

**FEATURES**

- Green-Mode PWM
- Supports the “Blue Angel” Standard
- Low Start-up Current (5uA)
- Low Operating Current (2mA)
- Leading-Edge Blanking
- Constant Output Power Limit
- Universal Input
- Built-in Synchronized Slope Compensation
- Current Mode Operation
- Cycle-by-cycle Current Limiting
- Under Voltage Lockout (UVLO)
- Programmable PWM Frequency
- Gate Output Voltage Clamped at 15V
- Low Cost
- Few External Components Required
- Small SOT-26 Package

**APPLICATIONS**

General-purpose switching mode power supplies and flyback power converters, such as

- Battery chargers for cellular phones, cordless phones, PDAs, digital cameras, and power tools
- Power adapters for ink jet printers, video game consoles, and portable audio players
- Open-frame SMPS for TV/DVD standby and other auxiliary supplies, home appliances, and consumer electronics
- Replacements for linear transformers and RCC SMPS
- PC 5V standby power.

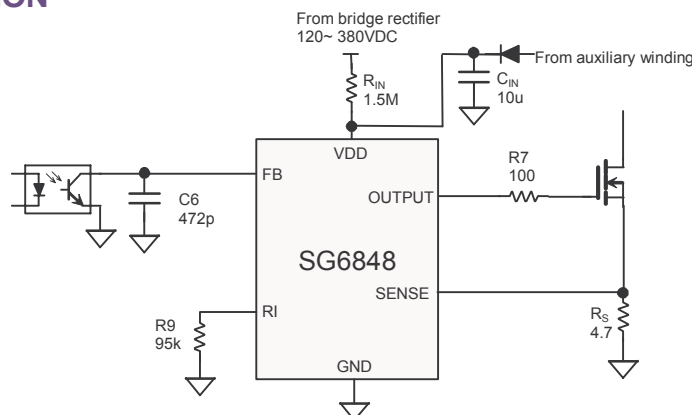
**DESCRIPTION**

This highly-integrated PWM controller provides several special enhancements designed to meet the low standby-power needs of low-power SMPS. To minimize standby power consumption, the proprietary green-mode function provides off-time modulation to linearly decrease the switching frequency under light-load conditions. This green-mode function enables the power supply to easily meet even the strictest power conservation requirements.

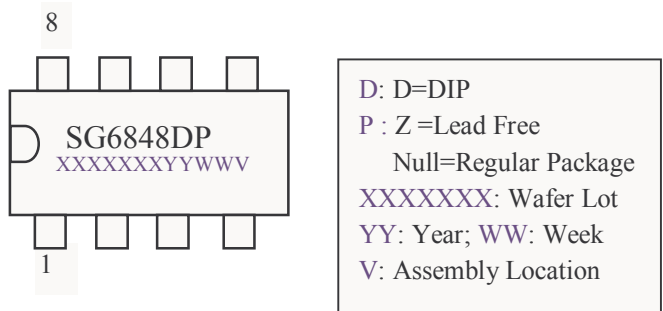
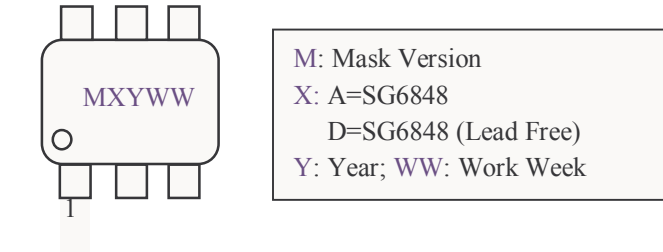
The BiCMOS fabrication process enables reducing the start-up current to 5uA, and the operating current to 2mA. To further improve power conservation, a large start-up resistance can be used. Built-in synchronized slope compensation ensures the stability of peak current mode control. Proprietary internal compensation provides a constant output power limit over a universal AC input range (90VAC to 264VAC). Pulse-by-pulse current limiting ensures safe operation even during short-circuits.

To protect the external power MOSFET from being damaged by supply over voltage, the SG6848’s output driver is clamped at 15V. SG6848 controllers can be used to improve the performance and reduce the production cost of power supplies. The SG6848 is the best choice for replacing linear and RCC-mode power adapters. It is available in 8-pin DIP and 6-pin SOT-26 packages.

