Description

S713XS is a family of high performance offline PSR power switch for low power AC/DC charger and adapter applications. S713XS provides accurate constant voltage and constant current (CV/CC) regulation without opto-coupler and secondary control circuitry.

In CC control, the current and output power setting can be adjusted by the sense resistor Rs connected to the CS pin. In CV control, multi-mode operation is utilized to achieve high performance and high efficiency. The device operates in (Pulse Frequency Modulation) PFM in CC mode as well on high load condition and it operates in the hybrid of AM (Amplitude Modulation) mode and (Frequency Modulation) FM mode on light/medium load. The chip can achieve audio noise free operation and optimized dynamic response. The chip consumes very low operation current; it can achieve less than 75mW standby power. In addition, good load regulation is achieved by the built-in cable drop compensation.

S713XS integrates multiple protections, such as Open Circuit Protection, Output Short Circuit Protection, VCC Over-voltage Protection and Over Temperature Protection to eliminate the external protection circuits and provide reliable operation.

S713XS adopts SOP-7 package.

Features

- ≤75mW low standby power consumption, which satisfies Doe level 6 requirements
- Quasi-resonant operation, higher overall efficiency
- Integrated low-cost BJT switch
- Constant-Current (CC) and Constant-Voltage (CV) with Primary Side Regulator
- Built-in Cable Compensation
- Built-in Line Compensation
- Built-in short circuit protection and VCC overvoltage protection
- Built-in VCC voltage clamp
- Built-in Over Temperature Protection

Applications

- Low power AC/DC adapter/chargers for cell phones, PDAs, digital cameras
- AC/DC LED Driver applications
- Linear AC/DC replacement
- Standby and Auxiliary Power Supplies, Set Top Boxes (STB)

Typical Application

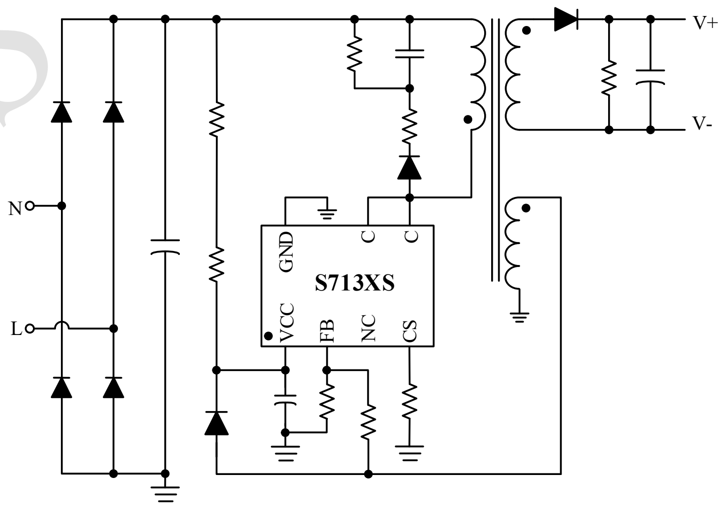


Figure 1 Typical Application Circuit

Ordering Information

Part Number	Package	Operating Ambient Temperature	Packing Method	Marking
S7132S	SOP-7	-40°C ~105°C	T&R 4,000 pcs/reel	S7132S XXXXXXX XXXXXXX
S7133S	SOP-7	-40°C ~ 105°C	T&R 4,000 pcs/reel	S7133S XXXXXXX XXXXXXX
S7134S	SOP-7	-40°C ~ 105°C	T&R 4,000 pcs/reel	S7134S XXXXXXX XXXXXXX

Pin Configuration and Marking Information

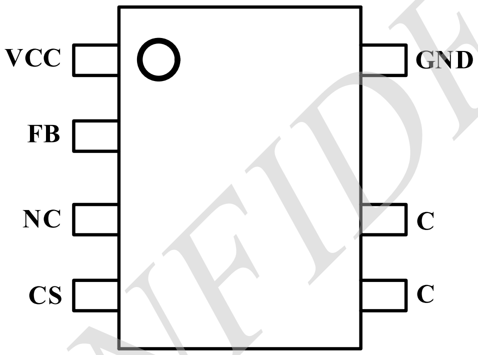


Figure 2. Pin configuration

Pin Definition

Pin No.	Name	Description
1	VCC	Power Supply
2	FB	Voltage feedback terminal
3	NC	Not connected
4	CS	Current sense terminal
5，6	C	Collector pin of Internal integrated BJT
7	GND	Power Ground

