

## FEATURES

- Linearly Decreasing PWM Frequency
- Green-Mode under Light-Load and Zero-Load Conditions
- Constant Voltage (CV) and Constant Current (CC)
- No Secondary Feedback
- Low Startup Current (5uA)
- Low Operating Current (3.6mA)
- Leading-Edge Blanking
- Constant Power Limit
- Universal AC Input Range
- Synchronized Slope Compensation
- 150°C OTP Sensor with Hysteresis
- $V_{DD}$  Over Voltage Clamping
- Cycle-by-Cycle Current Limiting
- Under Voltage Lockout (UVLO)
- Fixed PWM Frequency (65kHz/100kHz)
- Gate Output Maximum Voltage Clamped at 16.7V
- Small SOT-26 Package

## APPLICATIONS

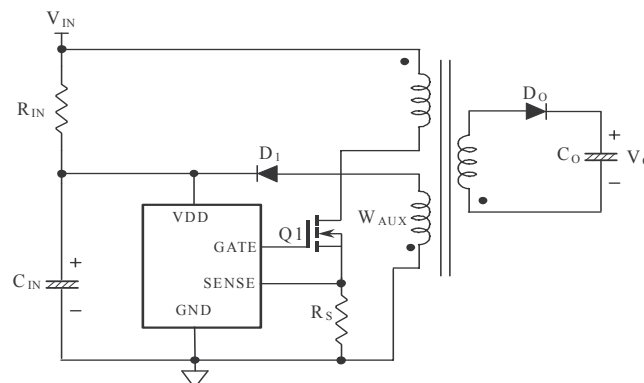
Low-power flyback power converters, such as

- 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, consumer electronics, and PC 5V standby-power.
- Replacements for linear transformers and RCC SMPS.

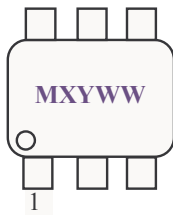
## DESCRIPTION

This highly integrated PWM controller provides several features to enhance the performance of low power flyback converters. To minimize standby power consumption, the proprietary green-mode function provides off-time modulation to linearly decrease the switching frequency under light-load and zero-load conditions. This green-mode function enables the power supply to easily meet international power conservation requirements. The supply voltage  $V_{DD}$  is also used for feedback compensation, to regulate the output voltage without requiring a conventional TL431 and a photo-coupler. Another advantage of the SG6849 is that the typical startup current is only 5uA, while the typical operating current can be as low as 3.6mA. A large startup resistance could be used to achieve even higher power conversion efficiency. Built-in synchronized slope compensation maintains the stability of peak current-mode control. Proprietary internal compensation ensures constant output power limiting over a universal range of AC input voltages, from 90VAC to 264VAC. The SG6849 provides many protection functions. Pulse-by-pulse current limiting ensures a constant output current, even if a short circuit occurs. Also, the internal protection circuit will disable PWM output, if  $V_{DD}$  exceeds 22.7V. The gate output is clamped at 16.7V to protect the power MOS from over-voltage damage. The built-in over temperature protection (OTP) function will shutdown the controller at 150°C with a 20°C hysteresis. The SG6849 is designed to provide a low-cost total solution for flyback converters. It is available in a small footprint, 6-pin, SOT-26 package.

## TYPICAL IC APPLICATION

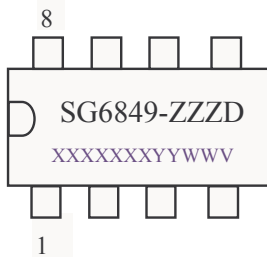
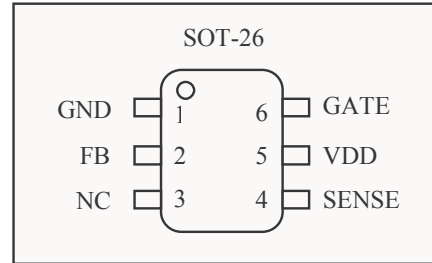


**MARKING INFORMATION**

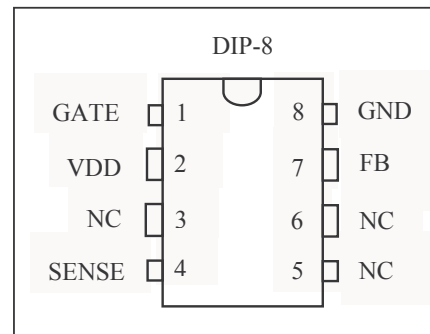


M: Mask Version  
 X: B= SG6849-65T  
   C= SG6849-100T  
 Y: Year  
 WW: Work Week

**PIN CONFIGURATION**



ZZZ: 65 or 100  
 XXXXXXXX: Wafer Lot  
 YY: Year  
 WW: Week  
 V: Assembly Location