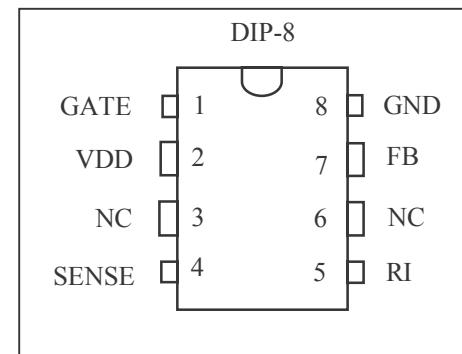
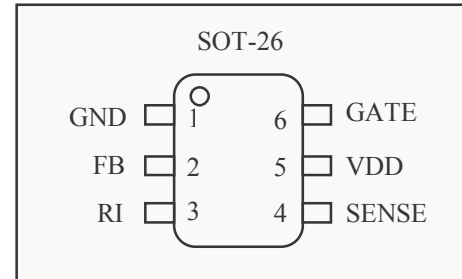
**TYPICAL APPLICATION**



**MARKING DIAGRAMS**



**PIN CONFIGURATION**



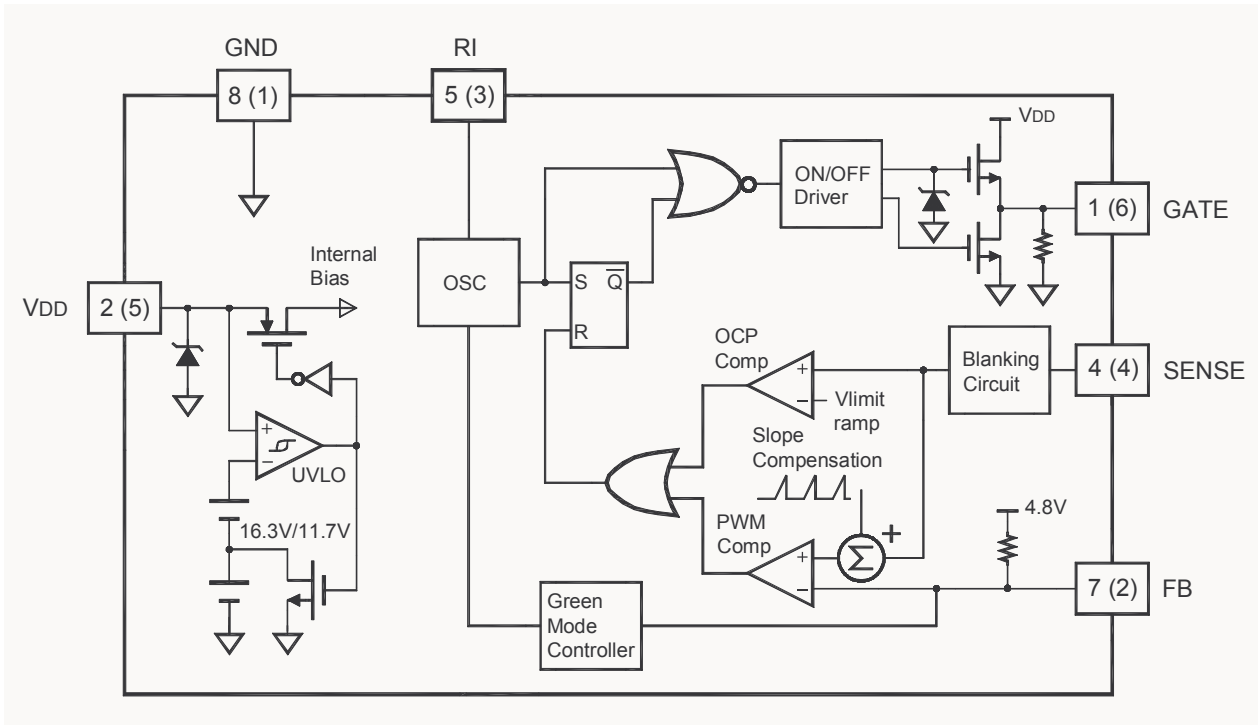
**ORDERING INFORMATION**

| Part Number | PWM Frequency | Package                  |
|-------------|---------------|--------------------------|
| SG6848T     | 70kHz         | 6-Pin SOT-26             |
| SG6848D     | 70kHz         | 8-pin DIP-8              |
| SG6848TZ    | 70kHz         | 6-Pin SOT-26 (Lead Free) |
| SG6848DZ    | 70kHz         | 8-pin DIP-8 (Lead Free)  |

