300KHZ, PFM Control, Synchronous Step-Up DC-DC Converter

General Description

The AF2304 Series is a Synchronous step-up DC/DC Converter with PFM Control.

With the AF2304 Series, a step-up switching DC/DC converter can be configured by using an external coil, capacitor. The built-in MOSFET is turned off by a protection circuit when the voltage at the LX pin exceeds the limit to prevent it from being damaged.

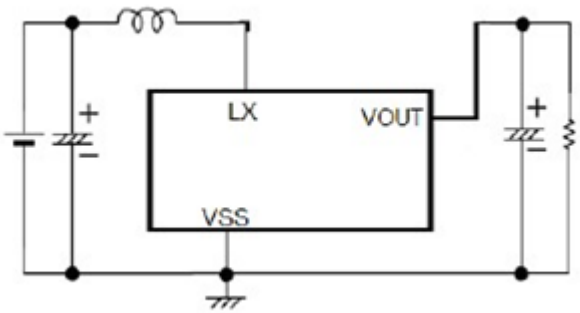
Features

- External parts: Coil, Capacitor
- Output voltage: Settable to between 2.1V to 5.5V in 0.1V steps
- Maximum Oscillation frequency : 300KHz
- Accuracy of ±2%
- High efficiency :95%
- Package:
  SOT23, SOT23-3 and SOT89

Applications

- Digital cameras
- Electronic notebooks and PDAs
- Portable CD/MD players
- Cameras , video equipment
- Communications equipment
- Power supply for microcomputers

Typical Application



Note: External Component Recommendation:

1) Coil value:47uH(Sumida)
2) Capacitor value:47uF/16V(Tantalum)

Order Information

AF2304①②③④

Designator	Symbol	Description
①②	Integer	Output Voltage (2.1~5.5) e.g:3.0V=①：3；②：0
③	P	Package:SOT89
	M	Package:SOT23-3
	N	Package:SOT23
④	R	RoHS / Pb Free
	G	Halogen Free

Pin Assignment

SOT23
SOT23-3
Top view

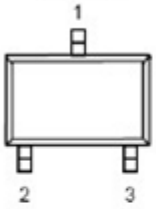


Table 1 AF2304 Series (SOT23/SOT23-3 PKG)

PIN NO.	PIN NAME	FUNCTION
1	V_{OUT}	Output voltage pin
2	V_{SS}	GND pin
3	LX	External inductor connection pin

SOT89
Top view

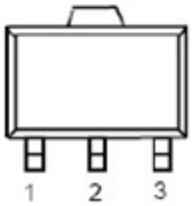


Table 2 AF2304 Series (SOT89 PKG)

PIN NO.	PIN NAME	FUNCTION
1	V_{SS}	GND pin
2	V_{OUT}	Output voltage pin
3	LX	External inductor connection pin

Absolute Maximum Ratings

(Unless otherwise specified, Ta=25℃)

PARAMETER		SYMBOL	RATINGS	UNITS
VOUT Pin Voltage		VOUT	VSS-0.3~VSS+8	V
EN Pin Voltage		EN	VSS-0.3~VSS+8	V
LX Pin Voltage		VLX	VSS-0.3~VSS+8	V
LX Pin Current		ILX	1000	mA
Power Dissipation	SOT23/SOT23-3	PD	250	mW
	SOT89		500	mW
Operating Temperature		TOPR	-40~+85	℃
Storage Temperature		TSTG	-40~+125	℃
Soldering Temperature & Time		TSOLDER	260℃，10s	

Note: These are stress ratings only. Stresses exceeding the range specified under “Absolute Maximum Ratings” may cause substantial damage to the device. Functional operation of this device at other conditions beyond those listed in the specification is not implied and prolonged exposure to extreme conditions may affect device reliability.