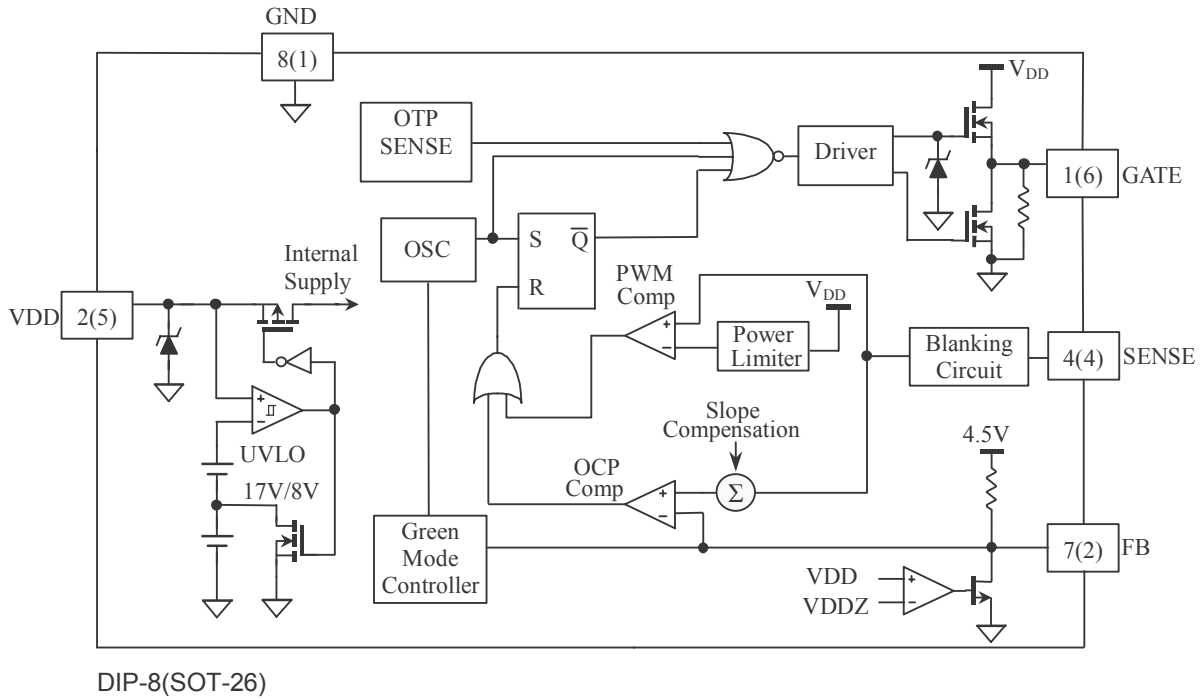
**ORDERING INFORMATION**

| Part Number | PWM Frequency | Package      |
|-------------|---------------|--------------|
| SG6849-65T  | 65kHz         | 6-Pin SOT-26 |
| SG6849-100T | 100kHz        | 6-Pin SOT-26 |
| SG6849-65D  | 65kHz         | 8-pin DIP-8  |
| SG6849-100D | 100kHz        | 8-pin DIP-8  |

**PIN DESCRIPTIONS**

| Name  | Pin No. |        | Type          | Function   |
|-------|---------|--------|---------------|--|
|       | DIP-8   | SOT-26 |               |  |
| GATE  | 1       | 6      | Driver Output | The totem-pole output driver to drive the power MOSFET.  |
| VDD   | 2       | 5      | Supply        | Power supply.  |
| NC    | 3       | NA     |               | NC pin.  |
| SENSE | 4       | 4      | Analog Input  | Current sense. It senses the voltage across a sensed resistor. To provide over-current protection, PWM output is disabled if the voltage exceeds an internal threshold. This pin also provides current information for current-mode control. |
| NC    | 5       | 3      |               | NC pin.  |
| NC    | 6       | NA     |               | NC pin.  |
| FB    | 7       | 2      | Analog Input  | Feedback. The FB pin provides feedback information to the internal PWM comparator. This feedback is used to control the duty cycle. When no feedback is provided, this pin is left open.   |
| 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                           | 30            | V     |      |
|                    | Zener Current                         | 10            | mA    |      |
| V <sub>FB</sub>    | FB Pin Input Voltage                  | -0.3 to 7     | V     |      |
| V <sub>SENSE</sub> | Sense Pin Input Voltage               | -0.3 to 7     | V     |      |
| P <sub>D</sub>     | Power Dissipation                     | 300           | mW    |      |
| R <sub>θJA</sub>   | Thermal Resistance (Junction to Air)  | SOT-26        | 243.3 | °C/W |
|                    |                                       | DIP-8         | 113.0 |      |
| R <sub>θJC</sub>   | Thermal Resistance (Junction to Case) | SOT-26        | 115   | °C/W |
|                    |                                       | DIP-8         | 67.1  |      |
| T <sub>J</sub>     | Operating Junction Temperature        | 150           | °C    |      |
| 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, Human Body 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             | <22.7      | V    |
| T <sub>A</sub>  | Operating Ambient Temperature | -30 to +85 | °C   |

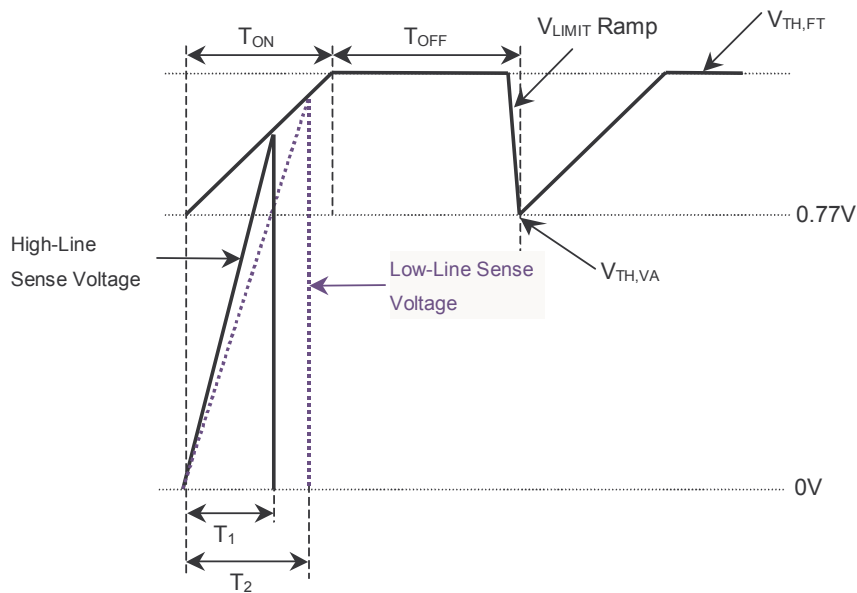
**ELECTRICAL CHARACTERISTICS (V<sub>DD</sub>=15V, T<sub>A</sub>=25°C)**
**Feedback Input Section**

| Symbol           | Parameter                                   | Test Condition           | Min. | Typ. | Max. | Unit |
|------------------|---|--------------------------|------|------|------|------|
| I <sub>OZ</sub>  | Zero Duty-Cycle FB Input Current            |                          |      | 1.15 | 1.4  | mA   |
| V <sub>FB</sub>  | Open Loop Voltage                           |                          |      | 4.5  |      | V    |
| R <sub>FB</sub>  | Input Impedance                             | FB Input Current = 0.1mA |      | 2.4  |      | kΩ   |
| V <sub>DDZ</sub> | V <sub>DD</sub> Feedback Threshold Voltage* | FB Input Current = 0mA   | 20   | 22.7 | 25   | V    |
|                  |   | FB Input Current = 0.8mA | 18   | 20   | 22   | V    |

\*The feedback input is pulled by a transistor that is controlled by the V<sub>DD</sub> signal while V<sub>DD</sub> ≥ V<sub>DDZ</sub>.

