

PWM Control 3A Step-Down Converter

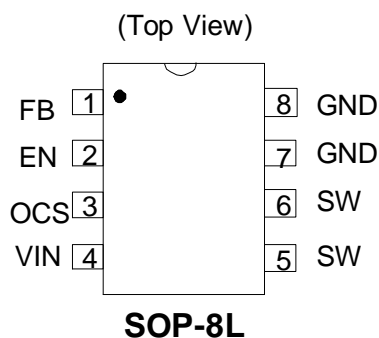
■ General Description

The GT1510 consists of step-down switching regulator with PWM control. This device includes a reference source, oscillation circuit, error amplifier, internal P-channel DMOS and etc.

GT1510 provides low-ripple power, high efficiency, and excellent transient characteristics. The PWM control circuit is able to vary the duty ratio linearly from 0 up to 100%. This converter also contains an error amplifier as well as a soft-start circuit that prevents an overshoot at startup. An enable function, over current protect function and a short circuit protect function are built inside, when OCP or SCP happens, the operation frequency will be reduced from 300KHz to 30KHz. Also, an internal compensation block is built in to minimum external component count.

With the addition of internal P-channel DMOS, a coil, capacitors, and a schottky diode connected externally, this IC serves as an ideal power supply unit for portable when coupled with the SOP-8L mini-package, providing such outstanding features as low current consumption. Since this converter can accommodate an input voltage up to 24V, it is also ideal when operating via an AC adapter.

■ Pin Assignments



■ Features

- Input voltage: 3.6V to 24V
- Adjustable output voltage range: 0.8V to VCC
- Duty ratio: 0% to 100% PWM control
- Oscillation frequency: 320KHz typ.
- Soft-start, Current limit, Enable function
- Thermal Shutdown function
- Built-in internal 60mΩ P-channel DMOS
- Up to 95% Efficiency
- Output load current: 3A
- SOP-8L Pb-Free Package
- Low power standby mode

■ Applications

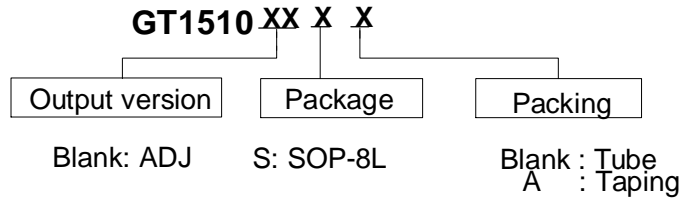
- Distributed Power Systems
- LCD Monitor
- DVD-Video Player
- Telecom Equipment
- ADSL Modem
- Printer and other Peripheral Equipment
- Battery Chargers
- Set-Top Boxes
- Cigarette Lighter Powered Devices

