

## Data Sheet Of INK1003 IC Driver

### Characteristics

- **3-Channel** constant current LED driver.
- Output current won't vary with the driving output voltage.
- Wide operating voltage:3.3~5.4V
- High gray level, **256 gray levels**.
- Polarity reverse function makes INK1003 suitable for high power full color LED lighting.
- Low output current deviation:
  - Between channels in a single chip:  $\pm 1\%$ ;
  - Between chips:  $\pm 3\%$ ;
- Data frequency range wide: 400~800KHz
- Schmitt trigger input
- High reliability, ESD susceptibility high: HBM 8KV

### Applications

- LED decorative lighting
- **Digital Dream Color Led Strip Light**
- Indoor/Outdoor LED video or massage display
- PWM signal generator
- All kinds of LED point light source
- LED strips operate between 5~12V

### General Description

INK1003 is a constant current LED driver. **It is a single line 3-Channel 256 Grey Level Driver.** It is designed for indoor/ outdoor LED displays and decorative LED lighting system. It is suitable for LED cascading applications. The INK1003 owns 3 output channels, each channel can sink 18.6mA constant current. INK1003 contains single line data transceiver decoder, data latches, output registers, band gap reference voltage generator, internal oscillator, and low saturation constant current sinks. The data received by INK1003 is decoded and then the decoded data is transferred in to the gray level comparator. The output of the gray level comparator controls the constant output current.

The output polarity reverse function is designed for driving high power LED by adapting the application circuitry. The single line control scheme reduces the engineering troubles mostly, the special designed input and output staged of INK1003, make INK1003 survive during output and input pin short with power source or GND. When 800KHz, it can achieve 1024Pixels cascade connection.

INK1003 is available in both SOP-8 and DIP-8 packages, the operating temperature is  $-40\sim 85^{\circ}\text{C}$ .

### PIN CONFIGURATION

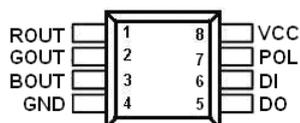
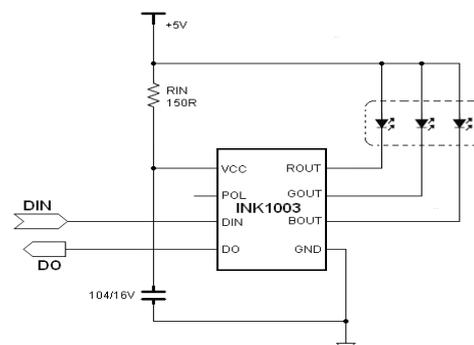


Fig1 SOP-8

### TYPICAL APPLICATION CIRCUIT



## Absolute Maximum Ratings

| Parameter  | Symbol             | Ratings                           | Unit |
|--|--------------------|-----------------------------------|------|
| Power Supply Voltage   | VCC                | -0.3 to 6V                        | V    |
| Input Voltage  | V <sub>IN</sub>    | -0.3 to VCC+0.3V                  | V    |
| Output Pin Voltage   | V <sub>OUT</sub>   | -0.3 to VCC+0.3V                  | V    |
| Driver PIN voltage   | V <sub>XOUT</sub>  | -0.3 to 10V, I <sub>OUT</sub> off | V    |
|  | V <sub>XOUT</sub>  | -0.3 to 5V,                       | V    |
| Output current   | I <sub>OUTCC</sub> | 18                                | mA   |
| Output Current Deviation (Constant Current Driving Mode)<br>Between output channels<br>Between chips | D <sub>IOI</sub>   | ±1                                | %    |
|  | D <sub>IOE</sub>   | ±3                                | %    |
| Input Clock Frequency  | F <sub>CLK</sub>   | 800                               | KHz  |
| Maximum Power Dissipation  | P <sub>D</sub>     | 1200                              | mW   |
| Operating Junction Temperature   | T <sub>opr</sub>   | -40 to + 150                      | °C   |
| Storage Temperature Range  | T <sub>stg</sub>   | -55 to + 150                      |      |
| ESD susceptibility   |                    | 8000                              | V    |