**Current Sense Section**

| Symbol             | Parameter  | Test Condition        | Min. | Typ. | Max. | Unit |
|--------------------|--|-----------------------|------|------|------|------|
| TPD                | Propagation Delay                                    |                       |      | 100  |      | ns   |
| V <sub>TH,VA</sub> | Current Limiting Valley Threshold Voltage for 65kHz  | V <sub>DD</sub> = 20V | 0.84 | 0.89 | 0.94 | V    |
|                    |  | V <sub>DD</sub> = 15V | 0.72 | 0.77 | 0.82 | V    |
|                    |  | V <sub>DD</sub> = 10V | 0.58 | 0.63 | 0.68 | V    |
|                    | Current Limiting Valley Threshold Voltage for 100kHz | V <sub>DD</sub> = 20V | 0.76 | 0.81 | 0.86 | V    |
|                    |  | V <sub>DD</sub> = 15V | 0.65 | 0.70 | 0.75 | V    |
|                    |  | V <sub>DD</sub> = 10V | 0.52 | 0.57 | 0.62 | V    |



**Oscillator Section**

| Symbol                 | Parameter   | Test Condition              | Min.                     | Typ.                     | Max.                     | Unit |
|------------------------|---|-----------------------------|--------------------------|--------------------------|--------------------------|------|
| F <sub>OSC</sub>       | SG6849–65 Frequency   |                             | 60                       | 65                       | 70                       | kHz  |
| F <sub>OSC</sub>       | SG6849–100 Frequency  |                             | 92                       | 100                      | 108                      | kHz  |
| F <sub>OSC-G-BK</sub>  | Green-Mode Burst Back Frequency*                                  |                             | 20                       | 25                       | 30                       | kHz  |
| F <sub>OSC-G-OFF</sub> | Green-Mode OFF Frequency*   |                             |                          | 0                        |                          | kHz  |
| I <sub>FB-G-OFF</sub>  | Green-Mode OFF FB Input Current                                   |                             | 0.9                      | 1.15                     | 1.4                      | mA   |
| F <sub>DV</sub>        | Frequency Variation versus V <sub>DD</sub> Deviation              | V <sub>DD</sub> = 10 to 20V |                          |                          | 2                        | %    |
| V <sub>DD-TH-G</sub>   | V <sub>DD</sub> -Low Threshold Voltage for Exiting Green-Mode OFF |                             | V <sub>DD OFF</sub> +1.0 | V <sub>DD OFF</sub> +1.5 | V <sub>DD OFF</sub> +2.0 | V    |

\*Please see the “Green-Mode Burst Back (F<sub>OSC-G-BK</sub>) and Green-Mode OFF Frequency (F<sub>OSC-G-OFF</sub>) vs. V<sub>DD</sub>” curves.

### Output Section

| Symbol             | Parameter                  | Test Condition                               | Min. | Typ. | Max. | Unit |
|--------------------|----------------------------|--|------|------|------|------|
| DCY <sub>MAX</sub> | Maximum Duty Cycle         |  | 70   | 75   | 80   | %    |
| Bnk                | Leading Edge Blanking Time |  |      | 310  |      | ns   |
| V <sub>OL</sub>    | Output Voltage Low         | V <sub>DD</sub> = 15V, I <sub>O</sub> = 10mA |      |      | 1.5  | V    |
| V <sub>OH</sub>    | Output Voltage High        | V <sub>DD</sub> = 15V, I <sub>O</sub> = 10mA | 8    |      |      | V    |
| T <sub>R</sub>     | Rising Time                | V <sub>DD</sub> = 15V, C <sub>L</sub> = 1nF  |      | 200  |      | ns   |
| T <sub>F</sub>     | Falling Time               | V <sub>DD</sub> = 15V, C <sub>L</sub> = 1nF  |      | 80   |      | ns   |
| V <sub>CLAMP</sub> | Output Clamp Voltage       | V <sub>DD</sub> = 20V                        |      | 16.7 | 18   | V    |

### Over Temperature Protection (OTP)

| Symbol       | Parameter                                     | Test Condition | Min. | Typ. | Max. | Unit |
|--------------|---|----------------|------|------|------|------|
| Temp-Off     | Protection Junction Temperature <sup>*1</sup> |                |      | 150  |      | °C   |
| Temp-Restart | Restart Junction Temperature <sup>*2</sup>    |                |      | 130  |      | °C   |

<sup>\*1</sup>When activated, the output is disabled and the latch is turned off.

