2MHz, 1.5A Flash LED Driver in TDFN-3×2-14L Package

General Description

The AP3267 is the ideal power solution for highpower flash LEDs used with cell phone camera modules or digital still cameras. It is a highly integrated step-up DC/DC converter with very high switching frequency, fixed at 2MHz, providing a very small total solution for portable photo flash. The AP3267 has separate Flash mode and Movie/Torch mode enable pins for maximum flexibility. Flash mode is usually used with 700ms timer control to generate a high intensity flash. The Flash mode and Movie/Torch mode LED current is programmed by external resistors respectively, making the flash LED solution simple to control. If both enable pins are at logic high, the LED current will be programmed by the Movie/Torch mode setting resistor.

The two LED output sinks can be shorted together externally for higher power single flash LEDs, up to 1.5A continuous LED current. Thermal regulation is integrated in Flash mode to limit the IC's temperature and continuously provide the maximum allowed output current.

Various protection features are built into the AP3267, including cycle-by-cycle input current limit protection, output over-voltage protection, LED fault (open or short) protection and thermal shutdown protection. The leakage current in shutdown is 0.1μA.

The AP3267 is available in Green TDFN-3×2-14L package. It operates over an ambient temperature range of -40℃ to +85℃.

Applications

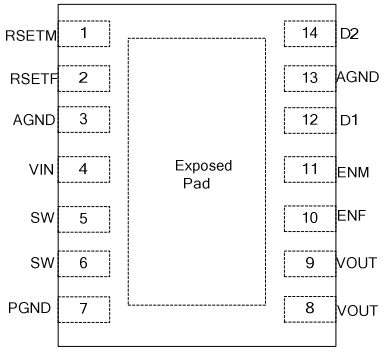
- Portable Equipments

Features

- Input Voltage Range: 3V to 5V
- Dual Flash LED Outputs
- Drive Up to Total 1.5A or 0.75A per Channel
- High Efficiency LED Driver (Up to 90%)
- 2MHz Step-Up Converter
- Very Small Inductor: 1.0μH
- Independent Flash Mode Enable and Movie/Torch
- Mode Enable Pins
- Movie/Torch Mode Dimming via PWM Control
- One Resistor Sets Flash Mode LED Current
- One Resistor Sets Movie/Torch Mode LED Current
- Integrated Thermal Regulation Control
- 700ms Flash Timer Control
- 200kΩ Pull-Down Resistor on ENM or ENF Pin
- LED Open or Short Protection
- Output Over-Voltage Protection
- Cycle-by-Cycle Inductor Current Limit
- 0.1μA Shutdown Current
- Available in Green TDFN-3×2-14L Package
- Temperature Range: -40℃ to +85℃

Package

TDFN-3×2-14L



Typical Application Circuit

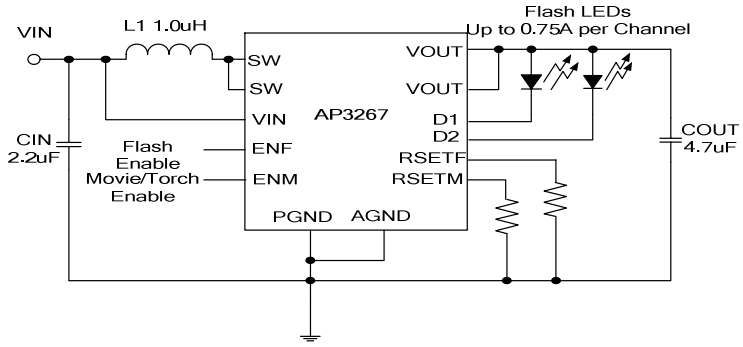


Figure 1. Basic Application Circuit with AP3267

Pin Description

Pin No.	Pin Name	Pin Function
1	RSETM	Movie and Torch Mode Current Setting Pin.
2	RSETF	Flash Mode Current Setting Pin.
3,13	AGND	Analog Ground Pin.
4	VIN	Input Supply Pin for the IC.
5，6	SW	Switching Node of the Step-Up Converter.
7	PGND	Power Ground Pin.
8，9	VOUT	Output Voltage Pin.
10	ENF	Flash Mode Enable Pin. This pin has an internal 200kΩ pull-down resistor to AGND.
11	ENM	Movie or Torch Mode Enable Pin. This pin has an internal 200kΩ pull-down resistor to AGND.
12	D1	Regulated Output Current Sink 1. Up to 0.75A current. D1 and D2 pins can be connected together to sink 1.5A combined.
14	D2	Regulated Output Current Sink 2. Up to 0.75A current. D1 and D2 Pins can be connected together to sink 1.5A combined.
Exposed Pad	AGND	Exposed Pad. Connected to ground for electrical and thermal usage. Exposed pad is internally connected to analog ground pin.

