A7506

DC-DC CONVERTER BOOST(STEP-UP) VIN AS LOW AS 0.85V MICRO-POWER SYNC

DESCRIPTION

The A7506 is synchronous, fixed frequency, step-up DC/DC converters delivering high efficiency in a SOT-26 package. Capable of supplying 3.3V at 100mA from a single AA cell input, the device contain an internal NMOS switch and PMOS synchronous rectifier.

A switching frequency of 1.0MHz minimizes solution footprint by allowing the use of tiny, low profile inductors and ceramic capacitors. The current mode PWM design is internally compensated, reducing external parts count. The A7506 features continuous switching at light loads. The device features low shutdown current of under 1uA.

The A7506 is available in SOT-26 package

ORDERING INFORMATION

Package Type		Part Number
SOT-26 SPQ: 3,000pcs/Reel	E6	A7506E6R-XXX
		A7506E6VR-XXX
Note	XXX=Output Voltage, ADJ=Adjustable V: Halogen free Package R : Tape & Reel	
AiT provides all RoHS products		

FEATURES

- High Efficiency: Up to 92%
- 1.0MHz Constant Switching Frequency
- 3.3V Output Voltage at I_{OUT}=100mA from a Single AA Cell; 5.0V Output Voltage at I_{OUT}=500mA from one Li battery.
- Low Start-up Voltage: 0.85V
- Integrated main switch and synchronous rectifier. No Schottky Diode Required
- 2.5V to 5V Output Voltage Range
- Automatic Pulse Skipping Mode Operation
- Tiny External Components
- <1μA Shutdown Current
- Available in SOT-26 package.

APPLICATION

- Cellular and Smart Phones
- Microprocessors and DSP Core Supplies
- Wireless and DSL Modems
- MP3 Player
- Digital Still and Video Cameras
- Portable Instruments

TYPICAL APPLICATION CIRCUIT

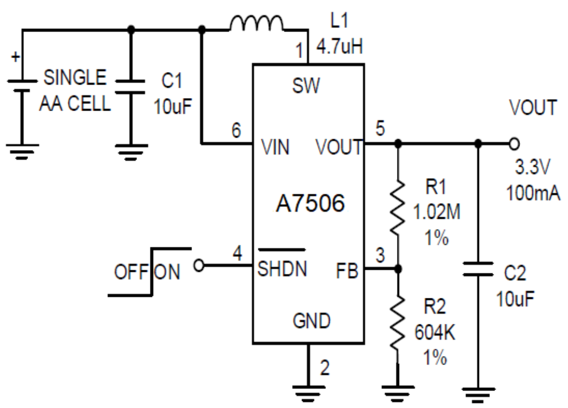
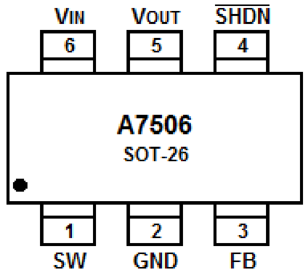


Fig 1. Typical Application Circuit

PIN DESCRIPTION



Top View

Pin #	Symbol	Function
1	SW	Power Switch Pin. It is the switch node connection to Inductor.
2	GND	Ground Pin
3	FB	Feedback Input Pin. Connect FB to the center point of the external resistor divider. The feedback threshold voltage is 1.23V.
4	$\overline{SHDN}$	Chip Shutdown Signal Input. Logic high is normal operation mode, Logic Low is Shutdown. Typically, this pin is connected to V_{IN} through a 1MΩ resistor.
5	V_{OUT}	Power Output Pin. V_{OUT} is held 0.6V below than V_{IN} in shutdown.
6	V_{IN}	Power Supply Input. Must be closely decoupled to GND, Pin 2, with a 10μF or greater ceramic capacitor.

