ACT6310 | White LED Step-Up Converter

FEATURES

- Inherently Matched LED Current
- Pin Compatible with '1937 with Higher Efficiency (Up to 86%)
- 30V High Voltage Switch
- 1.2MHz Switching Frequency
- Uses 0.22µF Output Capacitor
- SOT23-5 Package

APPLICATIONS

- Cellular Phones
- Digital Cameras
- PDAs, Handheld Computers
- MP3 Players
- GPS

GENERAL DESCRIPTION

The ACT6310 step-up DC/DC converter drives white LEDs with a programmable constant current. The device is capable of driving two, three or four white LEDs in series from a Lithium-Ion battery. Current matching and uniform brightness is inherent in series connection.

The ACT6310 incorporates a 30V high voltage switch. Operating at 1.2MHz, the device allows the use of very few tiny external components. The low feedback voltage of 95mV minimizes power loss in the current setting resistor for better efficiency.

The ACT6310 is available in SOT-23 package and requires very few external devices for operation.
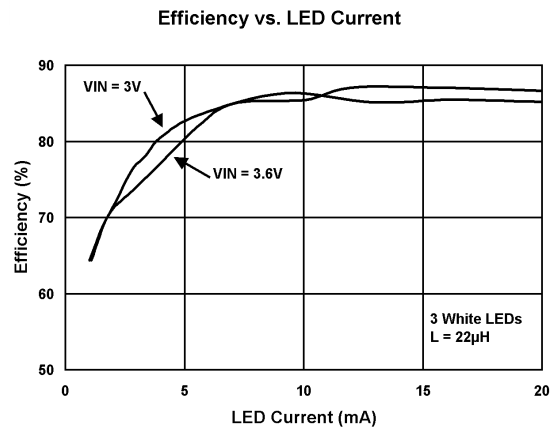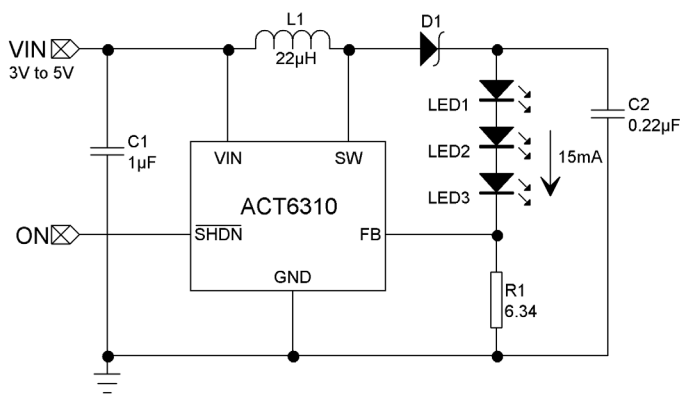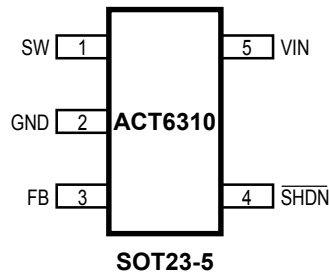

Figure 1. ACT6310 Supplying 3 White LEDs

ACT6310

ORDERING INFORMATION

PART NUMBER	TEMPERATURE RANGE	PACKAGE	PINS
ACT6310UC	-40°C to 85°C	SOT23-5	5

PIN CONFIGURATION

SOT23-5

PIN DESCRIPTION

PIN NUMBER	PIN NAME	PIN DESCRIPTION
1	SW	Switch Output. Connect this pin to the inductor and the Schottky diode. To minimize EMI, minimize the PCB trace path between this pin and the input bypass capacitor.
2	GND	Ground
3	FB	Feedback Input. This pin is referenced to 95mV. Connect this pin to the cathode of the lowest LED. Also connect a current feedback resistor R_1 between this pin and GND based on the following equation: $R_1 = 95mV / I_{LED}$
4	$\overline{SHDN}$	Shutdown Control. Connect to a logic high level to enable device. Connect to a logic low level to disable device.
5	VIN	Supply Input. Bypass to GND with a 1µF capacitor.

ABSOLUTE MAXIMUM RATINGS

(Note: Do not exceed these limits to prevent damage to the device. Exposure to absolute maximum rating conditions for long periods may affect device reliability.)