**PIN DESCRIPTIONS**

| Name  | Pin No.          | Type                | Function   |
|-------|------------------|---------------------|--|
|       | DIP-8 / (SOT-26) |                     |  |
| GATE  | 1 / (6)          | Driver Output       | The totem-pole output driver for driving the power MOSFET.   |
| VDD   | 2 / (5)          | Supply              | Power supply.  |
| NC    | 3                |                     | NC pin.  |
| SENSE | 4 / (4)          | Analog Input        | Current sense. This pin senses the voltage across a resistor. When the voltage reaches the internal threshold, PWM output is disabled. This activates over-current protection. This pin also provides current amplitude information for current-mode control.  |
| RI    | 5 / (3)          | Analog Input/Output | A resistor connected from the RI pin to ground will generate a constant current source for the SG6848. This current is used to charge an internal capacitor, to determine the switching frequency. Increasing the resistance will reduce the amplitude of the current source and reduce the switching frequency. A 95kΩ resistor R <sub>i</sub> results in a 50uA constant current I <sub>i</sub> and a 70kHz switching frequency. |
| NC    | 6                |                     | NC pin.  |
| FB    | 7 / (2)          | Analog Input        | Feedback. The FB pin provides the output voltage regulation signal. It provides feedback to the internal PWM comparator, so that the PWM comparator can control the duty cycle.  |
| GND   | 8 / (1)          | Supply              | Ground.  |

**BLOCK DIAGRAM**



## ABSOLUTE MAXIMUM RATINGS

| Symbol             | Parameter                            | Value         | Unit  |      |
|--------------------|--------------------------------------|---------------|-------|------|
| V <sub>DD</sub>    | DC Supply Voltage *                  | 25            | V     |      |
|                    | Zener Clamp                          | 26            | V     |      |
|                    | Zener Current                        | 10            | mA    |      |
| V <sub>FB</sub>    | Input Voltage to FB Pin              | -0.3 to 6 V   | V     |      |
| V <sub>SENSE</sub> | Input Voltage to Sense Pin           | -0.3 to 6V    | V     |      |
| P <sub>D</sub>     | Power Dissipation                    | 300           | mW    |      |
| T <sub>J</sub>     | Operating Junction Temperature       | 150           | °C    |      |
| R <sub>θJA</sub>   | Thermal Resistance (Junction to Air) | SOT-26        | 208.4 | °C/W |
|                    |                                      | DIP-8         | 82.5  | °C/W |
| T <sub>STG</sub>   | Storage Temperature Range            | -55 to +150   | °C    |      |
| T <sub>L</sub>     | Lead Temperature (Soldering)         | 20 sec SOT-26 | 220   | °C   |
|                    |                                      | 10 sec DIP-8  | 260   |      |
|                    | ESD Capability, HBM Model            | 3.0           | kV    |      |
|                    | ESD Capability, Machine Model        | 300           | V     |      |

\* All voltage values, except differential voltages, are given with respect to the network ground terminal.

## OPERATING CONDITIONS

| Symbol          | Parameter                     | Value       | Unit |
|-----------------|-------------------------------|-------------|------|
| V <sub>DD</sub> | DC Supply Voltage             | ≤ 20        | V    |
| T <sub>A</sub>  | Operating Ambient Temperature | -30 to +105 | °C   |

## ELECTRICAL CHARACTERISTICS (T<sub>A</sub> = 25°C, V<sub>DD</sub>=15V)

### Feedback Input Section

| Symbol          | Parameter                     | Test Condition | Min. | Typ. | Max. | Unit |
|-----------------|-------------------------------|----------------|------|------|------|------|
| I <sub>OZ</sub> | Zero Duty Cycle Input Current |                |      | 1.3  | 2.0  | mA   |
| V <sub>OP</sub> | Open Loop Voltage             |                |      | 4.5  |      | V    |

### Current Sense Section

| Symbol                 | Parameter                               | Test Condition | Min. | Typ. | Max. | Unit |
|------------------------|---|----------------|------|------|------|------|
| Z <sub>CS</sub>        | Input Impedance                         |                | 10   |      |      | kΩ   |
| T <sub>PD</sub>        | Delay to Output                         |                |      | 150  | 200  | nsec |
| V <sub>TH,FLT</sub>    | Current Limit Flatten Threshold Voltage |                |      | 1.0  |      | V    |
| V <sub>TH,VALLEY</sub> | Current Limit Valley Threshold Voltage  |                | 0.80 | 0.85 | 0.90 | V    |

### Oscillator Section

| Symbol                 | Parameter  | Test Condition                | Min. | Typ. | Max. | Unit  |
|------------------------|--|-------------------------------|------|------|------|-------|
| F <sub>OSC</sub>       | Frequency  | R <sub>I</sub> =95kΩ          | 65   | 70   | 75   | kHz   |
| F <sub>OSC-GREEN</sub> | Green-Mode Frequency   | R <sub>I</sub> =95kΩ          |      | 13   | 15   | kHz   |
| I <sub>G</sub>         | Green-Mode FB Input Current  |                               |      | 1.16 |      | mA    |
| I <sub>N</sub>         | Green-Mode Start Threshold FB Input Current<br>I <sub>n</sub> = 0.3mA for a Maximum Duty Cycle |                               |      | 1    |      | mA    |
| S <sub>G</sub>         | Green-Mode Modulation Slope  | R <sub>I</sub> =95kΩ          |      | 300  |      | Hz/uA |
| F <sub>DY</sub>        | Frequency Variation versus V <sub>DD</sub> Deviation   | V <sub>DD</sub> =12 to 20V    |      | 0.02 | 2    | %     |
| F <sub>DT</sub>        | Frequency Variation versus Temp. Deviation   | T <sub>A</sub> =-30 to 105 °C |      |      | 2    | %     |