Absolute Maximum Ratings (Note1)

Symbol	Parameters	Range	Units
FB	Feedback pin input voltage	-0.3~7	V
VCC	Power supply voltage	-0.3~22	V
CS	Current sense pin input voltage	-0.3~7	V
P_{DMAX}	Power dissipation (Note2)	0.45	W
θ_{JA}	Thermal resistance (Junction to Ambient)	145	℃/W
T_J	Operating junction temperature	-40 to 150	℃
T_{STG}	Storage temperature range	-55 to 150	℃
ESD	ESD (Note3)	2	kV

Note 1: Stresses beyond those listed under “absolute maximum ratings” may cause permanent damage to the device. Under “recommended operating conditions” the device operation is assured, but some particular parameter may not be achieved. The electrical characteristics table defines the operation range of the device, the electrical characteristics is assured on DC and AC voltage by test program. For the parameters without minimum and maximum value in the EC table, the typical value defines the operation range, the accuracy is not guaranteed by spec.

Note 2: The maximum power dissipation decreases if temperature rises, it is decided by T_{JMA}, θ_{JA}, and environment temperature (T_A). The maximum power dissipation is the lower one between $P_{DMAX} = (T_{JMAX} - T_A)/ \theta_{JA}$ and the number listed in the maximum table.

Note 3: Human Body mode, 100pF capacitor discharge on 1.5kΩ resistor

Recommended output power list

Products	Output power（85~264Vac）
S7132S	5V1A
S7133S	5V2A
S7134S	5V2.4A

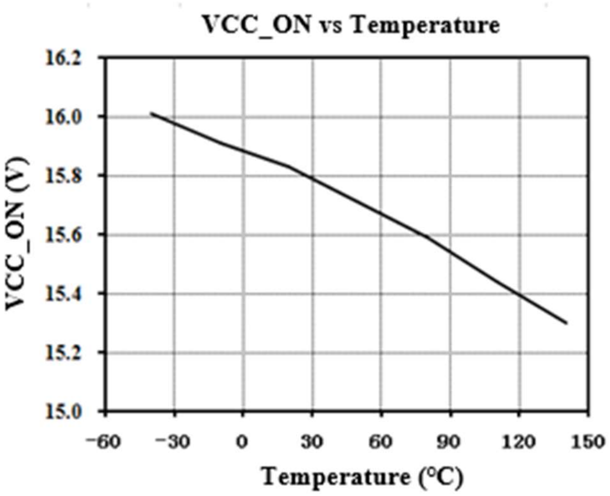
Electrical Characteristics (Notes 4, 5) (VCC =9V, Ta=25°C, unless otherwise specified)

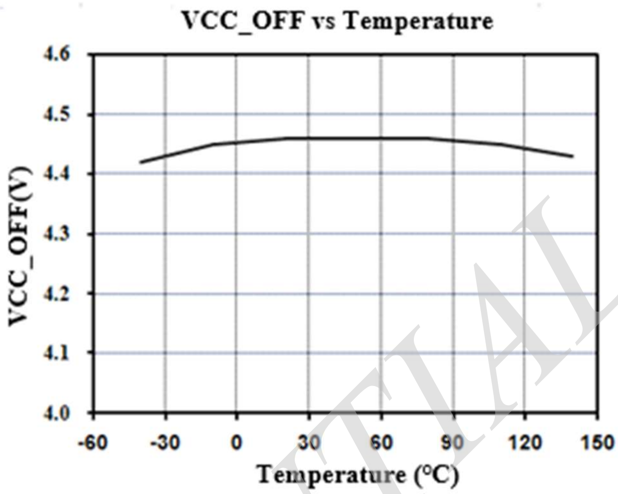
Parameter	Symbol		Condition	Min	Typ	Max	Unit
Supply Section							
Turn-on Voltage	VCC_ON				16		V
Turn-off Voltage	VCC_OFF			3.9	4.5	5.1	V
Start-up Current	ISTART		VCC_ON – 1V		2	5	uA
Standby current	ISTANDBY				0.5		mA
VCC OVP Threshold Voltage	VCC_OVP			18	20	22	V
Current Sense Section							
Maximum Current Threshold Voltage	VREF			485	500	515	mV
Leading edge blanking time	TLEB				500		ns
Feedback Section							
FB Threshold Voltage	VFB_REF			1.98	2	2.02	V
Maximum cable compensation current	Icable_max				60		uA
Demagnetization comparison voltage threshold	VFB_dem				25		mV
Output short circuit jitter removal time	TFB_short				70		mS
Protection Section							
FB OVP Threshold	VFB_OVP				2.8		V
FB Short Circuit Threshold	VFB_SCP				1.2		V
Shutdown Temperature	Tsd				150		°C
Power NPN Section							
Collector-Base breakdown voltage	VCBO	S7132S		850			V
		S7133S		700			V
		S7134S		700			V
Maximum collector current	Ipeak	S7132S			400		mA
		S7133S			700		mA
		S7134S			850		mA