PARAMETER	VALUE	UNIT
VIN Input Voltage	-0.3 to 6	V
SW Voltage	-0.3 to 30	V
FB Voltage	-0.3 to V_{IN} + 0.3	V
$\overline{SHDN}$ Voltage	-0.3 to 6	V
Operating Junction Temperature	-40 to 150	°C
Storage Temperature	-55 to 150	°C
Lead Temperature (Soldering, 10 sec)	300	°C

ELECTRICAL CHARACTERISTICS

(T_A = 25°C, VIN = 3V, $V_{\overline{SHDN}}$ = 3V, unless otherwise specified)

| PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Minimum Input Voltage			2.5			V
Maximum Input Voltage					5.5	V
Feedback Voltage	V_{FB}	V_{IN} = 3V	85	95	105	mV
FB Input Current				30		nA
Supply Current				0.7	1.5	mA
Supply Current in Shutdown		$\overline{SHDN}$ = GND		0	1	µA
Switching Frequency	f_{SW}		0.8	1.2	1.6	MHz
Maximum Duty Cycle	D_{MAX}		80	90		%
Switch Current Limit	I_{LIM}			320		mA
Switch On Voltage		I_{SW} = 200mA		350		mV
Switch Leakage Current					5	µA
$\overline{SHDN}$ Logic High Threshold			1.6			V
$\overline{SHDN}$ Logic Low Threshold					0.4	V
$\overline{SHDN}$ Input Current				0	1	µA
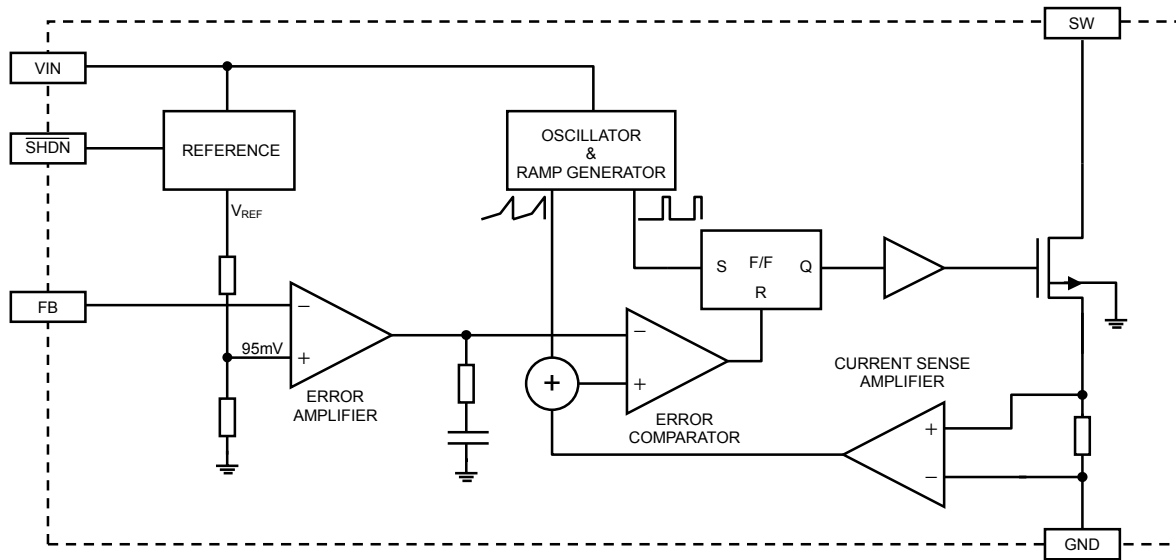
Figure 2. Functional Block Diagram

FUNCTIONAL DESCRIPTION

The ACT6310 is a highly efficient step-up DC/DC converter that employs a current-mode, fixed frequency pulse-width modulation (PWM) architecture with excellent line and load regulation. Figure 2 shows the functional block diagram of the IC. The flip-flop is set at the start of each oscillator cycle, and turns on the power switch. During this on time, the switch current level is sensed and added to a ramp signal, and the resulting sum is compared with the output of the error amplifier. If the error comparator output is high, the flip-flop is reset and the power switch turns off. Thus, the peak inductor current level is controlled by the error amplifier output, which is integrated from the difference between FB input and 95mV reference point.