■ Pin Descriptions 脚功能描述

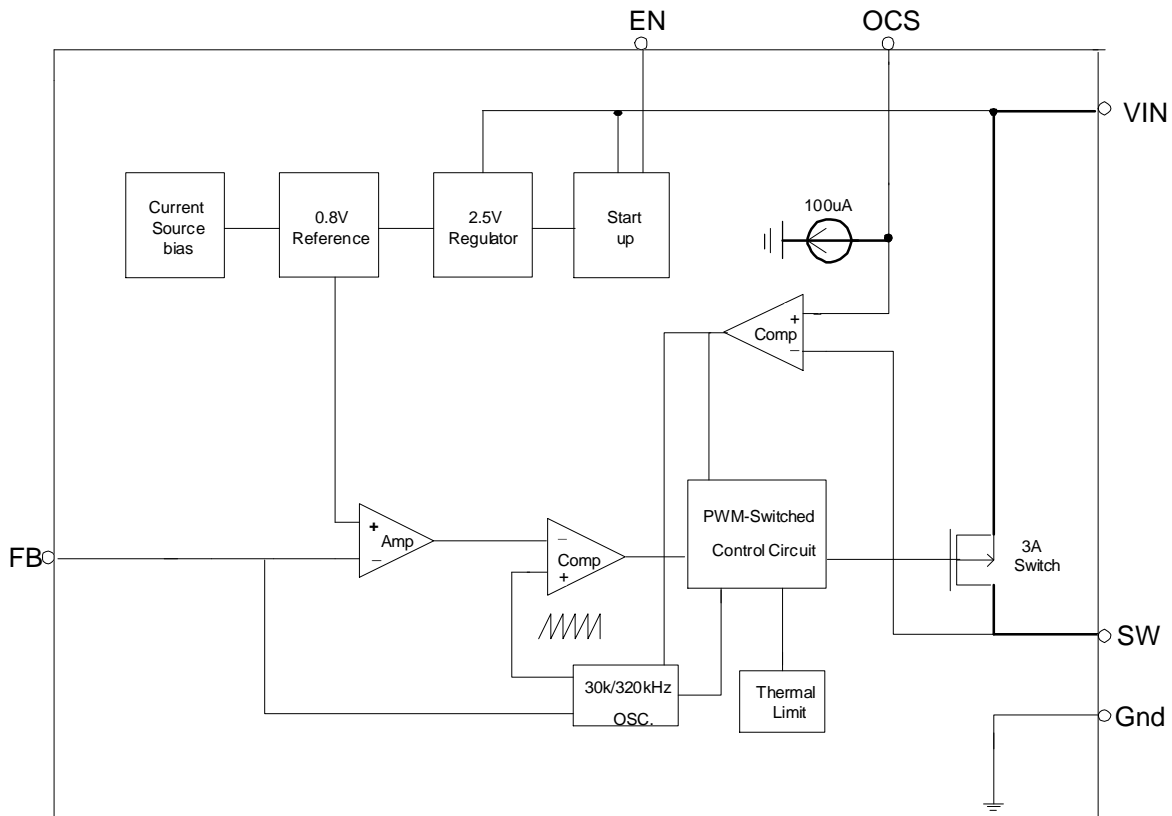
| Pin# | Name | Description |
|------|------|--|
| 1 | FB | Feedback pin 反馈脚 |
| 2 | EN | Power-off pin 使能脚 H: Normal operation L: Disable operation |
| 3 | OCS | Connects an external resistor to set maximum output current. 电流设置脚 (外接一个电阻设置最大输出电流) |
| 4 | VIN | IC power supply pin. 输入脚 |
| 5,6 | SW | Switch Pin. Connect external inductor/schottky diode here. 开关脚 (接一电感或者肖特基二极管) |
| 7,8 | GND | Ground Pin. 接地脚 |

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■ Ordering Information



■ Block Diagram



■ Absolute Maximum Ratings

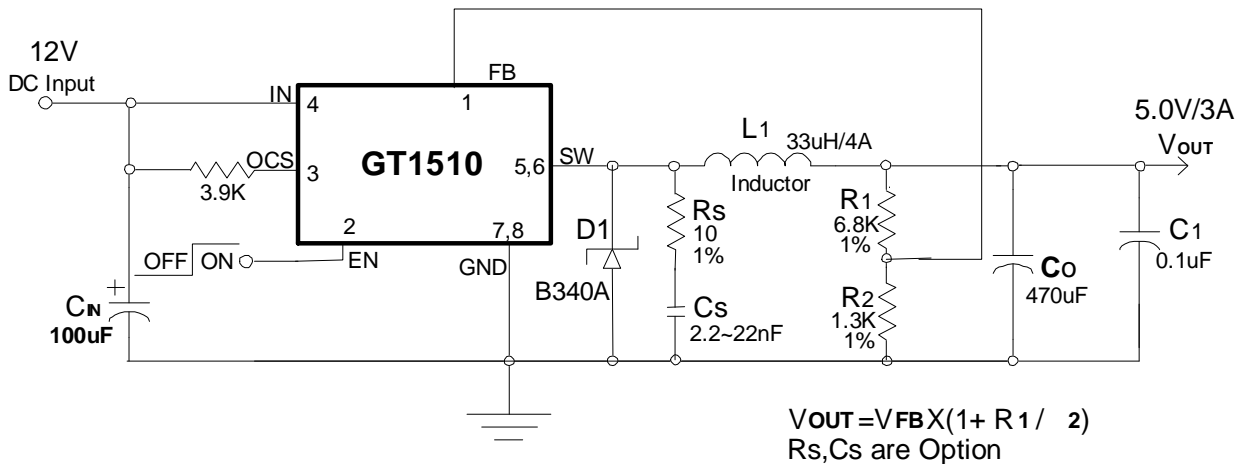
| Symbol | Parameter | Rating | Unit |
|------------------------|--------------------------|--------------------------|------|
| V _{CC} 输入电压 | Supply Voltage | +28 | V |
| V _{EN} 使能输入电压 | Enable Pin input voltage | -0.3 to +V _{IN} | V |
| V _{FB} 反馈电压 | Feedback Pin voltage | -0.3 to +6 | V |
| V _{OUT} 输出电压 | Output voltage to Ground | -1 | V |
| P _D 耗散功率 | Power dissipation | Internally limited | W |
| T _{ST} 储存温度 | Storage temperature | -65 to +150 | °C |
| T _{OP} 运行温度 | Operating temperature | -20 to +125 | °C |
| V _{OP} 运行电压 | Operating voltage | +3.6 to +24 | V |