ABSOLUTE MAXIMUM RATINGS

Input Supply Voltage	-0.3V ~ +6V
SW Voltage	-0.3V ~ +6V
FB, $\overline{SHDN}$ Voltages	-0.3V ~ +6V
V_{OUT} Voltage	-0.3V ~ +6V
Package Thermal Resistance[NOTE1]	
θ_{JA}	220℃/W
θ_{JC}	110℃/W
Operating Temperature Range	-40℃ ~ +85℃
Storage Temperature Range	-65℃ ~ +150℃
Lead Temperature (Soldering, 10s)	+ 260℃

Stresses above may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other conditions beyond those indicated in the Electrical Characteristics are not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

ELECTRICAL CHARACTERISTICS[NOTE2]

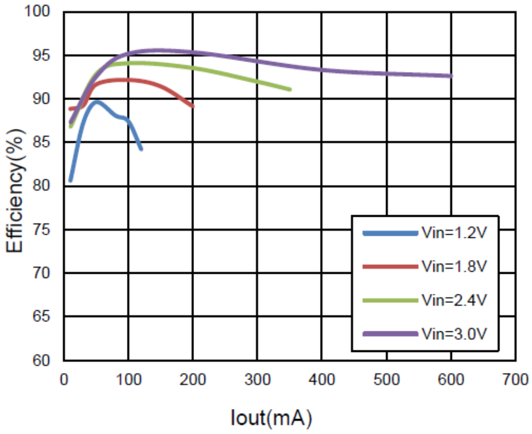
V_{IN} =1.2V, V_{OUT}=3.3V, T_A = 25°C, Test Circuit of Fig 1., unless otherwise specified.

Parameter	Conditions	Min.	Typ.	Max.	Unit
Minimum Start-Up Voltage	I_{OUT} = 1mA	-	0.85	1.05	V
Minimum Operating Voltage	$V_{\overline{SHDN}}$ = V_{IN}	-	0.75	-	V
Output Voltage Range		2.5	-	5	V
Feedback Voltage	-40°C ≤T_A≤ 85°C	1.192	1.230	1.268	V
Quiescent Current(Shutdown)	$V_{\overline{SHDN}}$ = 0V	-	0.01	1	μA
Quiescent Current(Active)	Measured on V_{OUT}	-	300	500	μA
NMOS Switch Leakage	V_{SW} = 5V	-	0.1	5	μA
PMOS Switch Leakage	V_{SW} = 0V	-	0.1	5	μA
NMOS Switch ON Resistance	V_{OUT} = 3.3V	-	0.40	-	Ω
	V_{OUT} = 5V	-	0.35	-	Ω
PMOS Switch ON Resistance	V_{OUT} = 3.3V	-	0.70	-	Ω
	V_{OUT} = 5V	-	0.60	-	Ω
Output Voltage	V_{OUT} = 3.3V, I_{OUT} = 1mA	3.201	3.300	3.399	V
	V_{OUT} = 5V , I_{OUT} = 1mA, V_{IN} = 2.4V	4.850	5.000	5.150	V
Line Regulation	V_{IN} = 0.8V to 3.0V, I_{OUT} = 10mA	-	1	-	%/V
Load Regulation	I_{OUT} = 1mA to 100mA	-	0.02	-	%/mA
NMOS Current Limit		600	850	-	mA
Current Limit Delay to Output	NOTE3	-	40	-	ns
Max Duty Cycle	V_{FB} = 1.15V, -40°C ≤T_A≤ 85°C	80	85	-	%
Switching Frequency		-	1.0	-	MHz
	-40°C ≤T_A ≤85°C	-	1.0	-	
$\overline{SHDN}$ Input Threshold		0.35	0.60	1.50	V
$\overline{SHDN}$ Input Current	$V_{\overline{SHDN}}$ = 5.5V	-	0.01	1	μA

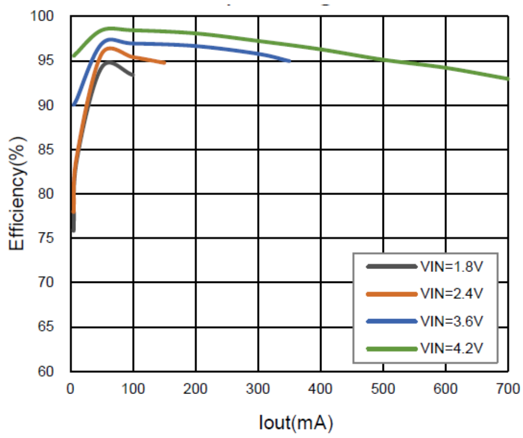
NOTE1: Thermal Resistance is specified with approximately 1 square of 1oz copper.
NOTE2:100% production test at +25°C. Specifications over the temperature range are guaranteed by design and characterization.
NOTE3: Guaranteed by design.