Electrical Characteristics

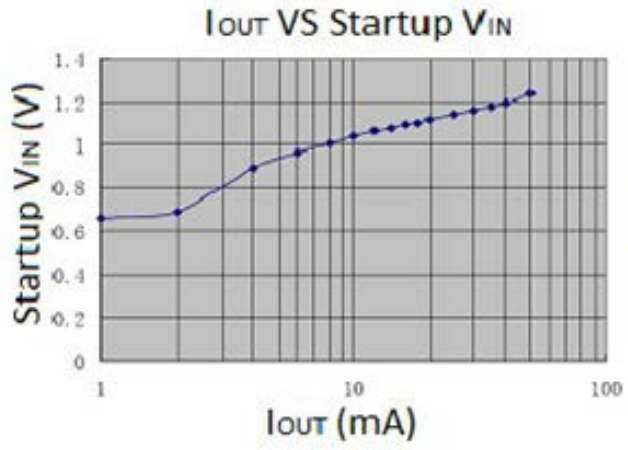
(Unless otherwise specified，Ta = 25℃)

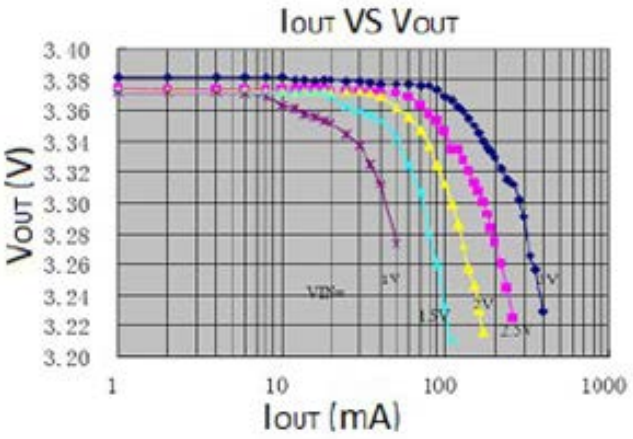
PARAMETER	SYMBOL	MIN	TYP	MAX	UNITS	CONDITION
Output Voltage	VOUT	VOUT(S) X0.98	VOUT	VOUT(S) X1.02	V	-
Input Voltage	VIN	-	-	7.5	V	-
Operation Start Voltage	VST1	-	-	0.9	V	IOUT=1mA
Input Current At No Load	ISS	-	15	-	uA	VIN=1.8V, VOUT=3.0V
Current Consumption 2	ISS2	-	6	10	uA	VOUT=VOUT(s)+0.5V
Current Consumption During Shutdown	ISSS	-	-	1.0	uA	VEN=0V
Maximum Oscillation Frequency	fosc		300		KHz	VOUT=0.95xVOUT(s), measure Waveform at LX pin
Duty Ratio1	Duty1	70	78	85	%	VOUT=0.95xVOUT(s)
Efficiency	EFF1		90		%	
Shutdown Pin Input Voltage	VSH	0.75	-	-	V	VOUT=0.95xVOUT(s), judge Oscillation at LX pin
	VSL1	-	-	0.3	V	VOUT=0.95xVOUT(s), judge stop at LX pin
Shutdown Pin input Current	ISH	-0.1	-	0.1	uA	VEN=6V
	ISL	-0.1	-	0.1	uA	VEN=0V

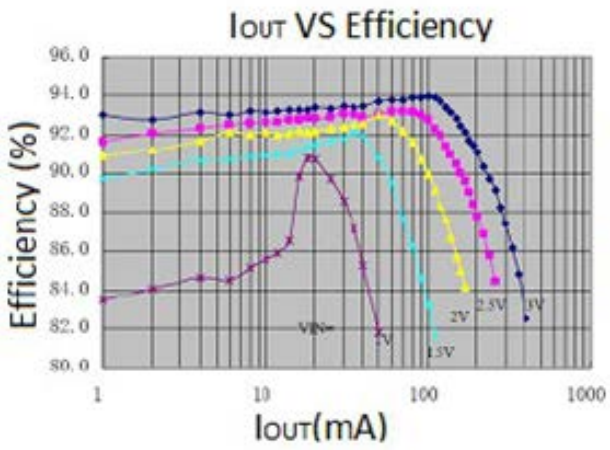
Remark: VOUT(S) specified above is the set output voltage value, and VOUT is the typical value of the actual output voltage.