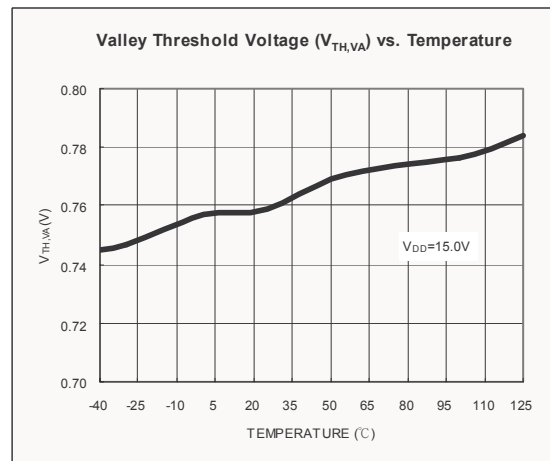
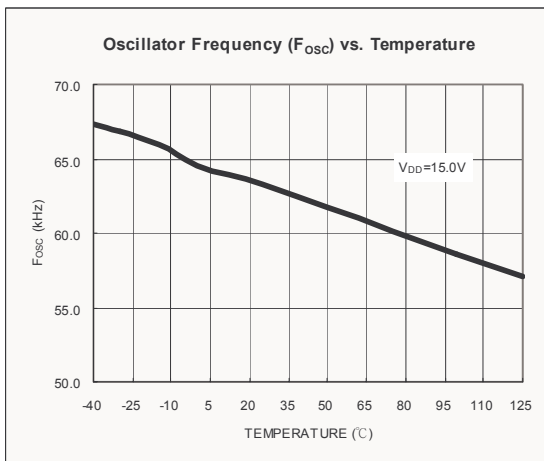
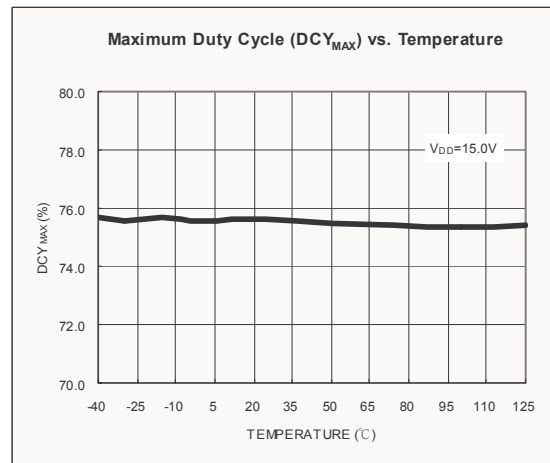
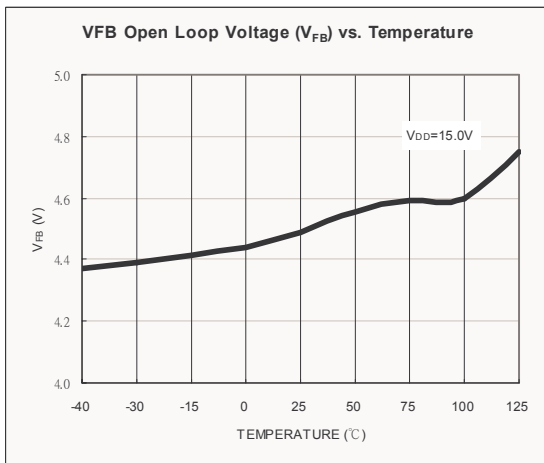
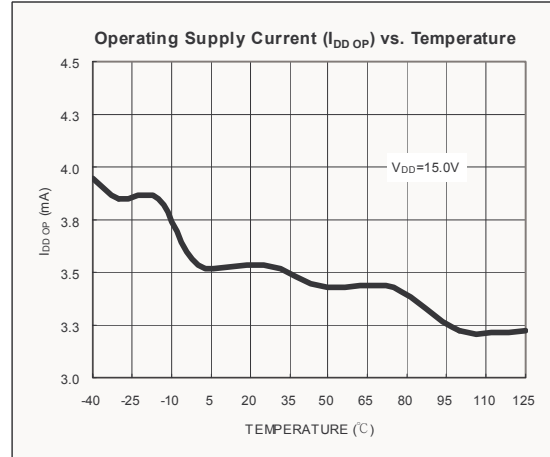
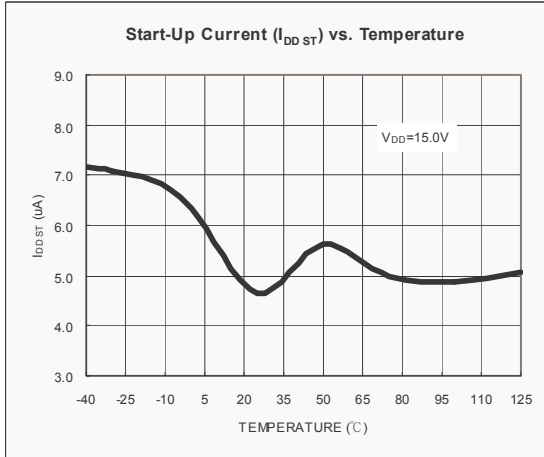
<sup>\*2</sup>This is the threshold temperature for enabling the output again and resetting the latch, after over temperature protection has been activated.