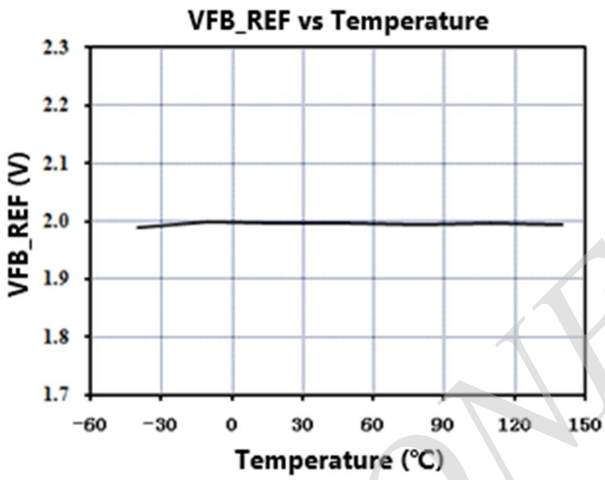
Note 4: *production testing of the chip is performed at 25°C.*

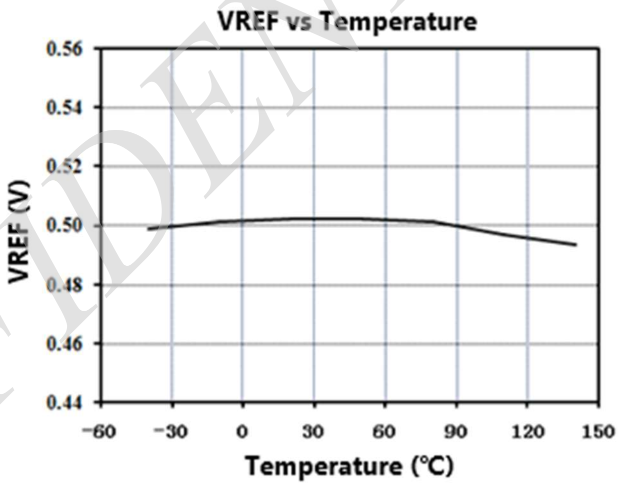
Note 5: *the maximum and minimum parameters specified are guaranteed by test, the typical value are guaranteed by design, characterization and statistical analysis*