The ACT6310 operates at constant switching frequency for output current higher than 4mA (for 3 LEDs from 4.2V supply). When the output current decreases further, the IC will enter pulse-skipping mode, resulting in some low frequency ripple.

For medium level output current, the IC operates in discontinous conduction mode (see *Switching Waveform in Discontinuous Mode* in Typical Performance Characteristics) and the waveform exhibits ringing as the inductor current drops to zero. This ringing has very low energy, and can be further suppressed by adding a 300Ω resistor in parallel with the inductor at the cost of some loss in efficiency.

APPLICATION INFORMATION

INDUCTOR SELECTION

Table 1. Recommended Inductors

PART NUMBER	CURRENT RATING (mA)	DCR (Ω)	SUPPLIER
CDRH3D16-220	350	0.5	Sumida
ELJPC220KF	160	4.0	Panasonic
LQH3C220	250	0.7	Murata
LEM2520-220	125	5.5	Taiyo Yuden

Typically, use a 22µH inductor for ACT6310. The inductor should have low DC resistance (DCR) and low losses at 1.2MHz. See Table 1 for examples of small size inductors.

CAPACITOR SELECTION

The ACT6310 only requires a 1µF input capacitor and a 0.22µF output capacitor for most applications. Ceramic capacitors are ideal for these applications. For best performance, use X5R and X7R type ceramic capacitors, which possess less degradation in capacitance over voltage and temperature ranges.

DIODE SELECTION

The ACT6310 requires a Schottky diode as the rectifier. Select a low forward voltage drop Schottky diode with forward current (IF) rating of 100mA to 200mA and sufficient peak repetitive reverse voltage (VRRM). The required minimum VRRM is 4.5V multiplied by the number of white LEDs. Some suitable Schottky diodes are listed in Table 2.

Table 2. Recommended Schottky Diodes

PART NUMBER	IF (mA)	VRRM (V)	SUPPLIER
CMDSH-3	100	30	Central
CMDSH2-3	200	30	Central
BAT54	200	30	Zetex

LED CURRENT SETTING

The LED current is determined by the value of the feedback resistor R1. Because the IC's FB input is regulated to 95mV, the LED current is $I_{LED} = 95mV / R_1$. The value of R_1 for different LED current is shown in table 3.

Table 3. R_1 Resistor Value Selection

I_{LED} (mA)	R_1 (Ω)
5	19.1
10	9.53
12	7.87
15	6.34
20	4.75

DIMMING CONTROL METHODS

The following are dimming control methods for the ACT6310:

1. PWM Signal Driving $\overline{SHDN}$

When a PWM signal is connected to the $\overline{SHDN}$ pin, the ACT6310 is on and off alternatively under the control of the PWM signal. And the current through the LEDs is either zero or full. By changing the duty cycle of the PWM signal (typically 1kHz to 10kHz), a controlled average current is obtained.

2. DC Voltage Control

Figure 3 shows an application in which a DC voltage is used to adjust the LED current. The LED current increases when V_{DC} is lower than V_{FB} and decreases when V_{DC} is higher than V_{FB}.
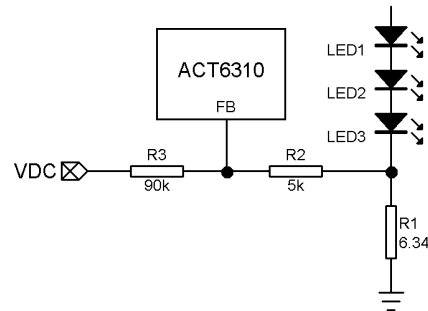
In Figure 3, the LED current range of 15mA to 0 is controlled by V_{DC} = 0 to 2V.
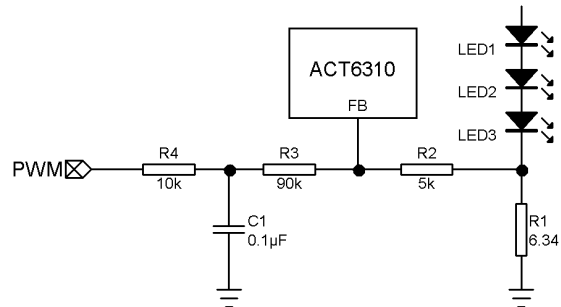
3. Filtered PWM Control