TYPICAL PERFORMANCE CHARACTERISTICS

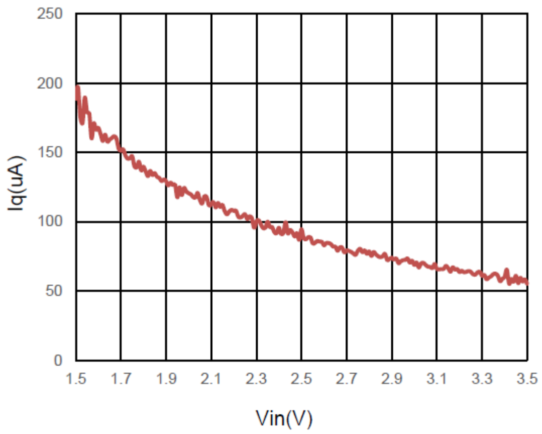
1. Efficiency vs. I_{OUT} @V_{OUT}=3.3V



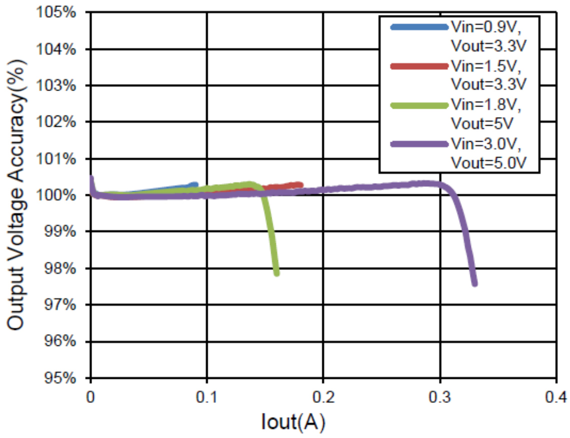
2. Efficiency vs. I_{OUT} @V_{OUT}=5V



3. Iq vs.V_{IN} @V_{OUT}=5V

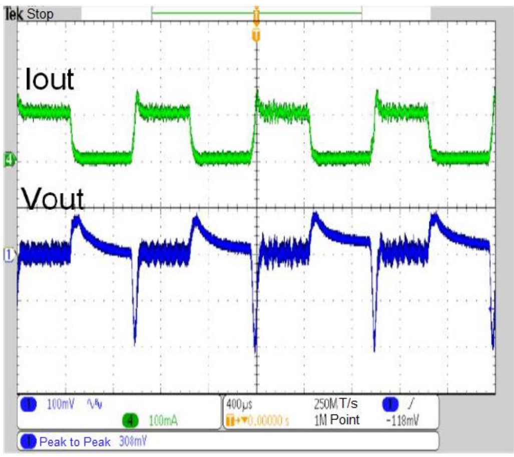


4. Output Voltage Accuracy vs. I_{OUT}



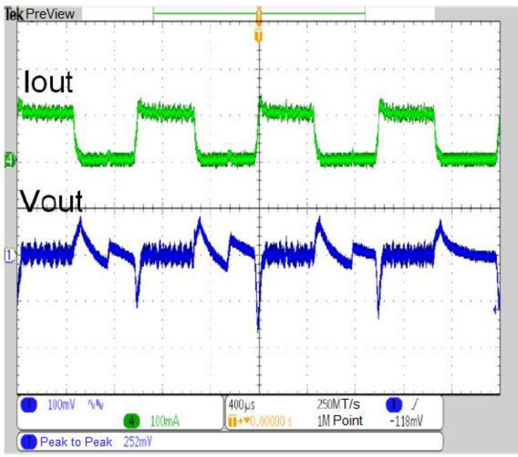
5. Transient response

V_{IN}=1.8V,V_{OUT}=3.3V,I_{OUT}=0-100mA

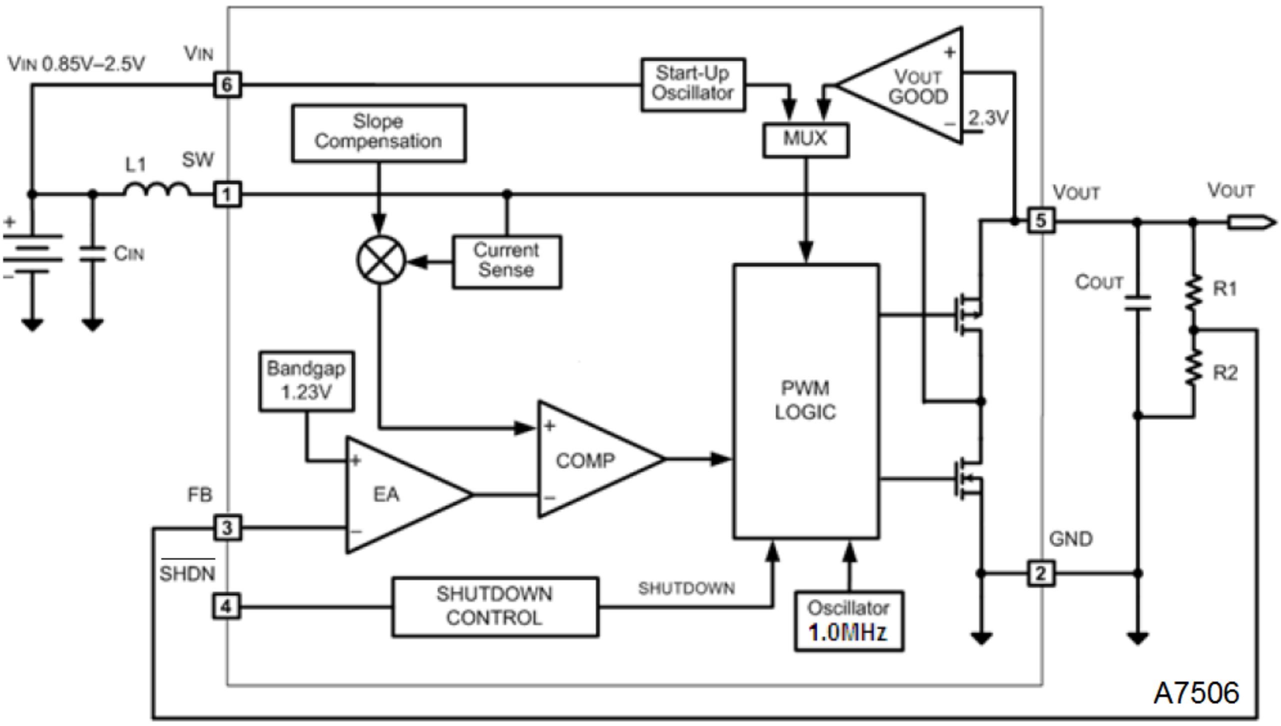


6. Transient response

V_{IN}=2.4V,V_{OUT}=3.3V,I_{OUT}=0-100mA



BLOCK DIAGRAM



DETAILED INFORMATION

Operation

The A7506 is 1.0MHz, synchronous boost converter housed in a SOT-26 package. Able to operate from an input voltage below 1V, the device features fixed frequency, current mode PWM control for exceptional line and load regulation. With its low $R_{DS\ (ON)}$ and gate charge internal MOSFET switches, the device maintains high efficiency over a wide range of load current. Detailed descriptions of the operating modes follow. Operation can be best understood by referring to the Block Diagram.

Synchronous Rectification

The A7506 integrates a synchronous rectifier to improve efficiency as well as to eliminate the external Schottky diode. The synchronous rectifier is used to reduce the conduction loss contributed by the forward voltage of Schottky diode. The synchronous rectifier is realized by a P-ch MOSFET with gate control circuitry that incorporates relatively complicated timing concerns.

Low Voltage Start-Up

The A7506 will start up at a typical VIN voltage of 0.85V or higher. The low voltage start-up circuitry controls the internal NMOS switch up to a maximum peak inductor current of 850mA (typical), with an approximate1.5us off-time during start-up, allowing the devices to start up into an output load. Once V_{OUT} exceeds 2.3V, the start-up circuitry is disabled and normal fixed frequency PWM operation is initiated. In this mode, the A7506 operate independent of V_{IN}, allowing extended operating time as the battery can droop to several tenths of a volt without affecting output voltage regulation. The limiting factor for the application becomes the ability of the battery to supply sufficient energy to the output.

Low Noise Fixed Frequency Operation

Oscillator: The frequency of operation is internally set to 1.0MHz.