■ Electrical Characteristics

Unless otherwise specified, V_{IN}=12V Ta=25 °C

| Symbol | Parameter | Conditions | Min. | Typ. | Max. | Unit |
|-------------------------------------|--|---|-----------------------|------|-------|------|
| V _{FB} | Feedback Voltage 反馈电压 | | 0.782 | 0.8 | 0.818 | V |
| F _{OSC} | oscillator frequency after regulation 震荡频率 | Measure waveform at SW pin 在SW脚测量波形 | 260 | 320 | 400 | Khz |
| F _{OSC1} | Oscillator frequency of short circuit or current limit 震荡频率(短路时) | Measure waveform at SW pin 在SW脚测量波形 | | 30 | | Khz |
| V _{IN} | Input voltage 输入电压 | | 3.6 | | 24 | V |
| V _{SH} | EN pin input voltage | Evaluate oscillation at SW pin | 2.0 | | | V |
| V _{SL} | 使能脚输入电压 | Evaluate oscillation stop at SW Pin 在SW脚震荡停止时评估 | | | 0.8 | |
| I _{SH} | EN pin input leakage | | | | 10 | uA |
| I _{SL} | Current EN脚泄漏电流 | | -10 | | | |
| I _{SW} | Switch Current 开关电流 | R _{ocs} = 3.9KΩ, V _{IN} =12V | 3.6 | 4.0 | 5.0 | A |
| I _Q | Quiescent Current 静态电流 | V _{FB} =12 force driver off | | 5 | 10 | mA |
| I _{STBY} | Standby Quiescent Current 待机静态电流 | V _{EN} =0V V _{IN} =12V | | 10 | | uA |
| ΔV _{OUT} /V _{OUT} | Line regulation | V _{IN} = 3.6V to 23V , I _{LOAD} =200mA | | 0.6 | 1 | % |
| ΔV _{OUT} /V _{OUT} | Load regulation 线路调整率 | I _{LOAD} =100mA to 2A | | 0.2 | 0.5 | % |
| I _{ocs} | OCS pin bias current ocs 脚偏流 | | 80 | 100 | 120 | uA |
| T _{SS} | Soft-Start time 软启动时间 | | 0.3 | 2 | 4 | ms |
| R _{DSON} | Internal MOS R _{DSON} | I _{SW} =3A | 55 | 60 | 90 | mΩ |
| EFFI | Efficiency 效率 | V _{IN} =12V V _{OUT} =5V | | 92 | | % |
| T _S | Over temperature 温控阈值 shutdown threshold | T _j increasing | Measured from GND pin | | 150 | °C |
| | | T _j decreasing | | | 100 | |

■ **Application Circuit**



| VCC=12V , IMAX=2A , ILIMIT=3.3A | | | | VCC=12V , IMAX=3A, ILIMIT=4.0A | | | |
|---------------------------------|-----------|-----------|-----------|--------------------------------|-----------|-----------|-----------|
| VOUT | 2.5V | 3.3V | 5V | VOUT | 2.5V | 3.3V | 5V |
| L1 | 15uH | 18uH | 22uH | L1 | 22uH | 27uH | 33uH |
| R1/ R2 | 2.2K/4.7K | 1.5K/4.7K | 1.3K/6.8K | R1/ R2 | 2.2K/4.7K | 1.5K/4.7K | 1.3K/6.8K |
| Rocs | 3.0K | | | Rocs | 3.9K | | |

■ **Detailed Description**

The GT1510 is a voltage-mode step down regulator with integrated high side PMOS switch , It operates from 3.6V to 24V input range and supplies up to 3A of Load current. The duty cycle can be adjusted from 0% to 100% allowing a wide range of output range. Features include enable control , fixed internal soft-start, adjustable current limit, thermal shutdown, short circuit protection.

The GT1510 is available in SO-8L package.

Enable and Soft Start

The GT1510 include internal soft start feature to limit inrush current and ensure the output voltage ramp up smoothly to regulation voltage. A soft start process begins when the input voltage rises to 3.6V and voltage on EN pin is above 2.0V. In soft start process, the output voltage is ramped to regulation voltage in typically 4ms. The 4ms soft start is set internally.

The EN pin of the GT1510 is active high. Connect the EN pin to VIN if enable function is not used. Connect it to ground will disable the GT1510. Open the EN pin is inhibited.

