The average load current, $I_{VLS}$, can be calculated from the power conservation law.

$$\eta \times V_{IN} \times I_{IN} = VLS \times I_{VLS}$$

where η is the power conversion efficiency. For a lower load current, the inductor current would decay to zero during the free-wheeling period and the output node would be disconnected from the inductor for the remaining portion of the switching period. The converter would operate in the discontinuous conduction mode .

Current mode control is well known for its robustness and fast transient response. An inner current feedback loop sets the on-time and the duty cycle such that the current through the inductor equals to the current computed by the compensator. This loop acts within one switching cycle. A slope compensation ramp is added to suppress sub-harmonic oscillations. An outer voltage feedback loop subtracts the voltage on the FB pin from the internal reference voltage and feeds the difference to the compensator operational transconductance amplifier. This amplifier is compensated by an external R-C network to allow the user to optimize the transient response and loop stability for the specific application conditions.

The output voltage VLS can be set by external resistor divider R1 and R2 connected to FB.

$$VLS = V_{FB} \times \left(1 + \frac{R_1}{R_2}\right)$$

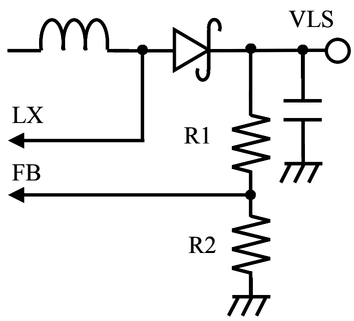



**Fig. 1 FB setup**

[Compensator selection]

This current mode boost converter has a current sense loop and a voltage feedback loop. The current sense loop does not need any compensation. The voltage feedback loop is compensated by an external series R-C network $R_{PC}$ and $C_{PC}$ from PC pin to ground. $R_{COMP}$ is set to define the high frequency integrator gain for loop bandwidth which relates to the transient response. $C_{PC}$ is set to ensure the loop stability.

[Output capacitor selection]

The output voltage ripple due to converter switching is determined by the output capacitor total capacitance, $C_{OUT}$, and the output

$$VLS_{rip} = \frac{D \times I_{OUT}}{F_{OSC} \times C_{OUT}} + I_{peak} \times ESR$$

$$I_{peak} = I_{IN} + \frac{\Delta I_{rip}}{2}$$

The first ripple component can be reduced by increasing $C_{OUT}$. Changing $C_{OUT}$ may require adjustment of compensation R and C in order to provide adequate phase margin and loop bandwidth.

The second ripple component can be reduced by selecting low-ESR ceramic capacitors and using several smaller capacitors in parallel instead of just one large capacitor.

[Inductor selection]

To prevent magnetic saturation of the inductor core the inductor has to be rated for a maximum current larger than $I_{PK}$ in a given application. Since the chip provides current limit protection of 1.6A, it is generally recommended that the inductor be rated at least for 1.6A.

Selection of the inductor requires trade-off between the physical size (footprint x height) and its electrical properties (current rating, inductance, resistance). Within a given footprint and height, an inductor with larger inductance typically comes with lower current rating and often larger series resistance. Larger inductance typically requires more turns on the winding, a smaller core gap or a core material with a larger relative permeability. An inductor with a larger physical size has better electrical properties than a smaller inductor.

It is desirable to reduce the ripple current $\Delta I_{rip}$ in order to reduce voltage noise on the input and output capacitors. In practice, the inductor is often much larger than the capacitors and it is easier and cheaper to increase the size of the capacitors. The ripple current $\Delta I_{rip}$ is then chosen the largest possible while at the same time not degrading the maximum input and output current that the converter can operate with before reaching the current limit of the chip or the rated current of the inductor.

$$I_{peak} = I_{IN} + \frac{\Delta I_{rip}}{2} \le I_{MAX}$$

For example, $\Delta I_{rip}$ could be set to 20% of $I_{MAX}$

## ***Protection circuits***

Under voltage lock out protection (UVLO)

The UVLO function is carried in order to prevent malfunction in the state where input voltage is low. A boost converter is suspended to the power supply voltage which can carry out operational stability. UVLO is released by more than 1.9V input voltage. And a boost converter carries out, after starting soft start operation.

If the feedback voltage pin FB is below 1V, the THV6511 activates an internal fault timer. If any condition indicates a continuous fault for the fault timer duration 54ms, the IC sets the fault latch to shut down its output except the reference. Once the fault condition is removed, cycle the input voltage (below the UVLO falling threshold) to clear the fault latch and reactivate the device.

Soft start (SS)

The boost converter carries the soft start function in order to prevent the rush current at a start-up. This function is to raise output voltage slowly. It is because overshooting and rush current occur when input voltage is inputted. This function is available in THV6511only. This IC uses a soft start circuit to minimize the inrush current. Connecting a capacitor $C_{SS}$ between SS pin and ground determines the soft start time $T_{SS}$.

$$T_{SS} = \frac{1.24V \times C_{SS}}{4\mu A}$$

If $C_{SS}$ is too small or not present at all, the internal soft start circuit ensures that the soft start period is at least 3.4ms.

Over current protection (OCP)

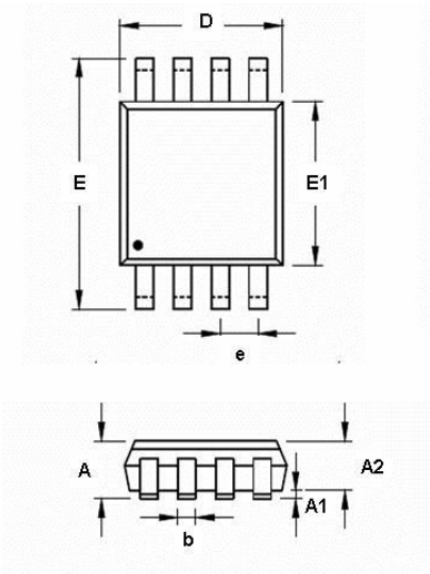
In order to restrict the over-current by the abnormalities of load, etc., the over-current protection circuit is built in. Over-current detection of pulse-by-pulse system is adopted. An output transistor is turned off if the current which flows into an output transistor reaches boost converter limit current (Ilim). An over-current protection circuit detects the peak current of an inductor. Input-and-output voltage and ripple current is taken into consideration.

Thermal shut down (TSD)

In order to prevent destruction by heat, the thermal shutdown circuit is built in. If the junction temperature Tj is 125$^{o}$C or more, the thermal shutdown circuit will operate and it will stop switching operation. Moreover, the hysteresis of a thermal shutdown circuit is 20$^{o}$C. If Tj falls, output voltage will return.

## Package Dimensions

MSOP-8pin




| DIMENSION | MIN (mm) | MAX (mm) |
|---|---|---|
| A | --- | 1.100 |
| A1 | 0.000 | 0.150 |
| A2 | 0.750 | 0.950 |
| b | 0.220 | 0.380 |
| D | 2.900 | 3.100 |
| E1 | 2.900 | 3.100 |
| E | 4.800 | 5.000 |
| e | 0.650 BSC | |
| L | 0.400 | 0.800 |

Notes:
1) All dimensions are in millimeters.

## Notices and Requests

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