Error Amp: The error amplifier is an internally compensated trans-conductance type (current output) with a trans-conductance (gm) = 33 micro-siemens. The internal 1.23V reference voltage is compared to the voltage at the FB pin to generate an error signal at the output of the error amplifier. A voltage divider from V_{OUT} to ground programs the output voltage via FB from 2.5V to 5V using the equation:

$$V_{OUT} = 1.23V \cdot [1 + (R1/R2)]$$

Current Sensing: A signal representing NMOS switch current is summed with the slope compensator. The summed signal is compared to the error amplifier output to provide a peak current control command for the

PWM.

Peak switch current is limited to approximately 850mA independent of input or output voltage. The current signal is blanked for 40ns to enhance noise rejection.

Zero Current Comparator: The zero current comparator monitors the inductor current to the output and shuts off the synchronous rectifier once this current reduces to approximately 20mA. This prevents the inductor current from reversing in polarity improving efficiency at light loads.

Pulse Skipping Mode

At very light load, the A7506 automatically switches into Pulse Skipping Mode to improve efficiency. During this mode, the PWM control will skip some pulses to maintain regulation. If the load increases and the output voltage drop, the device will automatically switch back to normal PWM mode and maintain regulation.

Device Shutdown

When $\overline{SHDN}$ is set logic high, the A7506 is put into operation. If $\overline{SHDN}$ is set logic low, the device is put into shutdown mode and consumes lower than 1μA current. After start-up timing, the internal circuitry is supplied by V_{OUT}, however, if shutdown mode is enabled, the internal circuitry will be supplied by battery again.

Application

Setting the Output Voltage

An external resistor divider is used to set the output voltage. The output voltage of the switching regulator (V_{OUT}) is determined by the following equation:

$$V_{OUT} = 1.23V \times \left(1 + \frac{R1}{R2}\right)$$

Table 1. Resistor selection for output voltage setting

V_{OUT}	R1(Ω)	R2(Ω)
3.3V	1.02M	604k
5.0V	1.02M	332k

Inductor Selection

The high switching frequency of 1.0MHz allows for small surface mount inductors. For most designs, the A7506 operates with inductors of 2.2μH to 4.7μH. The equation below can help to select the inductor, the maximum output current can be got by this equation; where η is the efficiency, I_{peak} is the peak current limit, f is the switching frequency, L is the inductance value and D is the duty cycle.

$$I_{OUT} = \eta \times \left(I_{peak} - \frac{V_{IN} \times D}{2 \times f \times L} \right) \times (1 - D)$$

Larger inductors mean less inductor current ripple and usually less output voltage ripple. Larger inductors also mean more load power can be delivered. But large inductors are also with large profile and costly. The inductor ripple current is typically set for 20% to 40% of the maximum inductor current. When selecting an inductor, the DC current rating must be high enough to avoid saturation at peak current. For optimum load transient and efficiency, the low DCR should be selected. Table 2 list some typical surface mount inductors that meet target applications for the A7506:

Table 2. Typical Surface Mount Inductors

Part Number	L (μH)	Max DCR (mΩ)	Rated D.C. Current (A)	Size WxLxH (mm)
Sumida CR43	4.7	108.7	1.15	4.3x4.8x3.5
Sumida CDRH4D28	4.7	72	1.32	5.0x5.0x3.0
Toko D53LC	4.7	45	1.87	5.0x5.0x3.0

Output Capacitor Selection

The output capacitor is required to keep the output voltage ripple small and to ensure regulation loop stability. A 10μF output capacitor is sufficient for most applications. The output capacitor must have low impedance at the switching frequency. Ceramic capacitors with X5R or X7R dielectrics are recommended due to their low ESR and high ripple current ratings.

Input Capacitor Selection

The input capacitor reduces the surge current drawn from the input and switching noise from the device. A minimum 10μF input capacitor is needed for most applications. The input capacitor impedance at the switching frequency should be less than input source impedance to prevent high frequency switching current passing to the input. A low ESR input capacitor sized for maximum RMS current must be used. Ceramic capacitors with X5R or X7R dielectrics are highly recommended because of their low ESR and small temperature coefficients.