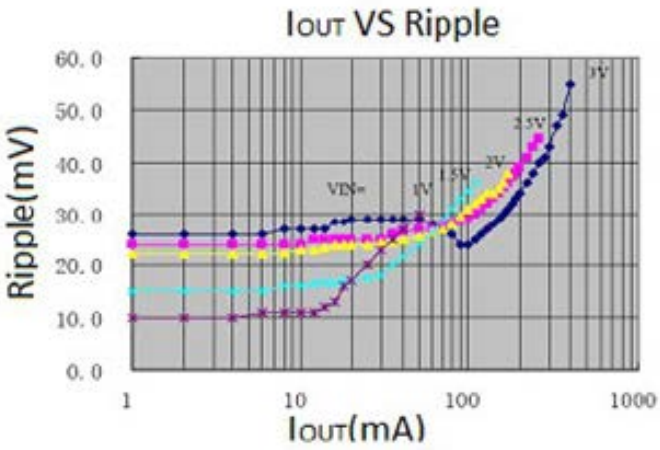
Typical Performance Characteristics

(Cin=Cout=100uF,L=47uH)

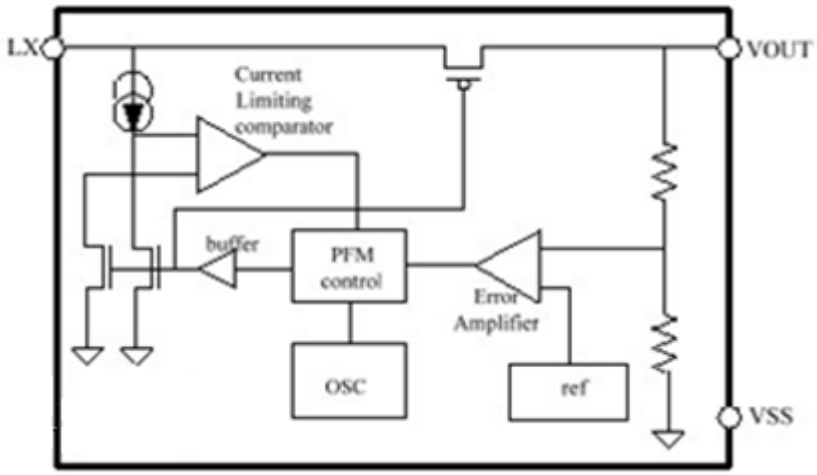








Block Diagram



Operation

The AF2304 is boost structure, voltage-type pulse-frequency modulation (PFM) step-up DC-DC converter with integrated schottky.Only two external components are necessary: an inductor and an output fitter capacitor. And the converter's low noise and low ripple output voltage can be adjusted from 2.1V to 5.5V, 0.1V step. By using the depletion techniques, the quiescent current drawn from power source is lower than 10uA. The high efficiency device consists of resistors for output voltage detection and trimming, a start-up voltage circuit, an oscillator, a reference circuit, a PFM control circuit, a switch protection circuit and a driver transistor.

The reference circuit provides stable reference voltage to output stable output voltage. Because internal trimming technology is used, the chip output changes less than ±2%. At the same time, the problem of temperature-drift coefficient of output voltage is considered in design, so temperature-drift coefficient of output voltage is less than 100ppm/℃.

PFM Mode Operation

The PFM control circuit is the core of the AF2304 IC. This block controls power switch on duty cycle to stabilize output voltage by calculating results of other blocks which sense input voltage, output voltage, output current and load conditions. In PFM modulation system, the frequency and pulse width is fixed. The duty cycle is adjusted by skipping pulses, so that switch on-time is changed based on the conditions such as input voltage output current and load. The oscillate block inside AF2304 provides fixed frequency and pulse width wave.

Main Energy Loss

High-gain differential error amplifier guarantees stable output voltage at difference input voltage and load. IN order to reduce ripple and noise, the error amplifier is designed with high band-with. Tough at very low load condition, the quiescent current of chip does affect efficiency certainly. The three main energy loss of Boost structure DC-DC converter in full load are the ESR of inductor, on resistor of internal N-channel MOSFET and its driver. In order to improve the efficiency, AF2304 integrates schottky, low on-resistor N-channel MOSFET and well design driver circuits. The switch energy loss is limited at very low level.