### PWM Section

| Symbol              | Parameter                  | Test Condition | Min. | Typ. | Max. | Unit |
|---------------------|----------------------------|----------------|------|------|------|------|
| DC <sub>(MAX)</sub> | Maximum Duty Cycle         |                | 70   | 75   | 80   | %    |
| DC <sub>(MIN)</sub> | Minimum Duty Cycle         |                | -    | 1    | 2    | %    |
| B <sub>NK</sub>     | Leading-Edge Blanking Time |                |      | 250  |      | nsec |

### Output Section

| Symbol             | Parameter            | Test Condition                             | Min. | Typ. | Max. | Unit |
|--------------------|----------------------|--|------|------|------|------|
| V <sub>OL</sub>    | Output Voltage Low   | V <sub>DD</sub> =15V, I <sub>o</sub> =20mA |      |      | 1.5  | V    |
| V <sub>OH</sub>    | Output Voltage High  | V <sub>DD</sub> =15V, I <sub>o</sub> =20mA | 8    |      |      | V    |
| T <sub>R</sub>     | Rising Time          | V <sub>DD</sub> =15V, C <sub>L</sub> =1nF  |      | 50   | 200  | nsec |
| T <sub>F</sub>     | Falling Time         | V <sub>DD</sub> =15V, C <sub>L</sub> =1nF  |      | 30   | 150  | nsec |
| V <sub>CLAMP</sub> | Output Clamp Voltage | V <sub>DD</sub> =20V                       |      | 15   | 17   | V    |

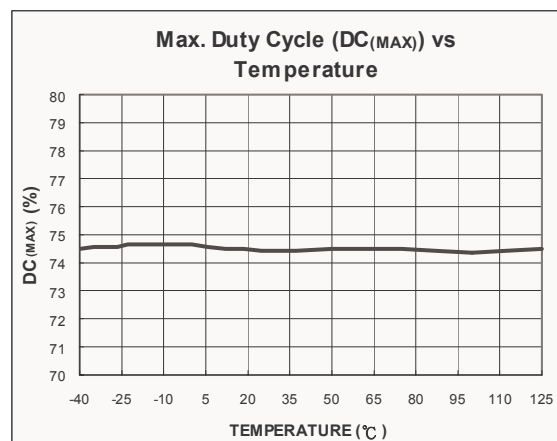
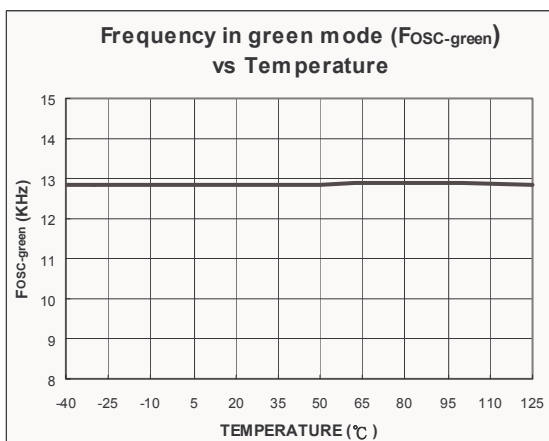
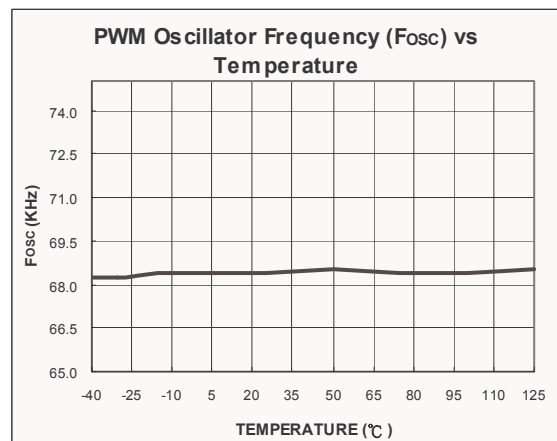
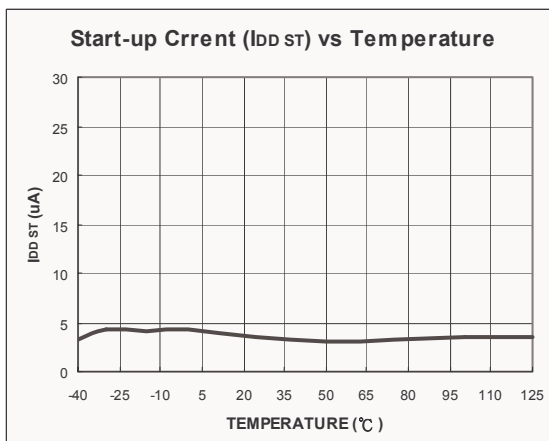
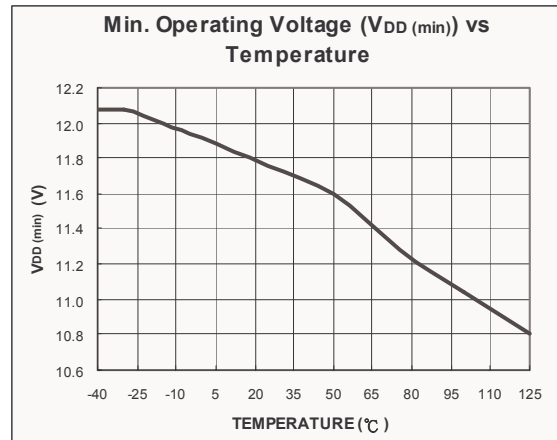
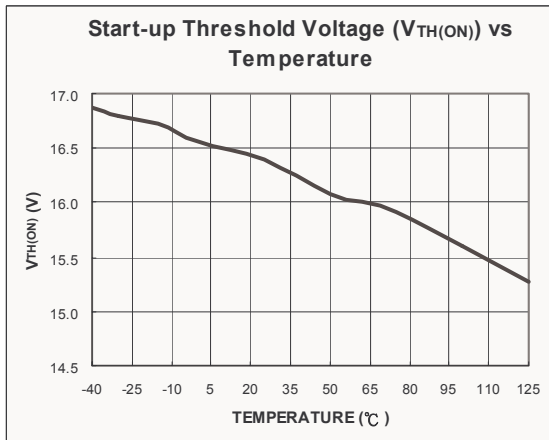
### Under Voltage Lockout Section