PCB Layout Guidance

The A7506 operates at 1.0MHz typically. This is a considerably high frequency for DC-DC converters. In such case PCB layout is important to guarantee satisfactory performance. It is recommended to make traces of the power loop, especially where switching node is involved as short and wide as possible. First of all, the inductor, input and output capacitor should be close to the device. Feedback and shut down circuit should avoid the proximity of large AC signals, e.g. the power inductor and switching nodes. While 2 layer PCB shown in Figure 4 is enough for most applications. Large and integral multi layer ground planes are ideal for high power applications. Large area of copper has lower resistance and helps to dissipate heat on the device. The converter's ground should join the system ground to which it supplies power at one point only. Figure 4 is an example PCB layout for A7506.

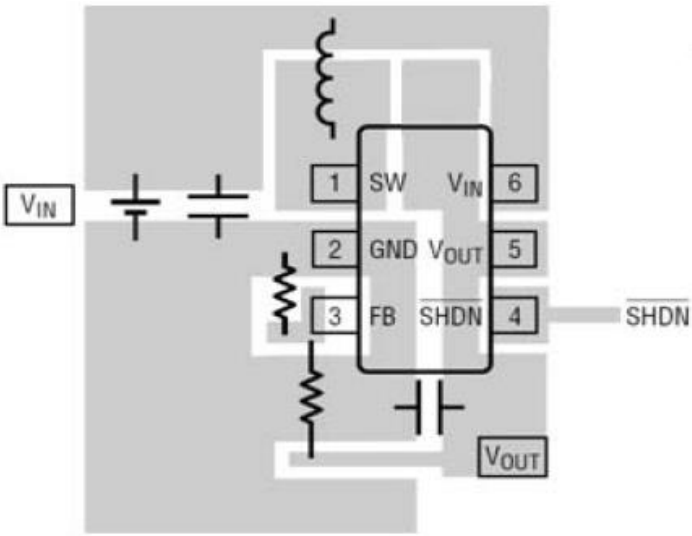
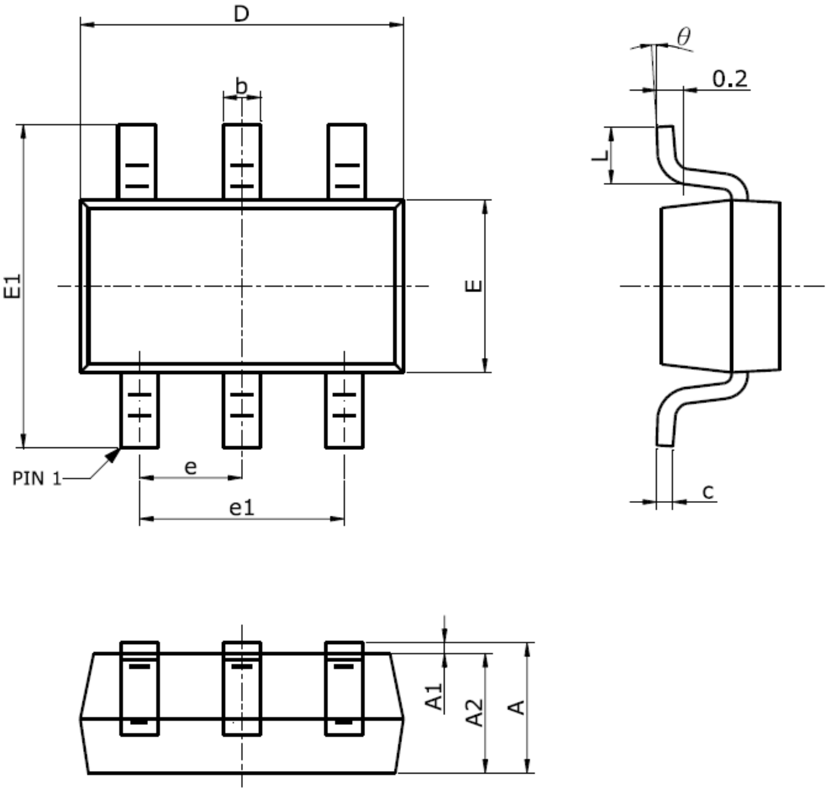


Figure 4. A7506 PCB layout

PACKAGING INFORMATION

Dimension in SOT-26 (Unit: mm)



Symbol	Millimeters		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°

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