Characterization Plots









Internal Block Diagram

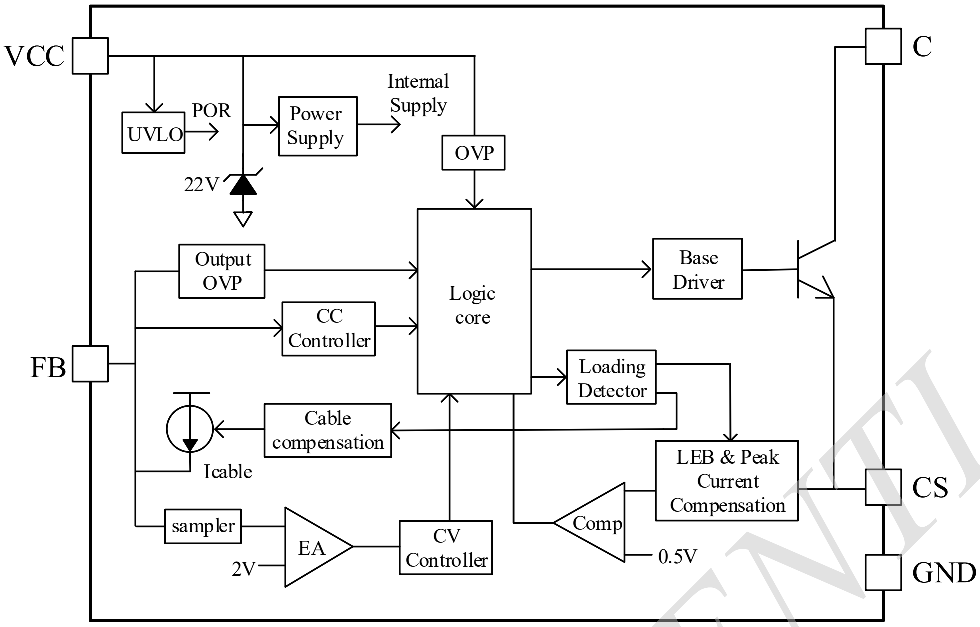


Figure 3. S713XS Internal Block Diagram

Operation Description

S713XS is a family of multi-mode, highly integrated DCM (Discontinuous Conduction Mode) Primary Side Regulation (PSR) controller. The built-in high precision CV/CC control with high level protection features makes it suitable for offline small power converter applications.

Startup Current and Startup Control

The startup current of S713XS is only 2uA, so that VCC can be charged up quickly. A large value startup resistor can therefore be used to minimize the power loss in application. When VCC reaches UVLO turn-on voltage of 16V (typical), S713XS begins switching. The hold-up capacitor continues to supply VCC before the auxiliary winding of the transformer takes the control of VCC voltage. Therefore, the capacitor value should be large enough to keep power supply before the auxiliary winding works, avoiding VCC drops to turn-off voltage.

Constant Current Control

In the chip, the peak current of inductor is detected cycle-by-cycle. The CS terminal is connected to the input terminal of the internal peak current comparator and compared with the internal reference voltage to control the power switch. The peak current can be limited, and the maximum output current of the system can be adjusted by changing the resistance value of the current detection resistor R_S connected to the ground, as shown in Figure 4. The input line voltage compensation function is built in the chip, which makes the output current change little with the input voltage.

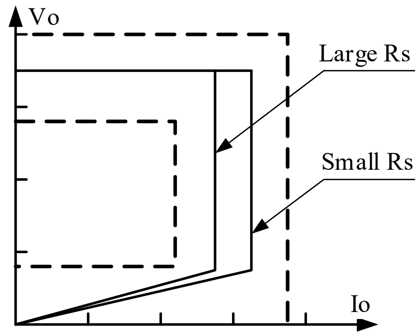


Figure 4. OCP is adjustable by changing R_S

The primary peak current in CC mode is given by:

$$I_{pk} = \frac{V_{REF}}{R_S} = \frac{0.5}{R_S}$$

R_S is the current sense resistor at CS pin as illustrated in typical application. The CC point output current is given by

$$I_O = 0.25 * I_{pk} * \frac{N_P}{N_S}$$

I_{pk} is the primary peak current, N_P is the turns of primary winding, N_S is the turns of secondary winding.

OCP compensation

Without compensation, the variation of max output current in CC mode will be very large. The OCP threshold value is self-adjusted higher when higher AC input. This OCP threshold slope adjustment helps to compensate the increased output current limit at higher AC voltage. In S713XS, an OCP compensation block is integrated and no external components are needed. The OCP threshold of S713XS is a function of the primary side switching ON time (Tonp). For the ON time is larger than 4.5uS, the CS threshold voltage is clamped to 500mV. For the ON time is between 4.5uS and 2.2uS, the CS threshold voltage changes linearly from 500mV to 482mV. For the ON time is below 2.2uS, the CS threshold voltage is clamped to 482mV. As shown in Figure 5. All the above time and voltage value is typical design value.

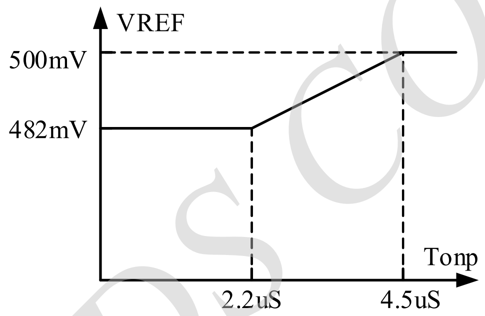


Figure 5. OCP compensation

Constant Voltage Control

S713XS captures the auxiliary winding feedback voltage at FB pin and operates in constant-voltage (CV) mode to regulate the output Voltage. Assuming the secondary winding is master, the auxiliary winding is slave during the D1 on-time. The auxiliary voltage is given by:

$$V_{AUX} = \frac{N_{AUX}}{N_S}(V_O + V_d)$$

Where V_d is the diode forward drop voltage, N_{AUX} is the turns of auxiliary winding, and N_S is the turns of secondary winding.