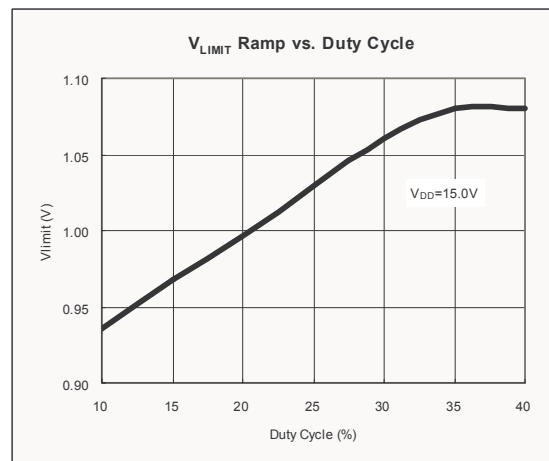
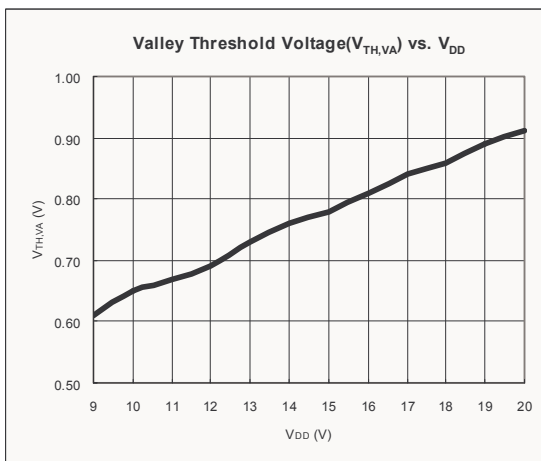
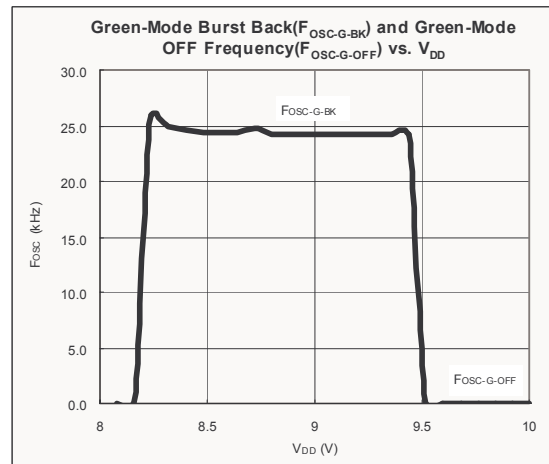
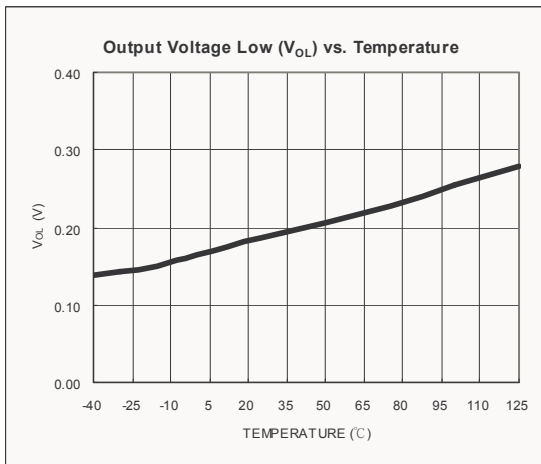
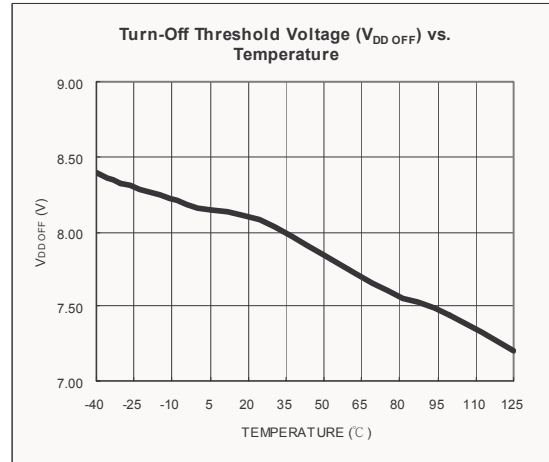
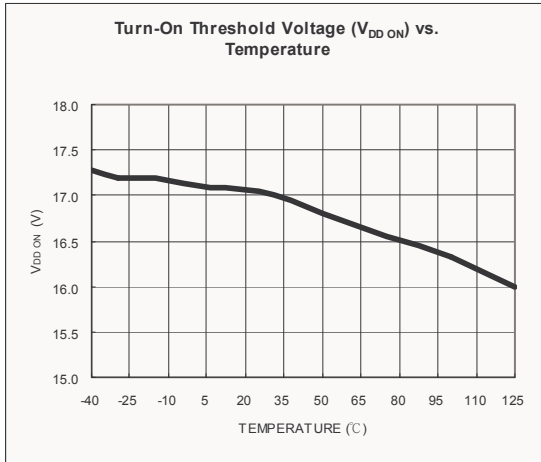
### VDD Section

| Symbol                | Parameter                     | Test Condition                        | Min. | Typ. | Max. | Unit |
|-----------------------|-------------------------------|---------------------------------------|------|------|------|------|
| V <sub>DD ON</sub>    | Turn-On Threshold Voltage     |                                       | 16   | 17   | 18   | V    |
| V <sub>DD OFF</sub>   | Turn-Off Threshold Voltage    |                                       | 7.5  | 8    | 8.5  | V    |
| I <sub>DD ST</sub>    | Startup Current               | V <sub>DD</sub> = 15V                 |      | 5    | 30   | uA   |
| I <sub>DD OP</sub>    | Operating Supply Current      | V <sub>DD</sub> = 15V<br>GATE is Open |      | 3.6  | 6    | mA   |
| V <sub>DD CLAMP</sub> | Zener Diode Breakdown Voltage | I <sub>DD</sub> = 10mA                |      | 28   | 30   | V    |

**TYPICAL CHARACTERISTICS**

**SG6849-65**







## OPERATION DESCRIPTION

SG6849 devices integrate many useful functions for low power switch mode power supplies. The following descriptions highlight the key features of the SG6849.

### Startup Current

The required startup current is only 5 $\mu$ A. This allows a high-resistance, low-wattage startup resistor to be used to supply the controller's startup power. A 1.5 M $\Omega$ /0.25W startup resistor can be used over a wide input range (100V-240V AC) with very little power loss.

### Operating Current

The operating current is normally 3.6mA. The low operating current results in higher efficiency and reduces the required  $V_{DD}$  hold-up capacitance. A 10 $\mu$ F/25V  $V_{DD}$  hold-up capacitor can be used over a wide input range (100V-240V AC) with very little power loss.

### Green Mode Operation

The proprietary green-mode function provides off-time modulation to linearly decrease the switching frequency under light-load and zero-load conditions. The on-time is limited to provide better protection against brownouts and other abnormal conditions.

This green-mode function dramatically reduces power consumption under light-load and zero-load conditions. Power supplies using the SG6849 can easily meet international restrictions regarding standby power-consumption.

### Constant Voltage (CV) and Constant Current (CC) without Feedback

The SG6849 can tightly regulate the output voltage and provide over current protection without requiring secondary-side feedback signals. For improved CV and CC accuracy, the transformer leakage inductance should be reduced as much as possible.