Figure 4 shows an application using a filtered PWM signal to control dimming.
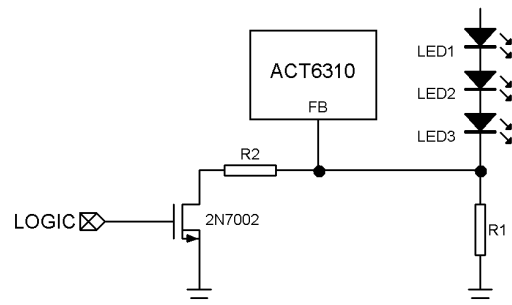
4. Logic Control

A logic signal can be used to adjust the LED current in a discrete step, as shown in Figure 5.
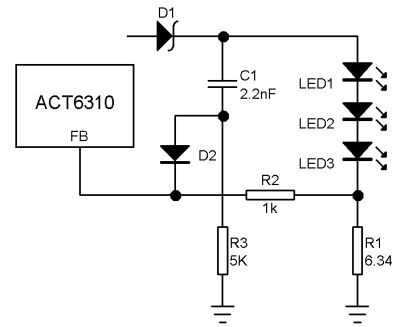

Figure 3. DC Voltage Controlled Dimming

Figure 4. Filtered PWM Controlled Dimming

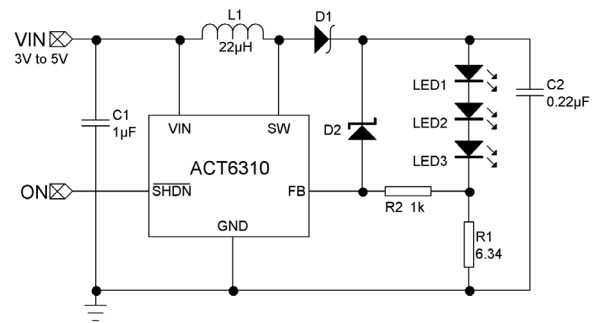**Figure 5. Logic Controlled Dimming**

START-UP AND INRUSH CURRENT

In order to start the ACT6310 quickly, soft-start circuit is excluded inside the IC. When the IC is first turned on with no external soft-start circuit, the inrush current is about 200mA. Figure 6 shows an implementation for soft-start. When soft-start and dimming controls are used simultaneously, use a low frequency PWM signal (less than 10kHz) or use methods in Figures 3, 4, and 5.

OPEN-CIRCUIT PROTECTION

When one of the LEDs is disconnected of fails, the FB voltage drops to zero and the IC switches at maximum duty cycle. This results in a high voltage that may exceed SW voltage rating. To limit this voltage, use a zener diode as shown in Figure 7. The zener voltage must be larger than the LEDs' total forward voltage and its current rating should be higher than 0.1mA.

BOARD LAYOUT

To minimize EMI, minimize the area and path length all traces connected to SW pin. Use a ground plane under the switching regulator and connect R1 directly to the GND pin of the IC.