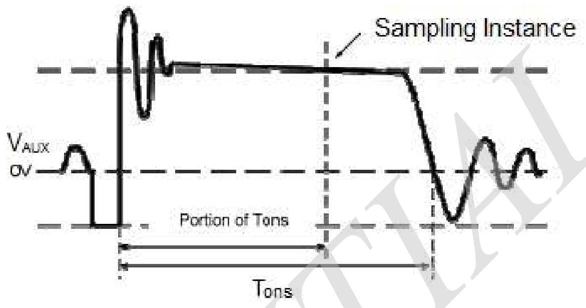


Figure6. Auxiliary winding Voltage Waveform

The diode drop voltage depends on the current. If the secondary voltage is always detected at a constant secondary current, the difference between the output voltage and the secondary voltage will be a fixed V_d. Figure 6 is the auxiliary winding voltage waveform. Via a resistor divider connected between the auxiliary winding and FB, the auxiliary voltage is sampled at two-thirds of the Tons (D1 on-time). The sampled voltage is compared with VFB_REF (typical 2V) and the error is amplified. The error amplifier output reflects the load condition and controls the switching off time to regulate the output voltage, thus constant output voltage can be achieved.

The output voltage is given by:

$$Vo = \frac{VFB_{\_REF} \times (R_{FBL} + R_{FBH})}{R_{FBL}} \times \frac{N_S}{N_{AUX}} - Vd$$

Inductor Calculation

The switching frequency of S713XS is adaptively controlled according to the load conditions and the operation modes. For fly-back operating in DCM, the maximum switching frequency is given by

$$F_{\max} = \frac{2 \times P_{O\_MAX}}{\eta \times L_P \times I_{pk}^2}$$

P_{O_MAX} is the maximum output power,

η is the transfer efficiency,

L_P indicates the inductance of primary winding,

I_{pk} is the peak current of primary winding.

After determining the max working frequency F_{max} of the system, the calculation formula of inductance can be achieved as follows:

$$L_P = \frac{2 \times P_{O\_MAX}}{\eta \times F_{\max} \times I_{pk}^2}$$

Cable Drop Compensation

In S713XS, cable drop compensation is implemented to achieve good load regulation. An offset voltage is generated at FB pin by an internal current sinking from the resister divider. The current is proportional to the output load current, thus the drop due to the cable loss can be compensated. As the load current decreases from full-load to no-load, the offset voltage at FB will also decrease. It can also be programmed by adjusting the resistance of the divider to compensate the drop for various cable lines used. The percentage of maximum compensation is given by the following equation:

$$\frac{\Delta V}{Vout} \approx \frac{I_{cable\_\max} \times (R_{FBL} \parallel R_{FBH})}{V_{FB\_REF}} \times 100\%$$

For example: R_{FBL}=2KΩ, R_{FBH}=10 KΩ and the cable current is 60uA, then the percentage of maximum compensation is

$$\frac{\Delta V}{Vout} \approx \frac{60uA \times (2K||10K)}{2.0V} \times 100\% \approx 5\%$$

Output over voltage protection and Short Circuit Protection

When FB detects that the platform voltage reaches the internal set open circuit protection threshold of 2.8V, the system enters the open circuit protection.

$$V_{OVP} = \frac{2.8 \times (R_{FBL} + R_{FBH})}{R_{FBL}} \times \frac{N_S}{N_{aux}}$$

V_{OVP} is output over voltage threshold value.

$$V_{SCP} = \frac{1.2 \times (R_{FBL} + R_{FBH})}{R_{FBL}} \times \frac{N_S}{N_{aux}}$$

V_{SCP} is output short circuit threshold value.

When FB detects that the platform voltage below the internal set short circuit protection threshold of 1.2V for over 70mS, the system enters the short circuit protection.