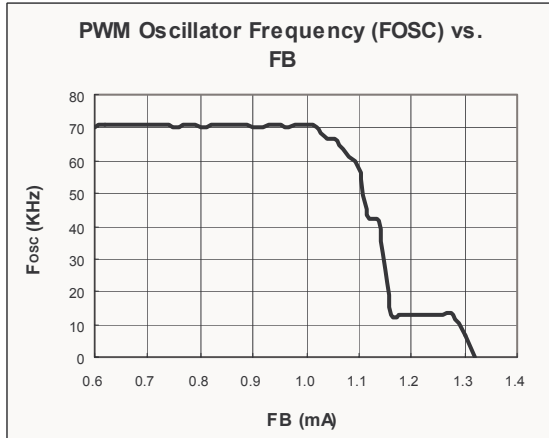
| Symbol               | Parameter               | Test Condition       | Min. | Typ. | Max. | Unit |
|----------------------|-------------------------|----------------------|------|------|------|------|
| V <sub>TH(ON)</sub>  | Start Threshold Voltage | T <sub>A</sub> =25°C | 15.3 | 16.3 | 17.3 | V    |
| V <sub>DD(MIN)</sub> | Min. Operating Voltage  | T <sub>A</sub> =25°C | 10.9 | 11.7 | 12.5 | V    |

### Total Standby Current Section

| Symbol             | Parameter                | Test Condition       | Min. | Typ. | Max. | Unit |
|--------------------|--------------------------|----------------------|------|------|------|------|
| I <sub>DD ST</sub> | Start-up Current         | V <sub>DD</sub> =15V |      | 5    | 30   | uA   |
| I <sub>DD OP</sub> | Operating Supply Current | V <sub>DD</sub> =15V |      | 2    | 5    | mA   |

**TYPICAL CHARACTERISTICS**





## OPERATION DESCRIPTION

SG6848 devices integrate many useful designs into one controller for low-power switch-mode power supplies. The following descriptions highlight some of the features of the SG6848 series.

### Start-up Current

The start-up current is only 5uA. Low start-up current allows a start-up resistor with a high resistance and a low-wattage to supply the start-up power for the controller. A 1.5 MΩ, 0.25W, start-up resistor and a 10uF/25V V<sub>DD</sub> hold-up capacitor would be sufficient for an AC-to-DC power adapter with a wide input range (100V<sub>AC</sub> to 240V<sub>AC</sub>).