Figure 6. Soft-start circuit

Figure 7. Open-Circuit Protection

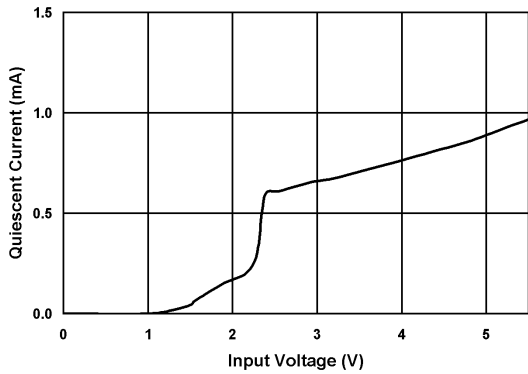# TYPICAL PERFORMANCE CHARACTERISTICS
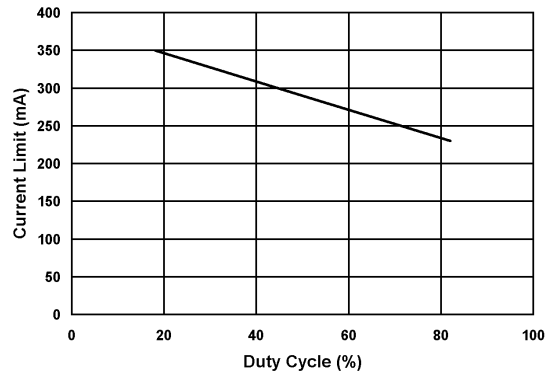
Efficiency vs. LED Current
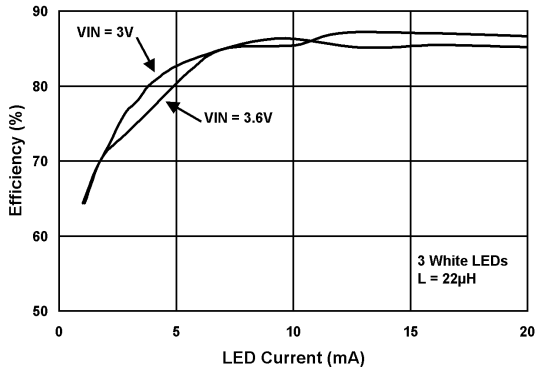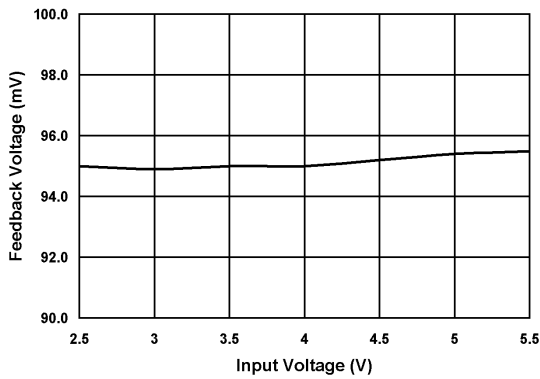

Switching Frequency vs. Temperature
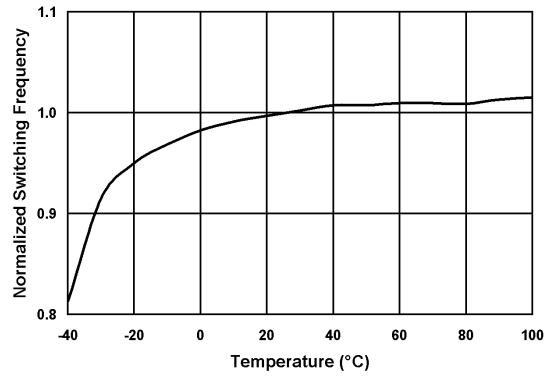
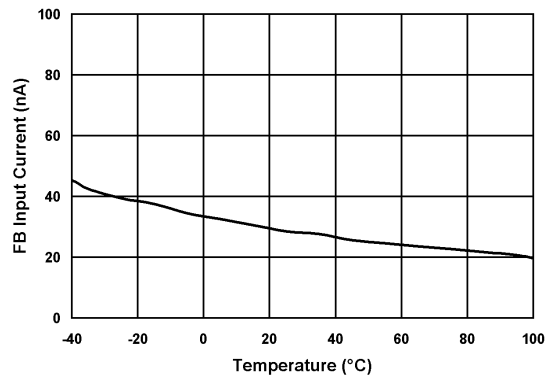**Quiescent Current vs. Input Voltage**
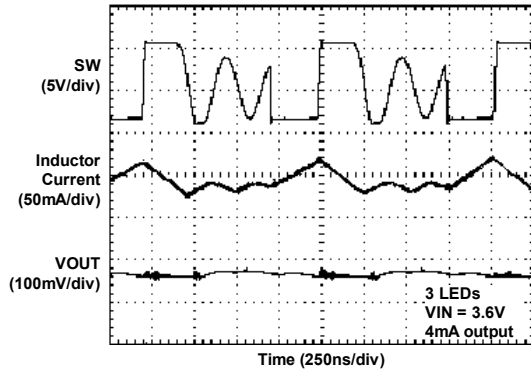

Current Limit vs. Duty Cycle

Feedback Voltage vs. Input Voltage

FB Input Current vs. Temperature

Switching Waveform in Discontinuous Mode

SW (5V/div)

Inductor Current (50mA/div)

VOUT (100mV/div)

3 LEDs
VIN = 3.6V
4mA output

Time (250ns/div)

Dimming by PWM Driving $\overline{\text{SHDN}}$

FB (100mV/div)

$\overline{\text{SHDN}}$ (2V/div)