Steady-State Operation

Under steady-state condition, the converter operates in fixed frequency and Continuous-Conduction Mode(CCM).

The GT1510 integrates an internal P-MOSFET as the high-side switch. Inductor current is sensed by the voltage drop across the drain to source of the high side power MOSFET. The output voltage is divided down by external voltage divider at FB pin. The difference of the FB pin voltage and constant voltage reference is amplified by the error amplifier and internal compensation network to produce a error voltage. Then, the error voltage is compared against the ramp oscillator voltage, if the ramp voltage is less than error voltage, the internal high side switch is on. The inductor current flows from the input through the inductor to the output. When the ramp voltage exceeds the error voltage, The high side switch is off. The inductor current is freewheeling through the external Schottky diode to output.

The GT1510 uses a P-Channel MOSFET as the high switch. It saves the bootstrap capacitor normally seen in a circuit which is using an NMOS switch.

Switching Frequency

The GT1510 switching frequency is fixed after regulation, The typical value of frequency is 330KHz. When FB drop below 0.5V or he short circuit protection is triggered and the frequency equals to 1/12 of normal switching frequency. The inductor average current is greatly reduced because of the lower frequency.

Output Voltage Programming

Output voltage can be set by feeding back the output to the FB pin with a resistor divider network. In the application circuit, The resistor divider network include R 1 and R2. Usually, a design is started by picking a fixed R2 value and calculating the required R1 with equation below.

$$V_O = 0.8 \times (R_1 + R_2) / R_2$$

Some standard value of R1 and R2 for most commonly used output voltage are listed below.

| Vo (V) | R1 (KΩ) | R2 (KΩ) | L1 Minimum |
|----------|---------|---------|------------|
| 0.8V | 0 | open | 5.6uH |
| 1.0V | 1.0 | 4 | 5.6uH |
| 1.2V | 1.5 | 3 | 6.8uH |
| 1.5V | 2.0 | 2.2 | 6.8uH |
| 1.8V | 2.5 | 2 | 10uH |
| 2.5V | 4.7 | 2.2 | 10uH |
| 3.3V | 4.7 | 1.5 | 15uH |
| 5.0V | 6.8 | 1.3 | 22uH |

Since the switch duty cycle can be as high as 100%, the maximum output voltage can be set as high as the input voltage minus the voltage drop on upper PMOS and inductor.

Protection Features

The GT1510 has multiple protection features to prevent system circuit damage under abnormal conditions.

Over Current Protection (OCP)

Over current protection is implemented by sensing the voltage drop across the drain to source of the high side power MOSFET. The $R_{DS(on)}$ of power MOSFET is between 60mΩ and 80 mΩ depending on input voltage and junction temperature. The drain to source voltage is then compared to a voltage level representing the over current threshold limit. The current limit threshold is set by external resistor connected between OCS pin and VIN. The stable current flow from VIN through resistor into OCS pin is about 100uA. When the load current reach the current limit threshold, the cycle by cycle current limit circuit turn off the high side switch immediately to terminate the current duty cycle. The inductor current stop rising. When cycle by cycle current limit circuit is triggered, the output voltage drops as the duty cycle decreasing and the frequency reduces to 1/12 of normal switching frequency.

Short Circuit Protection (SCP)

The GT1510 has internal short circuit protection to protect itself from catastrophic failure under output short circuit condition. The FB pin voltage is proportional to the output voltage. Whenever the short circuit protection circuit is triggered. As a result, the frequency drop to 1/12 of normal switching frequency. In short circuit protection mode, the inductor is greatly reduced.

Thermal Protection (OCP)

The internal temperature sensor monitors the junction temperature. It shut down the internal control circuit and high side PMOS if the junction temperature exceeds 150 °C. The regulator will restart automatically under the control of soft-start circuit when junction temperature decreases to 100°C.

Under Voltage Lockout (UVLO)

The under voltage lockout circuit of the GT1510 assures that the high-side MOSFET driver outputs remain in

the off state whenever the supply voltage drops below 3.3V. Normal operation resumes once VIN rises above 3.5V.

RDS(ON) Current Limiting

The current limit threshold is setting by the external resistor connecting from VIN supply to OCS pin. The internal 100uA sink current crossing the external resistor sets the voltage at the OCS pin. The power loss of the external resistor is less than the power loss of MOSFET, an over-current condition is triggered.

$$I_{LOAD} \times R_{DS(ON)} = I_{OCS} \times R_{OCS}$$

See above formula for setting the current limit value.

Thermal management and PCB layout Consideration

The thermal performance of the GT1510 is strongly affected by the PCB layout. The size of the heatsink depends on the input voltage, the output voltage, the load current and the ambient temperature.