Function Block Diagram

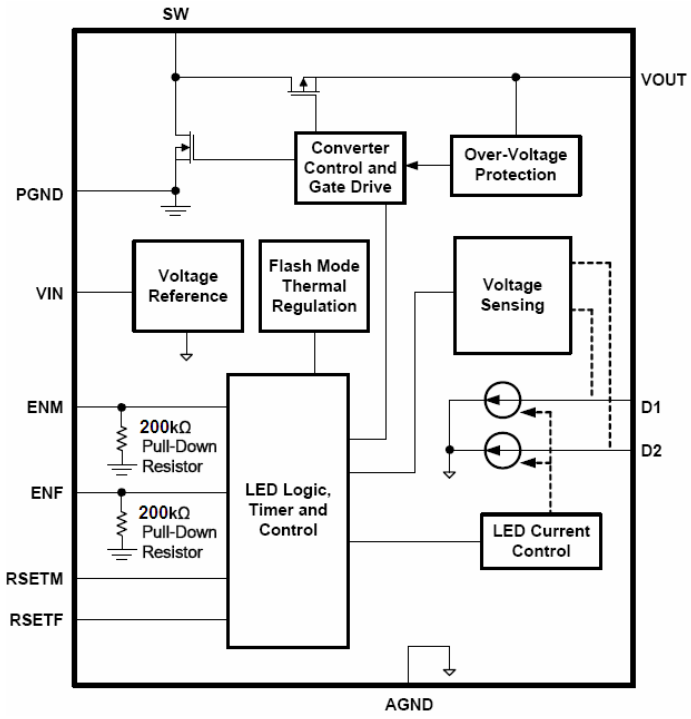
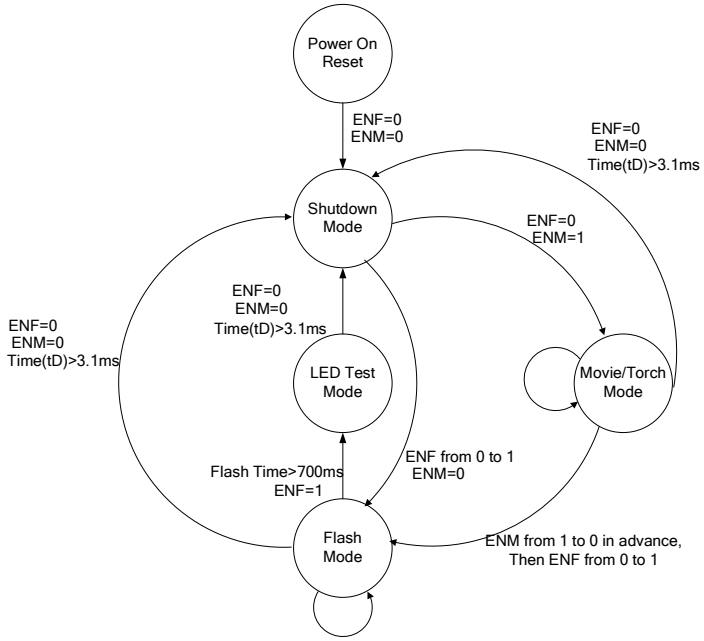


Figure 2 Function Block Diagram

State Diagram



Absolute Maximum Ratings (Note 1)

VIN, VOUT, D1 and D2 Voltages..... -0.3V to 6V
ENF, ENM, RSETF, RSETM .....-0.3V to VIN + 0.3V
SW Voltage..... -0.3V to 6.5V
Storage Temperature Range.....-65℃ to +150℃
Junction Temperature.....150℃
Operating Temperature Range.....-40℃ to +85℃
Lead Temperature (Soldering 10 sec).....260℃

Note 1. Stresses listed as the above "Absolute Maximum Ratings" may cause permanent damage to the device. These are for stress ratings. Functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may remain possibility to affect device reliability.