Time (250µs/div)
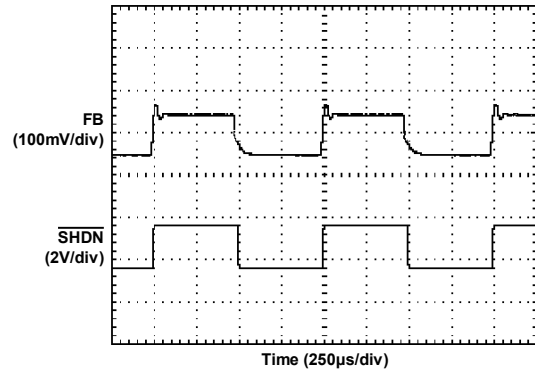
Start-Up without Soft-Start Circuit

3 LEDs
VIN = 3.6V
17mA

Input Current (50mA/div)

FB (100mV/div)

SHDN (2V/div)

Time (50µs/div)
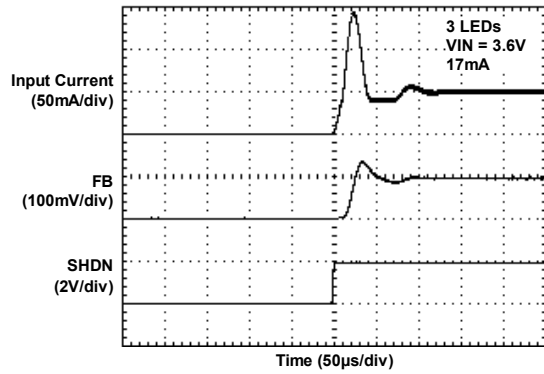
Start-Up with Soft-Start Circuit

3 LEDs
VIN = 3.6V
17mA

Input Current (50mA/div)

FB (100mV/div)

SHDN (2V/div)

Time (50µs/div)
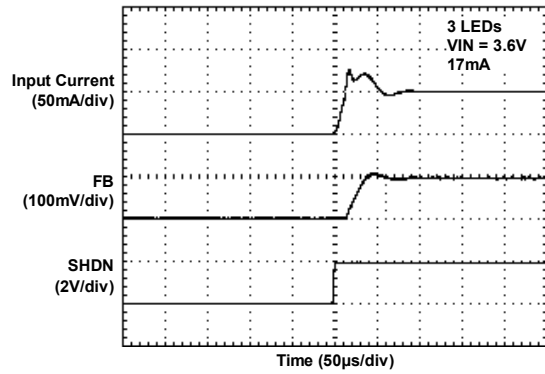
PACKAGE OUTLINE

SOT23-5 PACKAGE OUTLINE AND DIMENSIONS
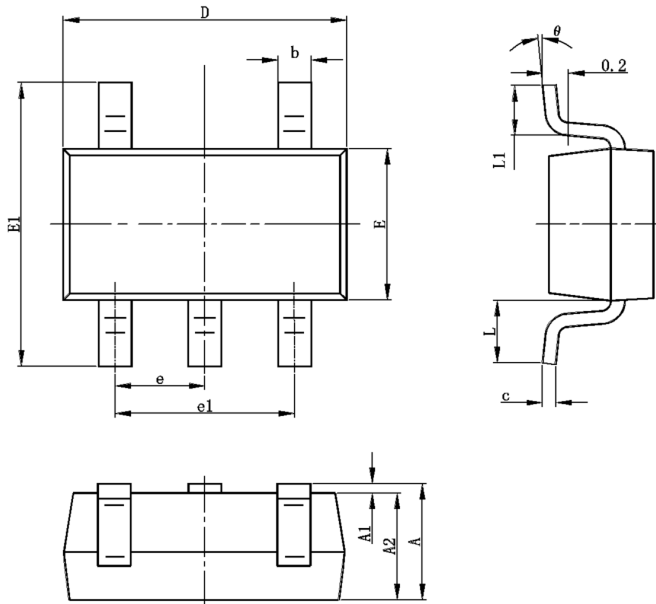
SYMBOL	DIMENSION IN MILIMETERS		DIMENSION IN INCHES	
	MIN	MAX	MIN	MAX
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.400	0.012	0.016
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950 TYP		0.037 TYP	
e1	1.800	2.000	0.071	0.079
L	0.700 REF		0.028 REF	
L1	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°