In the GT1510 buck regulator circuit, the major power dissipating component are the GT1510, The Schottky diode and output inductor. The total power dissipation of converter circuit can be measured by input power minus output power.

$$P_{total_loss} = V_{IN} \times I_{IN} - V_{O} \times I_{O}$$

The power dissipation in Schottky diode can be approximated as: (D: PWM Duty cycle)

$$P_{diode_loss} = I_{O} \times (1 - D) \times V_{FW_Schottky}$$

The power dissipation of inductor can be approximated as:

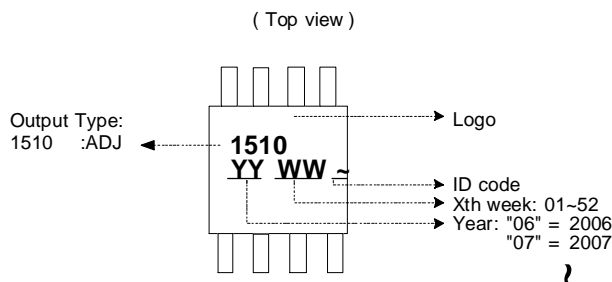
$$P_{inductor_loss} = I_{O}^2 \times R_{inductor}$$

The actual junction temperature can be calculated with power dissipation in the GT1510 and thermal impedance from junction to ambient. ($\Theta_{JA} = 65^{\circ}C / W$)

$$T_{junction} = (P_{total_loss} + P_{diode_loss} + P_{inductor_loss}) \times \Theta_{JA}$$

The maximum junction temperature of GT1510 is 150°C, which limits the maximum load current capability. The two SW pin are connected to internal MOSFET drain. They are low resistance thermal conductor path and most noisy switching node. Connected a copper plane to SW pin to help thermal dissipation. The copper plane should not be too larger otherwise switching noise may be coupled to other part of circuit in PCB.

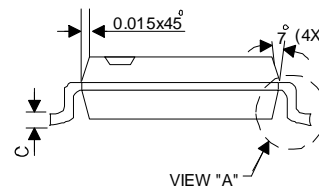
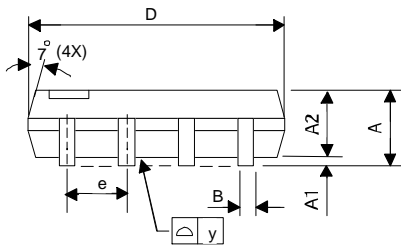
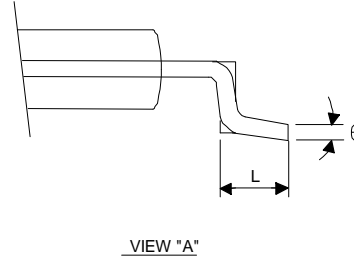
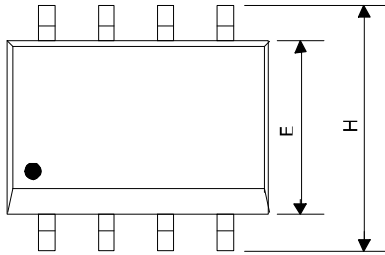
■ Marking Information



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■ Package Information

Package Type: SOP-8L



| Symbol | Dimensions In Millimeters | | | Dimensions In Inches | | |
|----------|---------------------------|------|-----------|----------------------|-------|-----------|
| | Min. | Nom. | Max. | Min. | Nom. | Max. |
| A | 1.40 | 1.60 | 1.75 | 0.055 | 0.063 | 0.069 |
| A1 | 0.10 | - | 0.25 | 0.040 | - | 0.100 |
| A2 | 1.30 | 1.45 | 1.50 | 0.051 | 0.057 | 0.059 |
| B | 0.33 | 0.41 | 0.51 | 0.013 | 0.016 | 0.020 |
| C | 0.19 | 0.20 | 0.25 | 0.0075 | 0.008 | 0.010 |
| D | 4.80 | 4.85 | 5.05 | 0.189 | 0.191 | 0.199 |
| E | 3.80 | 3.91 | 4.00 | 0.150 | 0.154 | 0.157 |
| e | - | 1.27 | - | - | 0.050 | - |
| H | 5.79 | 5.99 | 6.20 | 0.228 | 0.236 | 0.244 |
| L | 0.38 | 0.71 | 1.27 | 0.015 | 0.028 | 0.050 |
| y | - | - | 0.10 | - | - | 0.004 |
| θ | 0° | - | 8° | 0° | - | 8° |