Electrical Characteristics

(VIN=VEN=3.6V, TA = 25°C, unless otherwise specified)

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Input Operating Range	VIN		3		5	V
Input Under Voltage Lockout	UVLO	Rising edge		2.4		V
UVLO Hysteresis	$UVLO_{HYST}$			0.2		V
IC Operating Current	I_Q	Not switching		340		uA
VIN Pin Shutdown Current	I_{SHDN}	ENF = ENM = GND		0.1		uA
Peak NMOS Current Limit	I_{LIM}			3.4		A
Oscillator Frequency	F_{SW}			2		MHz

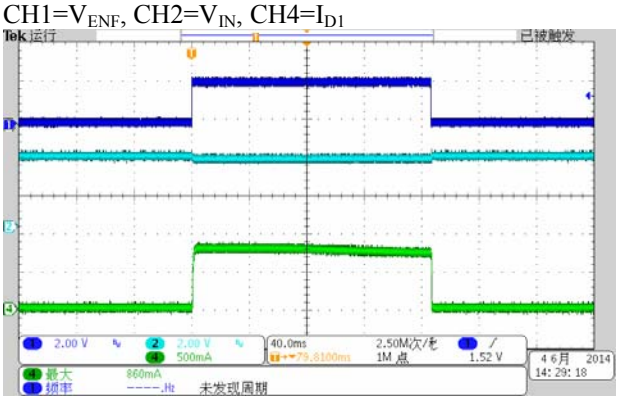
Internal OVP Threshold of VOUT	V_{OVP}			5.3		V
Flash Mode Soft-Start Time	T_S			1		ms
Total Output Current, Movie/Torch Mode	I_D	ENM = HIGH, R_{SETM} = 75kΩ, D1 + D2		200		mA
Total Output Current, Flash Mode	I_D	ENF = HIGH, ENM = GND, R_{SETF} = 12kΩ, D1 + D2		1.5		A
Output Current Matching (Note 2)	I_D	100mA each channel		1		%
		750mA each channel		1		%
LED Short Checking Current	I_{SHORT}			2.5		mA
ENF, ENM Pin Logic Low Threshold	V_{TH-L}				0.6	V
ENF, ENM Pin Logic High Threshold	V_{TH-H}		1.5			V
ENF Internal Pull-Down Resistance	$R_{PD(ENF)}$			200		K Ω
ENM Internal Pull-Down Resistance	$R_{PD(ENM)}$			200		K Ω
IC Junction Thermal Shutdown Threshold	T_{J-TH}			150		°C
IC Junction Thermal Shutdown Hysteresis	T_{J-TH}			28		°C
Delay Time	T_D	Delay time to shutdown status in Movie/Torch Mode		3.1		ms
Hardware Flash Timer	T_{TIME}			700		ms

Note 2. The current matching between channels is defined as $(I_{D1} - I_{D2})/(I_{D1} + I_{D2})$.