### Over Temperature Protection (OTP)

The SG6849 has a built-in temperature sensing circuit to shut down PWM output once the junction temperature exceeds 150°C. While PWM output is shut down, the  $V_{DD}$  voltage will gradually drop to the UVLO voltage. Some of the SG6849's internal circuits will be shut down, and  $V_{DD}$  will gradually start increasing again. When  $V_{DD}$  reaches 17V, all the internal circuits, including the temperature sensing circuit, will start operating normally. If the junction temperature is still higher than 150°C, the PWM controller will be shut down immediately. This situation will continue until the temperature drops below 130°C. The PWM output will then be turned back on. The temperature hysteresis window for the OTP circuit is 20°C.

### $V_{DD}$ Over Voltage Clamping

$V_{DD}$  over voltage clamping is built in to prevent damage from over-voltage conditions. When  $V_{DD}$  exceeds 22.7V, PWM output is shut down. Over-voltage conditions may be caused by an open photo-coupler loop or a short circuit in the output.

### Oscillator Operation

The oscillation frequency is fixed at 65kHz for the SG6849-65, and at 100kHz for the SG6849-100.

### 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 310ns leading-edge blanking time is built in. Conventional RC filtering is not necessary. During this blanking period, the current-limit comparator is disabled, and it cannot switch off the gate drive.

### Constant Output Power Limit

When the SENSE voltage across the sense resistor  $R_S$  reaches the threshold voltage (around 1.0V), the output GATE drive will be turned off following a small

propagation delay  $T_{PD}$ . This propagation delay will introduce an additional current proportional to  $T_{PD} * V_{IN} / L_p$ . The propagation delay is nearly constant regardless of the input line voltage  $V_{IN}$ . Higher input line voltages will result in larger additional currents. Thus, under high input-line voltages the output power limit will be higher than under low input-line voltages.

Over a wide range of AC input voltages, the variation can be significant. To compensate for this, the threshold voltage is adjusted by adding a positive ramp. This ramp signal can vary from 0.77V to 1.05V for SG6849-65 and 0.70 to 1.03V for SG6849-100, and it flattens out at 1.05V and 1.03V respectively. A smaller threshold voltage forces the output GATE drive to terminate earlier, thus reducing total PWM turn-on time and making the output power equal to that of the low line input. This proprietary internal compensation feature ensures a constant output power limit over a wide range of AC input voltages (90VAC to 264VAC).

### Under Voltage Lockout (UVLO)

The turn-on/turn-off thresholds of the SG6849 are fixed internally at 17V/8V. To enable the SG6849 during startup, the hold-up capacitor must first be charged to 17V through the startup resistor.

The hold-up capacitor will continue to supply  $V_{DD}$  before energy can be delivered from the auxiliary winding of the main transformer.  $V_{DD}$  must not drop below 8V during this startup process. This UVLO hysteresis window ensures that the hold-up capacitor can adequately supply  $V_{DD}$  during startup.

### Gate Output

The SG6849 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 16.7V Zener diode in order to protect the power MOSFET transistors against any harmful over-voltage gate signals.

### Slope Compensation

The sensed voltage across the current sense resistor is used for current mode control and pulse-by-pulse current limiting. The built-in slope compensation function improves power supply stability. Furthermore, it prevents sub-harmonic oscillations that normally would occur because of peak current mode control. A positively sloped, synchronized ramp is activated by the SG6849 with every switching cycle. The slope of the ramp is

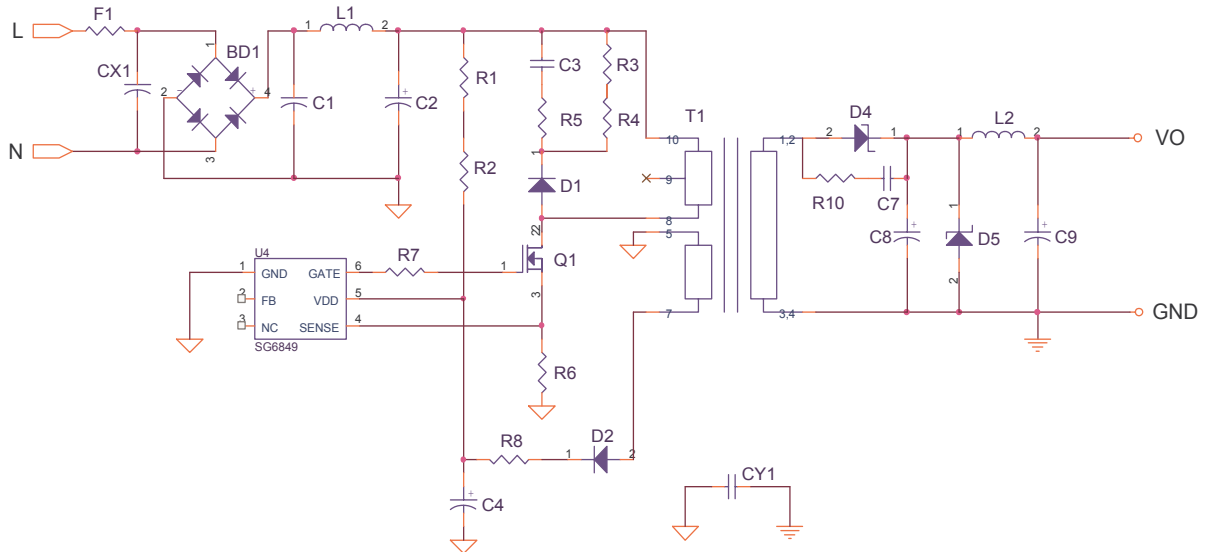
$$\frac{0.33 \times Duty}{Duty(max)}$$

### Noise Immunity

Noise from the current sense or the control signal may cause significant pulse width jitter, particularly in continuous-conduction mode. Slope compensation helps alleviate this problem. Good placement and layout practices should be followed. The designer should avoid long PCB traces and component leads. Compensation and filter components should be located near the SG6849. Finally, increasing the power-MOS gate resistance is advised.