Selection of the external components

Thus it can be seen, the inductor affect the conversion efficiency greatly. The inductor and the capacitor also have great influence on the output voltage ripple of the converter. So it is necessary to choose a suitable inductor and a capacitor, to obtain high efficiency, low ripple and low noise. Before discussion, we define:

$$D = \frac{V_{OUT} - V_{IN}}{V_{OUT}}$$

Inductor Selection

Above all, we should define the minimum value of the inductor that can ensure the boost DC-DC to operate in the continuous current-mode condition.

$$L_{MIN} = \frac{D*(1-D)^2*R_L}{2*f}$$

The above expression is got under conditions of continuous current mode, neglect schottky diode's voltage, ESR of both inductor and capacitor. The actual value is greater that it. If inductor's value is less than LMIN, the efficiency of DC-DC converter will drop greatly, and the DC-DC circuit will not be stable. Secondly, consider the ripple of the output voltage,

$$\Delta I = \frac{D*V_{IN}}{L*f}$$

$$\mathrm{I}max = \frac{V_{IN}}{(1-D)^2*R_L} + \frac{D*V_{IN}}{2*L*f}$$

If inductor value is too small, the current ripple through it will be great. Then the current through diode and power switch will be great. Because the power switch on chip is not ideal switch, the energy of switch will improve. The efficiency will fall. Thirdly, in general, smaller inductor values supply more output current while larger values start up with lower input voltage and acquire high efficiency. An inductor value of 3uH to 1mH works well in most applications. If DC-DC converter delivers large output current (for example: output current is great than 50mA), large inductor value is recommended in order to improve efficiency. If DC-DC must output very large current at low input supply voltage, small inductor value is recommended. The ESR of inductor will effects efficiency greatly. Suppose ESR value of inductor is RL, RLOAD is load resistor, then the energy can be calculated by following expression:

$$\Delta\eta = \frac{R_L}{R_{LOAD}*(1-D)^2}$$

For example: input 1.5V, output is 3.0V, RLOAD=20Ω, RL=0.5Ω.
The energy loss is 10%. Consider all above, inductor value of 47uH, ESR<0.5Ω is recommended in most applications. Large value is recommended in high efficiency applications and smaller value is recommended.

Capacitor Selection

Ignore ESR of capacitor, the ripple of output voltage is:

$$R = \frac{\Delta V_{OUT}}{V_{OUT}} = \frac{D}{R_{LOAD}*C*f}$$

So large value capacitor is needed to reduce ripple. But too large capacitor value will slow down system reaction and cost will improve. So 100uF capacitor is recommended. Larger capacitor value will be used in large output current system. If output current is small (<10mA), small value is needed. Consider ESR of capacitor, ripple will increase:

$$r' = r + \frac{\mathrm{Im}\,ax * R_{ESR}}{V_{OUT}}$$

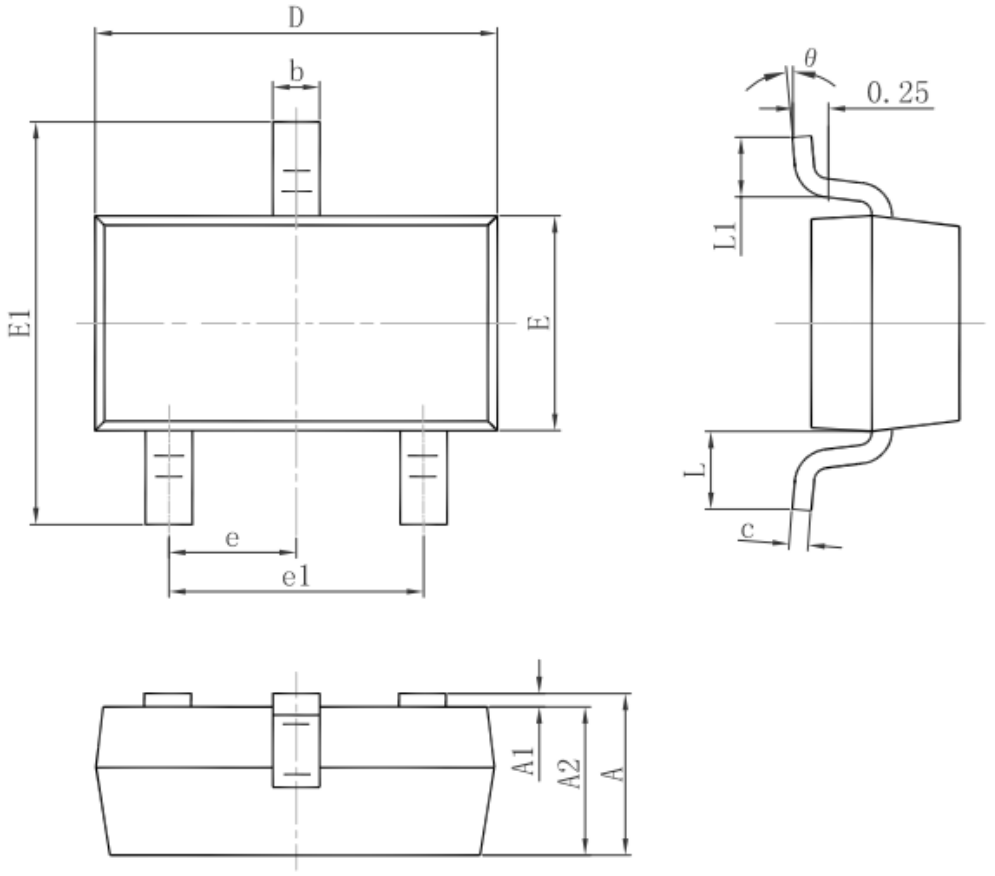
When current is large, ripple caused by ESR will be main factor. It may be greater than 100mV. The ESR will affect efficiency and increase energy loss. So low-ESR capacitor (for example: tantalum capacitor) is recommend or connect two or more filter capacitors in parallel.