Typical Performance Characteristics

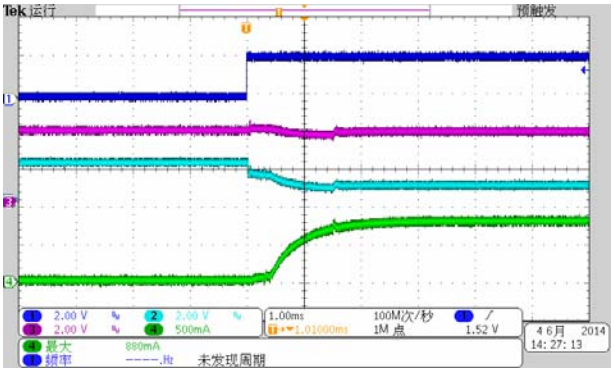
1.5A Flash Operation

CH1=V_{ENF}, CH2=V_{IN}, CH4=I_{D1}

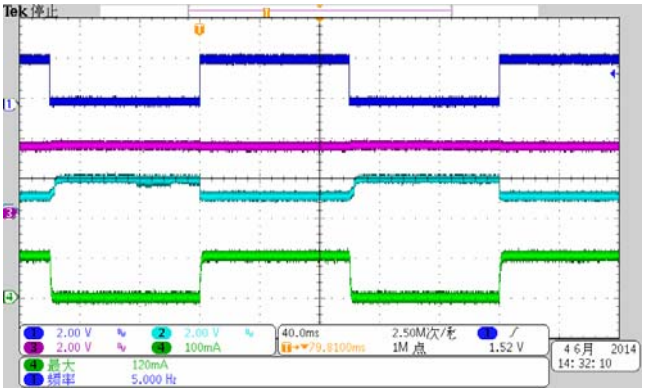


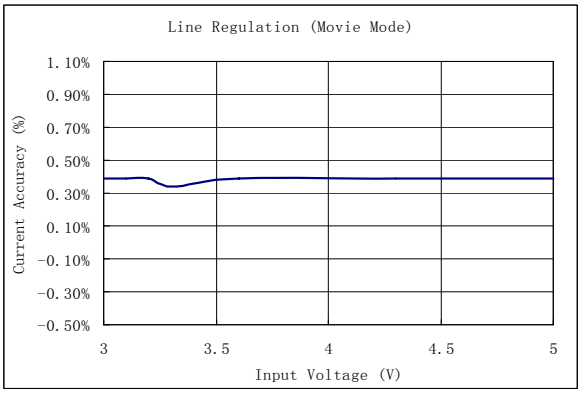
Flash Turn On in Soft-Start

CH1=V_{ENF}, CH2= V_{D1}, CH3= V_{OUT}, CH4= I_{D1}



Movie Mode Turn On or Off
CH1=V_{ENm}, CH2= V_{D1}, CH3= V_{OUT}, CH4= I_{D1}





Ordering Information

Order codes	Mark	Package
AP3267DF14ER	AP3267 YYWWP[1]	TDFN3*2-14L

1.YYWW=date code
P=Package factory

Applications Information

Functional Description

The AP3267 is a very high switching frequency step-up (boost) flash LED driver. Two current regulating devices are integrated to drive up to 2 flash LEDs.

The voltage step-up is accomplished by a boost topology, using an inductor-based DC/DC switching converter, in which the inductor serves as an energy storage device. By integrating optimized power MOSFETs, the AP3267 internal switching frequency is 2MHz while still maintaining high power efficiency. Unlike a traditional DC/DC boost converter with a fixed output voltage, the AP3267 dynamically changes its output voltage depending on the flash LED forward voltage and current. The use of unique control schemes maintains accurate current regulation in each of the two current sinks while leaving the output voltage at a minimum, increasing the overall conversion efficiency. The internal step-up converter boosts the output voltage high enough to drive the LEDs with the highest forward voltage. The two current sinks can be shorted together to drive a higher current single flash LED, sinking up to 1.5A combined. The control interface is designed for maximum design flexibility and compatibility with various types of system controls. When the ENF is pulled high while the ENM is low, the LED current will be ramped up to the Flash mode current level which is programmed by RSETF resistor. When ENM is pulled high while the ENF is low, the LED current will be ramped up to the Movie/Torch mode current level which is programmed by RSETM resistor. However, if both ENM and ENF are high, the LED current will be set to Movie/Torch mode current. The driver IC and the flash LEDs will be shutdown when both ENF and ENM are at logic low.

Flash Mode LED Current

D1 and D2 Flash mode LED current can be programmed up to a maximum total current of 1.5A or up to 0.75A per channel. The sink current in D1 and D2 are internally matched in the AP3267. The Flash mode current in each channel is set by the RSETF resistor. For the desired Flash mode current in each output, the resistor value can be calculated using the following equation:

$I_{FLASH\ (D1)} = I_{FLASH\ (D2)} = 9000/R_{SETF}$

For AP3267, the minimum flash time is 150ms. A flash event is initiated by asserting the ENF pin while ENM is at logic low level. A flash event is automatically terminated when ENF is deasserted or when ENM is asserted. Automatic thermal regulation control is active when AP3267 is in Flash mode. If Flash mode is enabled and the flash current is set to a high current value, the temperature of the IC can increase quickly. Once the IC's temperature goes above 100℃, the two sinks' currents will be automatically decreased according to the thermal regulation control loop. This can prevent the IC from

triggering thermal shutdown and causing the LEDs to flicker. Depending on the thermal layout of the PCB and the Flash mode current setting, the AP3267 sink current can be lower than the programmed value due to the thermal regulation protection feature.