**REFERENCE CIRCUIT**

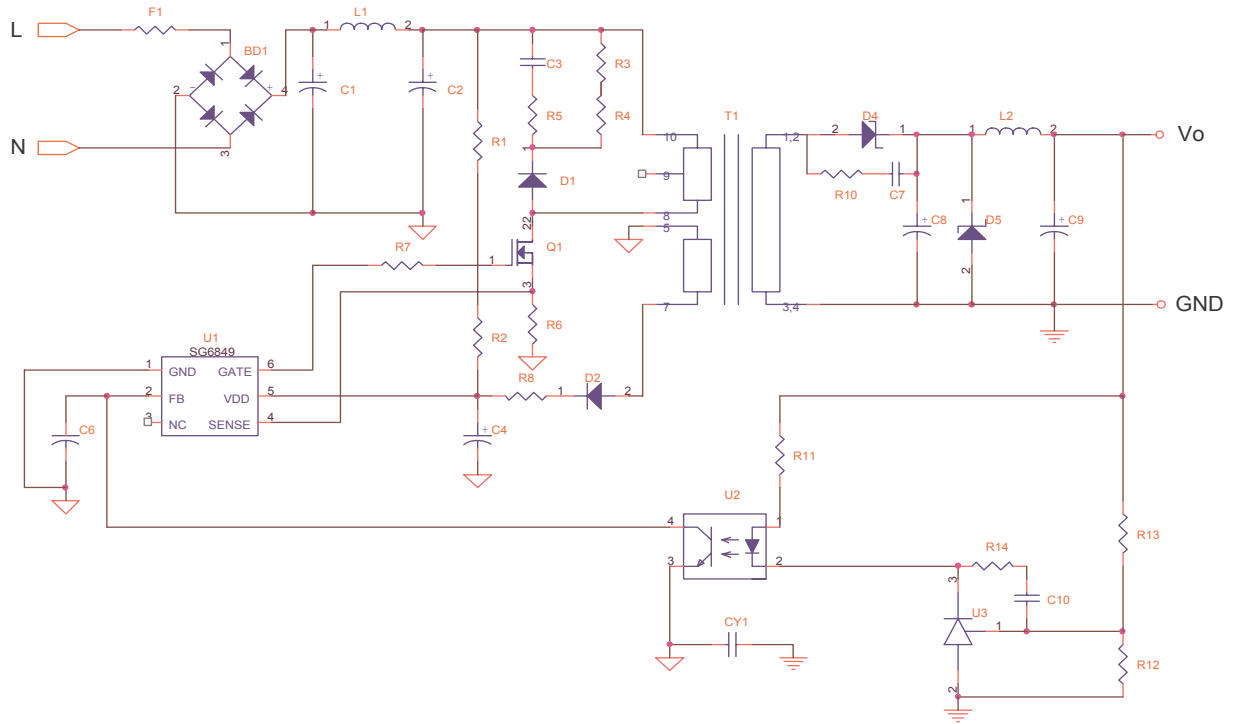
**3W Flyback 5V/0.6A Circuit, without Secondary-Side Feedback**



**BOM**

| Symbol       | Component          | Symbol       | Component                |
|--------------|--------------------|--------------|--------------------------|
| BD1          | BD 1A/500V         | L1           | 20mH 6*8mm               |
| CX1 (Option) | YC 472pF/400V (Y1) | L2           | 10uH 6mm                 |
| CY1 (Option) | YC 102pF/400V (Y1) | Q1           | MOSFET 1A/600V           |
| C2           | EC 10uF/400V 105°C | R1,R2        | R 750kΩ 1206             |
| C1           | CC 103pF/500V      | R3,R4        | R 47kΩ 1206              |
| C3           | CC 1000pF/500V     | R5           | R 47Ω 1206               |
| C4           | EC 10uF/50V        | R6           | R 4.7Ω 1206              |
| C7 (Option)  | CC 102pF/100V 1206 | R7           | R 100Ω 0805              |
| C8           | EC 470uF/10V 105°C | R8           | R 10Ω 1206               |
| C9           | EC 220uF/10V 105°C | R10 (Option) | R 10Ω 1206               |
| D1           | Diode FRI07        | T1           | EE-16                    |
| D2           | Diode FR102        | U4           | IC SG6849 (Green PWM IC) |
| D4           | Diode SB360        |              |                          |
| D5 (Option)  | ZD 6.8V 0.5W       |              |                          |
| F1           | R 1Ω/0.5W          |              |                          |