Input capacitor

If supply voltage is stable, the DC-DC circuit can output low ripple, low noise and stable voltage without input capacitor. If voltage source is far away from DC-DC circuit, input capacitor value greater than 10uF is recommended.

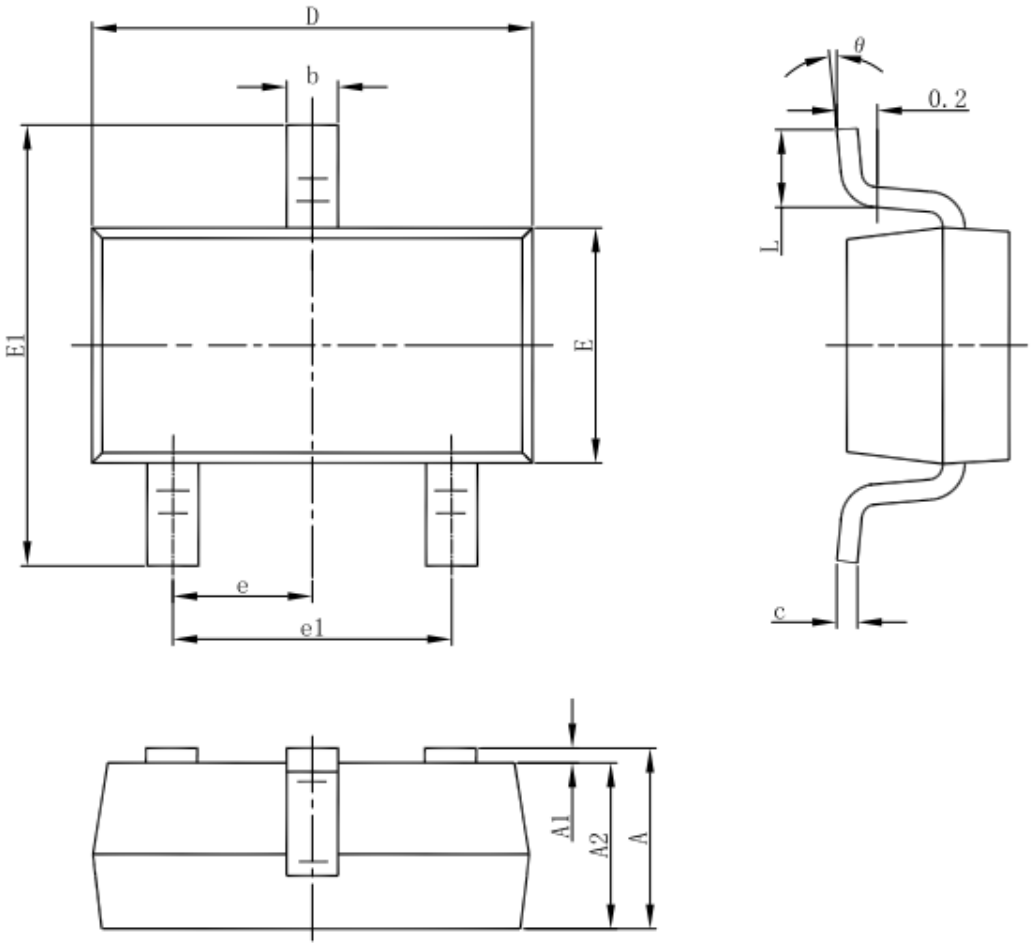
Package Information

3-pin SOT23 Outline Dimensions



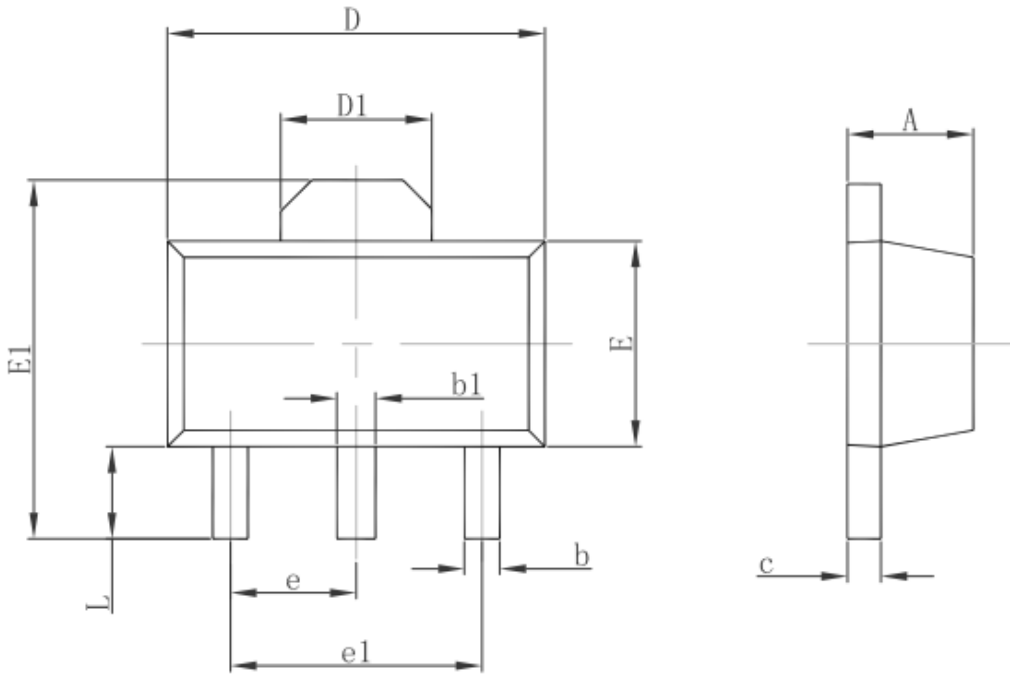
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	0.900	1.150	0.035	0.045
A1	0.000	0.100	0.000	0.004
A2	0.900	1.050	0.035	0.041
b	0.300	0.500	0.012	0.020
c	0.080	0.150	0.003	0.006
D	2.800	3.000	0.110	0.118
E	1.200	1.400	0.047	0.055
E1	2.250	2.550	0.089	0.100
e	0.950 TYP.		0.037 TYP.	
e1	1.800	2.000	0.071	0.079
L	0.550 REF.		0.022 REF.	
L1	0.300	0.500	0.012	0.020
θ	0°	8°	0°	8°

3-pin SOT23-3 Outline Dimensions



Symbol	Dimensions In Millimeters		Dimensions 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	0.500	0.012	0.020
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(BSC)		0.037(BSC)	
e1	1.800	2.000	0.071	0.079
L	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°

3-pin SOT89 Outline Dimensions



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	1.400	1.600	0.055	0.063
b	0.320	0.520	0.013	0.020
b1	0.400	0.580	0.016	0.023
c	0.350	0.440	0.014	0.017
D	4.400	4.600	0.173	0.181
D1	1.550 REF.		0.061 REF.	
E	2.300	2.600	0.091	0.102
E1	3.940	4.250	0.155	0.167
e	1.500 TYP.		0.060 TYP.	
e1	3.000 TYP.		0.118 TYP.	
L	0.900	1.200	0.035	0.047