LED Short Protection

When the AP3267 is enabled, there is a 2.5mA (typical) LED sensing current through each current sink. It is used to detect whether either LED is shorted by generating a voltage drop through each LED. The IC internally compares the voltage difference between VOUT and each sink node (D1 and D2). If this difference is below a preset threshold, the IC will treat the respective LED as shorted and disable its Flash/Movie mode current through this LED channel. However, the 2.5mA sensing current will be kept to generate the LED's voltage drop. Because some normal flash LEDs may have larger than desired leakage current (up to hundreds of microamps) even it's not fully turned on, this 2.5mA sensing current can guarantee that a properly functioning LED will not mistakenly be treated as a shorted LED. If the short circuit is removed during operation, the channel will automatically recover to the programmed current setting.

LED Open Protection

In case of LED open, the open channel will control the loop first so that VOUT will reach OVP (approximately 5.3V), and then AP3267 will automatically detect which channel's LED is open and disable that channel. From that point, the other channel with properly operating LED will control the loop and VOUT will be regulated down to a normal operating voltage. This protection feature avoids unnecessary power consumption in the current sink by regulating the output voltage at the lowest level possible to maintain regulation for the active channel. Not only does this protect from open LEDs failures, but also allows only single flash LED operation with the unused channel floating or open. Open-circuit LED fault protection is reset when the IC is powered down and up again.

Movie/Torch Mode LED Current

D1 and D2 Movie/Torch mode LED current can be programmed up to a maximum total current of 400mA or up to 200mA per channel. Just as in Flash mode operation, the output currents in D1 and D2 are internally matched. The Movie/Torch mode current in each channel is set by the RSETM resistor. For the desired Movie/Torch mode current in each output, the resistor value can be calculated using the following equation:

$I_{MOVIE\ (D1)} = I_{MOVIE\ (D2)} = 7500/R_{SETM}$

A Movie/Torch mode event is initiated by asserting the ENM pin. For additional flexibility, a lower Movie/Torch mode current than the value calculated above can be realized by applying a PWM dimming signal (see Figure 3) at ENM pin while ENF is held low. The average Movie/Torch mode current will be proportional to the PWM duty ratio.

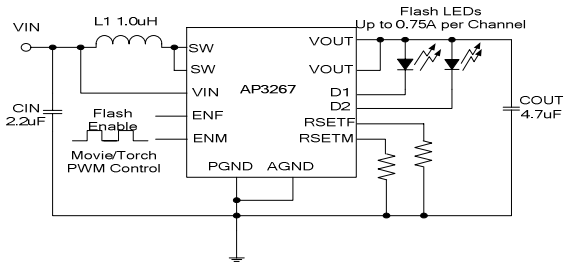


Figure 3. Controlling Movie/Torch Mode with PWM Dimming Signal

Single/Dual LED Applications

Each of the sinks' (D1 and D2) current is regulated and matched for applications requiring two LEDs. For single LED applications, D1 and D2 can be connected together to drive one LED (see Figure 4). The current per sink follows the equations in Flash mode LED Current and Movie/Torch mode LED Current sections above.

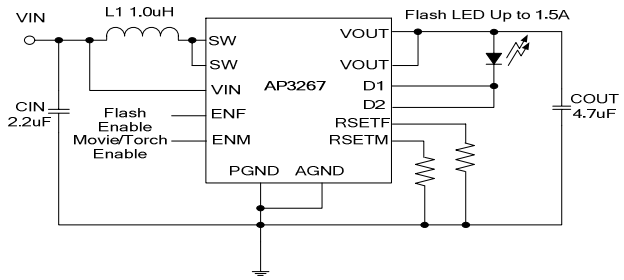


Figure 4. Optional Single LED Configuration

Inductor Selection

The AP3267 is designed to use a 1.0µH to 4.7µH inductor. To prevent core saturation, ensure that the inductor-saturation current rating exceeds the peak inductor current for the application. The worst-case peak inductor current can be calculated with the following formula:

$$I_{PEAK(L)} = \frac{V_{O(MAX)} \times I_{LED(MAX)}}{0.8 \times V_{IN(MIN)}} + \frac{V_{IN(MIN)} \times t_{ON(MAX)}}{2 \times L}$$

Where 0.8 is the estimated efficiency of 80%.