Protection Control

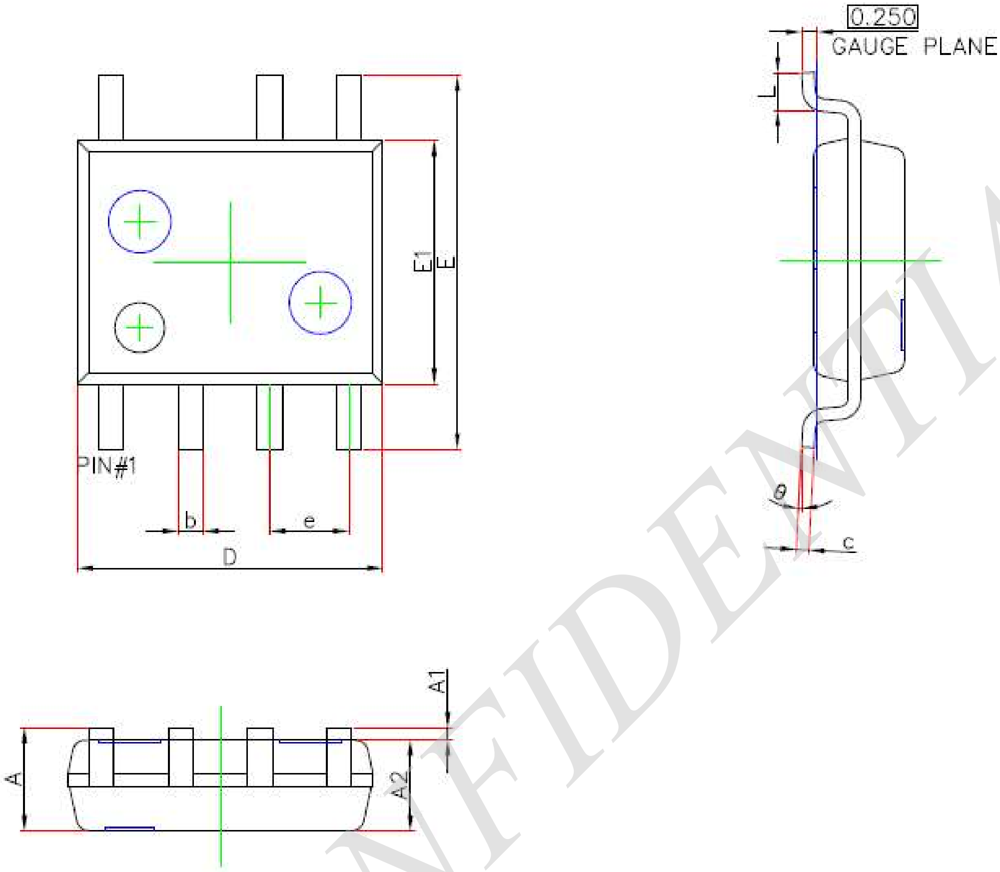
S713XS is built-in rich protection features, including cycle-by-cycle current limiting (OCP), output over voltage protection, VCC over voltage protection, short circuit protection, under voltage lockout on VCC (UVLO), and over temperature protection (OTP).

PCB Layout Consideration

Comply with the following rules will achieve better performance when design PCB Layout:

1) **The Area of Power Loop:** The area of the main current loop should be as small as possible to reduce EMI radiation, such as the primary current loop, the snubber circuit and the secondary rectifying loop. Drain pin increases the copper area of the drain terminal for heat dissipation. And the PCB trace should be wide and short for thermal consideration.
2) **Bypass Capacitor and FB divider resistor:** The bypass capacitor of VCC and the FB divider resistor should be placed as close as possible to pin out. And the negative node of VCC capacitor and the FB down resistor should be connected directly to the IC GND pin before single point connected to the negative node of the output capacitor.
3) **Ground Path:** The GND path of the input power loop and IC controller path should be separated and connected at the negative terminal of input capacitor by single point, such as power sense resistor, the negative of the auxiliary winding and the IC GND.

SOP-7 Physical Dimensions



Symbol	Dimensions in Millimeters		Dimensions in Inches	
	Min.	Max.	Min.	Max.
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.250	1.650	0.049	0.065
b	0.33	0.51	0.013	0.020
c	0.17	0.25	0.007	0.010
D	4.700	5.100	0.185	0.201
E	5.800	6.200	0.228	0.244
E1	3.700	4.100	0.146	0.161
e	1.270（BSC）		0.050（BSC）	
L	0.400	0.800	0.016	0.038
θ	0°	8°	0°	8°