### Operating Current

The operating current has been reduced to 2mA. The low operating current results in higher efficiency and reduces the V<sub>cc</sub> hold-up capacitance requirement.

### Green-Mode Operation

The proprietary green-mode function provides off-time modulation to linearly decrease the switching frequency under light-load conditions. On-time is limited to provide stronger protection against brownouts and other abnormal conditions. The feedback current, which is sampled from the voltage feedback loop, is taken as the reference. Once the feedback current exceeds the threshold current, the switching frequency starts to decrease. This green-mode function dramatically reduces power consumption under light-load and zero-load conditions. Power supplies using the SG6848 can easily meet even the strictest regulations regarding standby power consumption.

### Oscillator Operation

A resistor connected from the RI pin to ground will generate a constant current source for the SG6848. This current is used to charge an internal capacitor. The charge-time determines the internal clock speed and the

switching frequency. Increasing the resistance will reduce the amplitude of the input current and reduce the switching frequency. A 95kΩ resistor R<sub>i</sub> results in a 50uA constant current I<sub>i</sub> and a 70kHz switching frequency. The relationship between R<sub>i</sub> and the switching frequency is:

$$f_{\text{PWM}} = \frac{6650}{R_i \text{ (k}\Omega\text{)}} \text{ (kHz)}$$

The range of the oscillation frequency is designed to be within 50kHz ~ 100kHz.

### Leading-Edge Blanking

Each time the power MOSFET is switched on, a turn-on spike will inevitably occur at the sense-resistor. To avoid premature termination of the switching pulse, a 250 nsec leading-edge blanking time is built in. Conventional RC filtering can therefore be omitted. During this blanking period, the current-limit comparator is disabled and it cannot switch off the gate driver.

### Constant Output Power Limit

When the SENSE voltage across the sense resistor R<sub>s</sub> reaches the threshold voltage (around 1.0V), the output GATE drive will be turned off following a short propagation delay t<sub>D</sub>. This propagation delay will introduce an additional current proportional to t<sub>D</sub>\*V<sub>in</sub>/L<sub>p</sub>. The propagation delay is nearly constant regardless of the input line voltage V<sub>IN</sub>. Higher input line voltages will result in larger additional currents. At high input line voltages, the output power limit will be higher than at low input line voltages.

To compensate for this output power limit variation across a wide AC input range, the threshold voltage is adjusted by adding a positive ramp. This ramp signal rises from 0.85V to 1.0V, and then flattens out at 1.0V. A smaller threshold voltage forces the output GATE drive to terminate earlier. This reduces the total PWM turn-on time and makes the output power equal to that of low line input. This proprietary internal compensation ensures a constant output power limit for a wide AC input voltage range (90VAC to 264VAC).



## Under Voltage Lockout (UVLO)

The turn-on and turn-off thresholds of the SG6848 are fixed internally at 16.3V/11.7V. During start-up, the hold-up capacitor must be charged to 16.3V through the start-up resistor, so that the SG6848 will be enabled. The hold-up capacitor will continue to supply  $V_{DD}$  until power can be delivered from the auxiliary winding of the main transformer.  $V_{DD}$  must not drop below 11.7V during this start-up process. This UVLO hysteresis window ensures that hold-up capacitor will be adequate to supply  $V_{DD}$  during start-up.

## Gate Output

The SG6848 BiCMOS output stage is a fast totem pole gate driver. Cross conduction has been avoided to minimize heat dissipation, increase efficiency, and enhance reliability. The output driver is clamped by an internal 15V Zener diode in order to protect power MOSFET transistors against undesired over-voltage gate signals.

## Built-in Slope Compensation

The sensed voltage across the current sense resistor is used for current mode control and pulse-by-pulse

current limiting. Built-in slope compensation will improve stability and prevent sub-harmonic oscillations due to peak-current mode control. The SG6848 has a synchronized, positively-sloped ramp built-in at each switching cycle. The slope of the ramp is:

$$\frac{0.33 \times Duty}{Duty(max)}$$

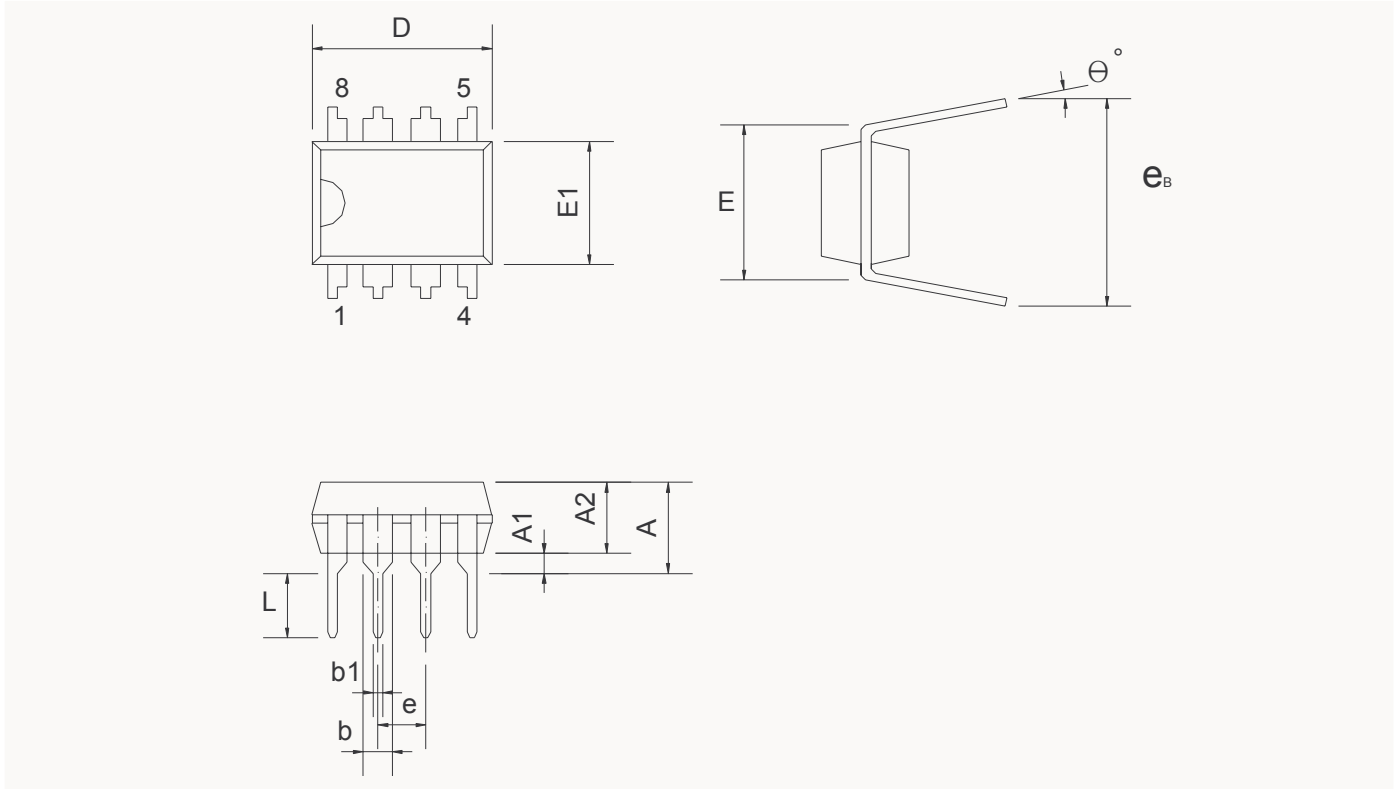
## Noise Immunity

Noise from the current sense or the control signal can cause significant pulse width jitter, particularly in continuous-conduction mode. While slope compensation helps alleviate these problems, further precautions should still be taken. Good placement and layout practices should be followed. Avoiding long PCB traces and component leads, locating compensation and filter components near the SG6848, and increasing the power MOS gate resistance is advised.