For example, for a 1.5A total (or 0.75A per channel) LED current, the peak inductor current for a 1.0µH inductor could be as high as (estimated 50% as the maximum duty ratio at the minimum input voltage, maximum LED forward voltage and maximum load current conditions):

$$I_{PEAK(L)} = \frac{4V \times 1.5A}{0.8 \times 3.5V} + \frac{3.5V \times 0.25}{2 \times 1} = 2.6A$$

If the inductor value is smaller, the inductor peak current will increase. To maintain stable operations for the boost converter, the inductor peak current must be less than both the AP3267 current limit threshold and the inductor saturation current rating. Manufacturer's specifications of inductors list both the inductor DC current rating, which is a thermal limitation, and peak inductor current rating, which is determined by the saturation characteristics. Measurements at full load and high ambient temperature should be performed to ensure that the inductor does not saturate or overheat due to its parasitic resistance. Bench measurements are recommended to confirm actual inductor peak current IPEAK and to ensure that the inductor does not saturate at maximum LED current and minimum input supply voltage.

Capacitor Selection

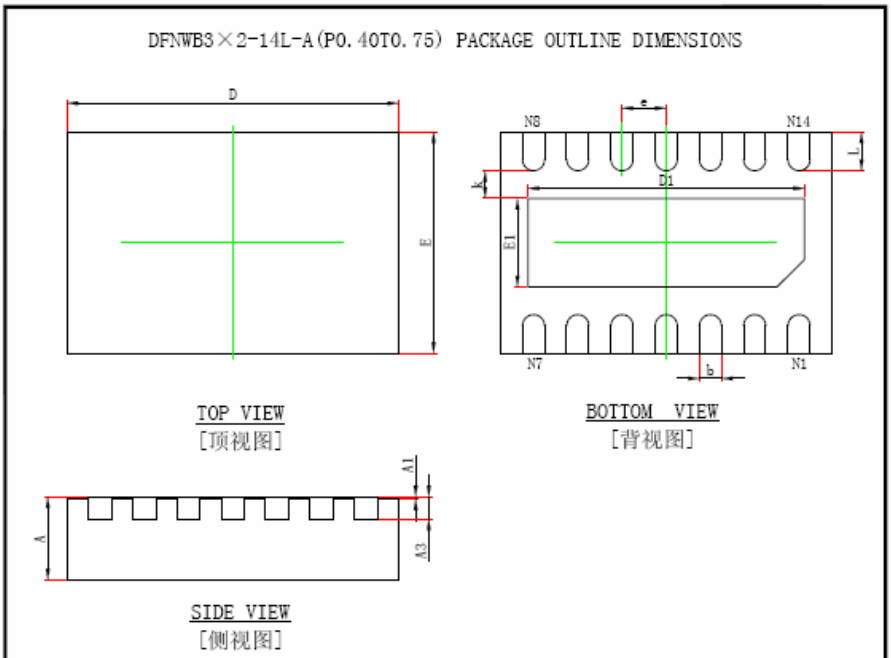
For good input voltage filtering low ESR ceramic capacitors are recommended. At least a 2.2μF input capacitor is recommended for high current flash LEDs to improve transient behavior of the regulator and EMI behavior of the total power supply circuit. The input capacitor should be placed as close as possible to the input pin and the PGND pin of the AP3267. The output capacitance required depends on the required LED current. A 2.2μF or 4.7μF ceramic capacitor works well in most situations, but a 1.0μF capacitor is acceptable for lower LED current conditions.

PC Board Layout

Due to the fast switching transitions and high-current paths, careful PC board layout is required. Connect AGND pin directly to the exposed paddle underneath the IC; connect the exposed paddle to the PCB ground plane. The output bypass capacitor should be placed as close to the IC as possible. Minimize trace lengths between the IC and the inductor, the input capacitor, and the output capacitor; keep these traces short, direct, and wide. The ground connections of CIN and COUT should be as close together as possible and connected to PGND.

Package Information

TDFN-3×2-14L



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	0.700	0.800	0.028	0.031
A1	0.000	0.050	0.000	0.002
A3	0.203REF.		0.008REF.	
D	2.900	3.100	0.114	0.122
E	1.900	2.100	0.075	0.083
D1	2.400	2.600	0.094	0.102
E1	0.700	0.900	0.028	0.035
b	0.150	0.250	0.006	0.010
e	0.400TYP.		0.016TYP.	
k	0.200MIN.		0.008MIN.	
L	0.274	0.426	0.011	0.017

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