**3W Flyback 5V/0.6A Circuit, with Secondary-Side Feedback**

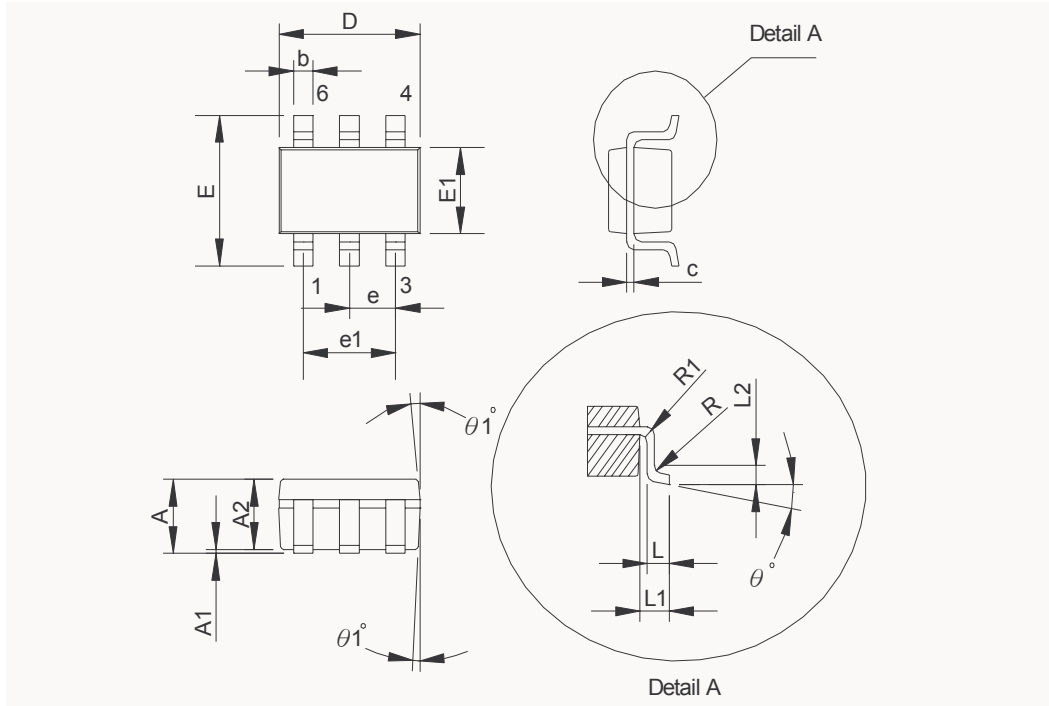


**BOM**

| Symbol               | Component                | Symbol | Component             |
|----------------------|--------------------------|--------|-----------------------|
| BD1 (Reference only) | DI106 1A/600V            | L2     | 10uH 6mm              |
| CY1 (Option)         | YC 102p/400V             | Q1     | MOSFET 1A/600V        |
| C2                   | 10uF/400V 10Φ*16mm 105°C | R1,R2  | 750k 1206             |
| C1                   | 103p/500V (0.01uF/500V)  | R4,R3  | 47k/1206              |
| C3                   | 1000p/500V CER           | R5     | 47 1206               |
| C4                   | 10u/50V 5mm              | R6     | 3.7 1206              |
| C6                   | 472p 0805                | R7     | 100 0805              |
| C7                   | 102p/100V 1206           | R10    | 10 1206               |
| C8                   | 470u/10V 8Φ*11.5mm 105°C | R8     | 5 1206                |
| C9                   | 470u/10V 8Φ*11.5mm 105°C | R11    | 100 1/8W              |
| C10                  | 222p 0805                | R12    | 33k 0805              |
| D1                   | FR107                    | R13    | 33k 1/8W              |
| D2                   | FR102                    | R14    | 4.7k 0805             |
| D4                   | SB360 (3A/60V; Schottky) | T1     | EE-16                 |
| D5 (Option)          | ZD/6.8V 0.5W             | U1     | SG6849 (Green PWM IC) |
| F1                   | 1Q1/2W Resistor          | U2     | PC817                 |
| L1                   | 20mH 6*8mm               | U3     | TL431                 |
| BD1 (Reference only) | DI106 1A/600V            | L2     | 10uH 6mm              |

**PACKAGE INFORMATION**

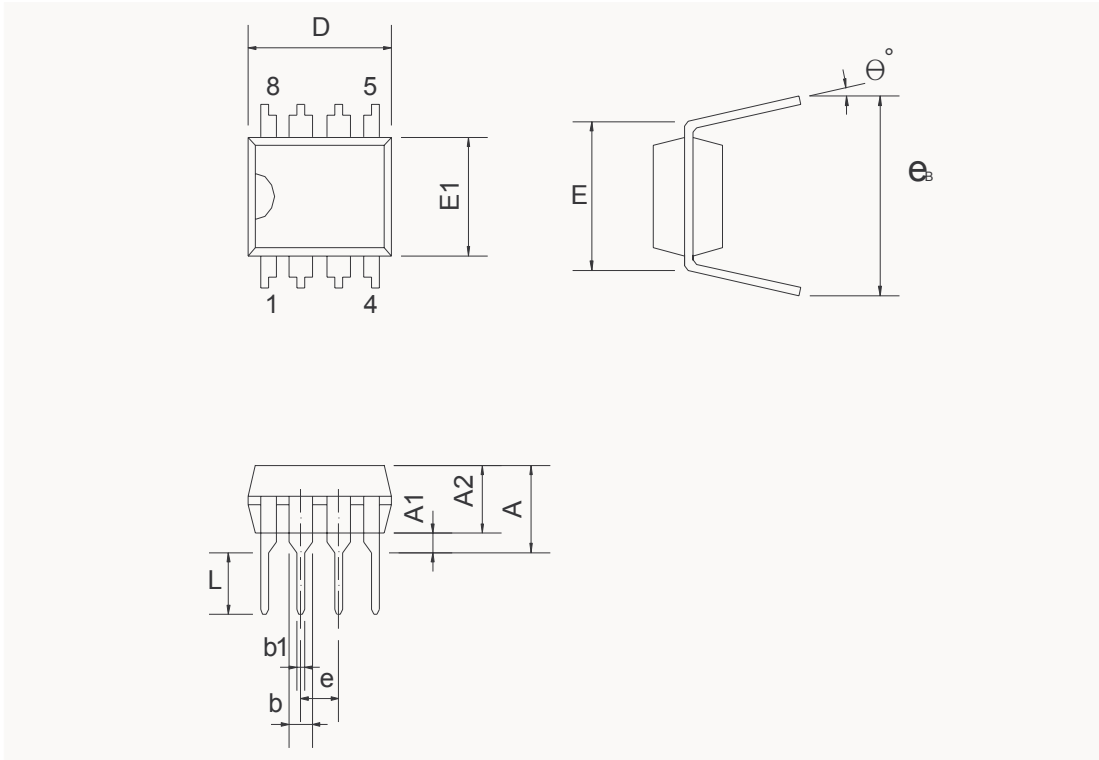
**The SOT-26 Package**



**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 | 0.24  |
| L1      |             | 0.60 |      |        | 0.024 |       |
| L2      |             | 0.25 |      |        | 0.010 |       |
| R       | 0.10        |      |      | 0.004  |       |       |
| R1      | 0.10        |      | 0.25 | 0.004  |       | 0.25  |
| theta°  | 0°          | 4°   | 8°   | 0°     | 4°    | 8°    |
| theta1° | 5°          | 10°  | 15°  | 5°     | 10°   | 15°   |

**The DIP-8 Package**



**Dimensions:**

| Symbol         | Millimeter |       |        | Inch  |       |       |
|----------------|------------|-------|--------|-------|-------|-------|
|                | 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 |
| $e_R$          | 8.509      | 9.017 | 9.525  | 0.335 | 0.355 | 0.375 |
| $\theta^\circ$ | 0          | 7     | 15     | 0     | 7     | 15    |

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