**PACKAGE INFORMATION**

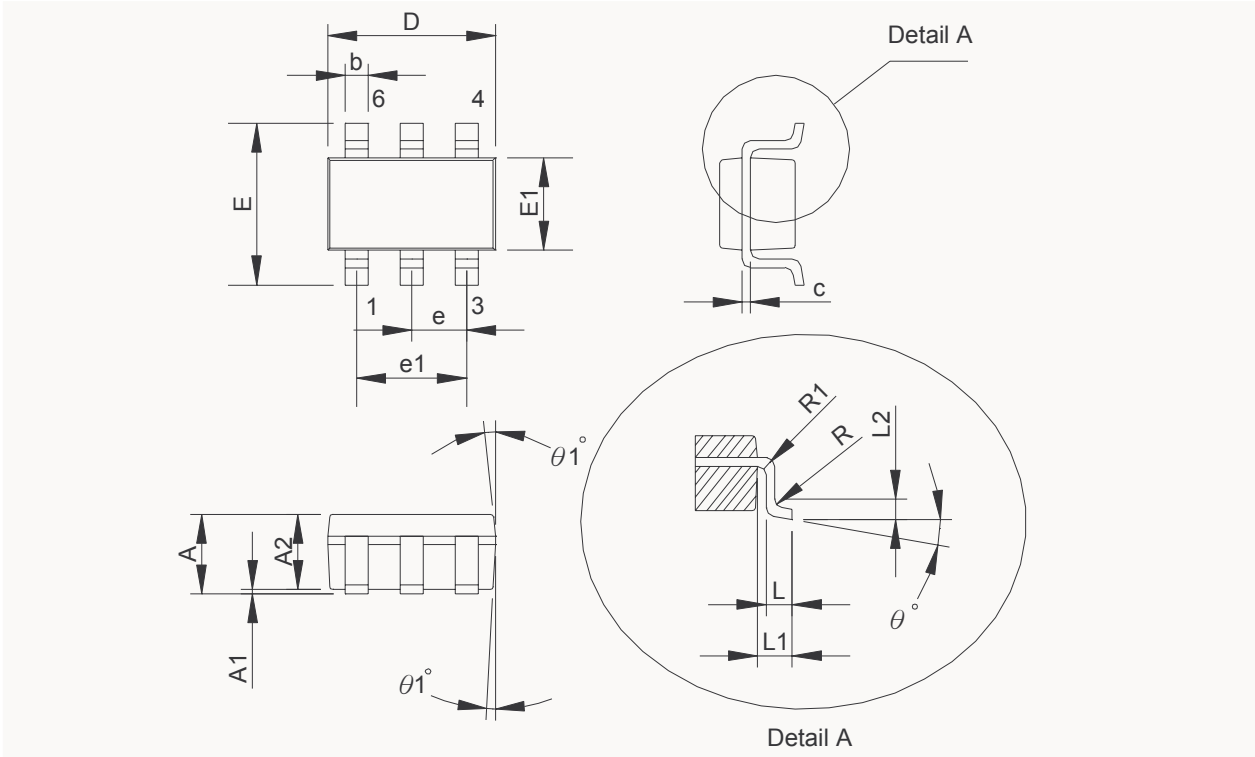
**8 PINS -- DIP (D)**



**Dimensions**

| Symbol         | Millimeters |       |        | Inches |       |       |
|----------------|-------------|-------|--------|--------|-------|-------|
|                | Min.        | Typ.  | Max.   | Min.   | Typ.  | Max.  |
| A              |             |       | 5.334  |        |       | 0.210 |
| A1             | 0.381       |       |        | 0.015  |       |       |
| A2             | 3.175       | 3.302 | 3.429  | 0.125  | 0.130 | 0.135 |
| b              |             | 1.524 |        |        | 0.060 |       |
| b1             |             | 0.457 |        |        | 0.018 |       |
| D              | 9.017       | 9.271 | 10.160 | 0.355  | 0.365 | 0.400 |
| E              |             | 7.620 |        |        | 0.300 |       |
| E1             | 6.223       | 6.350 | 6.477  | 0.245  | 0.250 | 0.255 |
| e              |             | 2.540 |        |        | 0.100 |       |
| L              | 2.921       | 3.302 | 3.810  | 0.115  | 0.130 | 0.150 |
| e <sub>B</sub> | 8.509       | 9.017 | 9.525  | 0.335  | 0.355 | 0.375 |
| θ°             | 0°          | 7°    | 15°    | 0°     | 7°    | 15°   |

**SOT-26 (S)**



**Dimensions**

| Symbol           | Millimeters |      |      | Inches |       |       |
|------------------|-------------|------|------|--------|-------|-------|
|                  | Min.        | Typ. | Max. | Min.   | Typ.  | Max.  |
| A                |             |      | 1.45 |        |       | 0.057 |
| A1               |             |      | 0.15 |        |       | 0.006 |
| A2               | 0.90        | 1.15 | 1.30 | 0.036  | 0.045 | 0.051 |
| b                | 0.30        |      | 0.50 | 0.011  |       | 0.020 |
| c                | 0.08        |      | 0.22 | 0.003  |       | 0.009 |
| D                |             | 2.90 |      |        | 0.114 |       |
| E                |             | 2.80 |      |        | 0.110 |       |
| E1               |             | 1.60 |      |        | 0.063 |       |
| e                |             | 0.95 |      |        | 0.037 |       |
| e1               |             | 1.90 |      |        | 0.075 |       |
| L                | 0.30        | 0.45 | 0.60 | 0.020  | 0.018 | 0.024 |
| L1               |             | 0.60 |      |        | 0.024 |       |
| L2               |             | 0.25 |      |        | 0.010 |       |
| R                | 0.10        |      |      | 0.004  |       |       |
| R1               | 0.10        |      | 0.25 | 0.004  |       | 0.010 |
| $\theta^\circ$   | 0°          | 4°   | 8°   | 0°     | 4°    | 8°    |
| $\theta_1^\circ$ | 5°          | 10°  | 15°  | 5°     | 10°   | 15°   |

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