**Note:** If the voltage on the pins exceeds the maximum ratings may cause permanent damage to the device.

## Electrical Parameters (VCC=5V, TA= 25°C, specified otherwise.)

| Parameter                            | Symbol               | Conditions   | Min     | Typ  | Max     | Units |
|--------------------------------------|----------------------|--|---------|------|---------|-------|
| VCC range                            | V <sub>CC</sub>      |  | 3       | --   | 5       | V     |
| Output voltage                       | V <sub>OUT</sub>     | I <sub>OUT</sub> =1uA  | -0.3    | --   | 10      | V     |
| Output Current                       | I <sub>OUTH</sub>    | V <sub>XOUT</sub> =2V  | 17      | --   | 19      | mA    |
|                                      | I <sub>OUTL</sub>    | Output= "HIGH" ,<br>V <sub>OUT</sub> =10V                          | --      | 1    | 10      | uA    |
|                                      | I <sub>SOURCE</sub>  | Other output   | --      | 1    | --      | mA    |
|                                      | I <sub>SINK</sub>    | Other output   | --      | -1   | --      | mA    |
| Quiescent Current                    | I <sub>STB</sub>     |  | --      | 1000 | 1600    | μA    |
| VCC clamp voltage                    | V <sub>CCCLAMP</sub> | V <sub>IN</sub> =12V   | 5.3     | 5.4  | 5.6     | V     |
| Minimum constant current output time | I <sub>OH</sub>      | V <sub>IN</sub> =V <sub>IH</sub> or V <sub>IL</sub> ,              | --      | 2    | --      | uS    |
| Input current                        | I <sub>IN</sub>      | PIN: CKI, SDI<br>V <sub>IN</sub> =VDD or GND                       | --      | --   | ±1      | uA    |
| Input voltage level                  | V <sub>IH</sub>      | TA= -40~125°C  | 0.8*VDD | --   | VDD     | V     |
|                                      | V <sub>IL</sub>      |  | GND     | --   | 0.2*VDD | V     |
| Output current voltage regulation    | %dV <sub>OUT</sub>   |  | --      | ±1   | --      | %/V   |
| Output current line regulation       | %dV <sub>CC</sub>    | V <sub>CC</sub> =4~5.5V, V <sub>OUT</sub><br>between 1.0V and 3.0V | --      | ±1   | --      | %/V   |
| Pull down resistor                   | R <sub>INLOW</sub>   | R <sub>LIN</sub> ,   | --      | 300  | --      | KΩ    |

Function Block Diagram

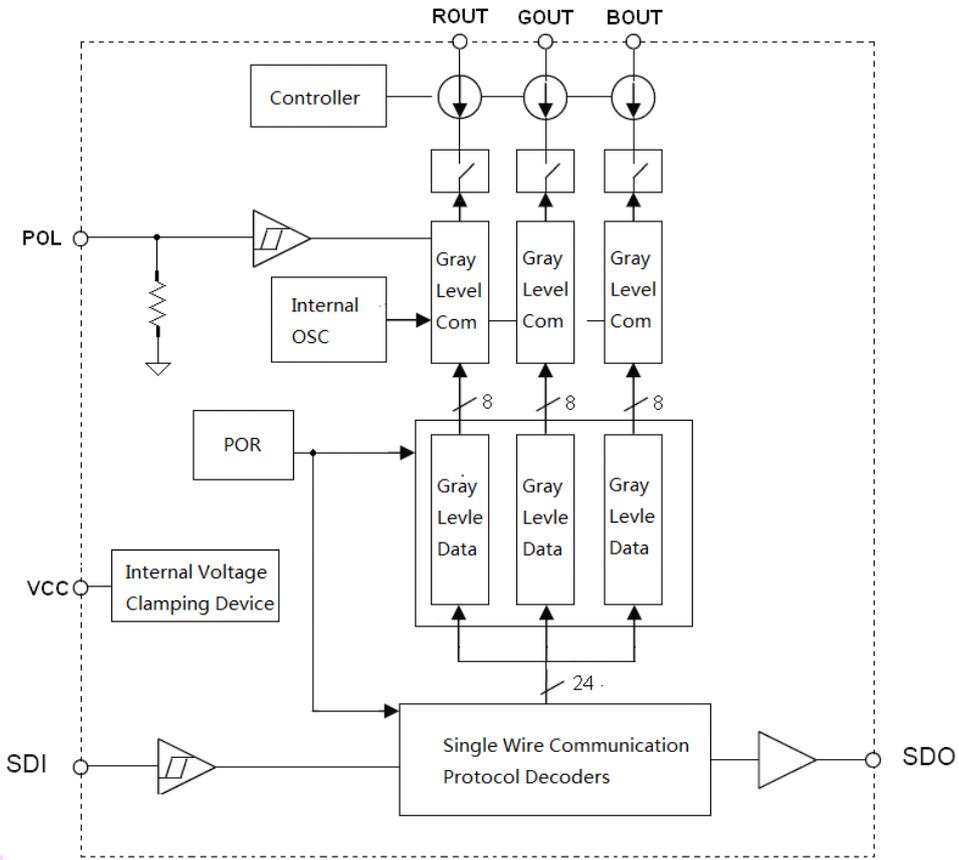


Fig2, Internal Function Block Diagram of INK1003

PIN Description

| PIN | NAME | FUNCTION   |
|-----|------|--|
| 1   | ROUT | 18mA low saturation constant current driver  |
| 2   | GOUT | 18mA low saturation constant current driver  |
| 3   | BOUT | 18mA low saturation constant current driver  |
| 4   | GND  | Ground   |
| 5   | SDO  | Buffered serial data output  |
| 6   | SDI  | Serial data input  |
| 7   | POL  | Output polarity reverse:<br>POL= "HIGH" output is reversed;<br>POL= "LOW" , normal operation |
| 8   | VCC  | Power supply   |

**APPLICATIONS INFORMATION**

**Constant Current Output**

In LED displays and decorative LED lighting system, INK 1003 can provide a constant output current varies precious little with output voltage, as several reasons bellow:

- 1) Advanced circuit construction results in Low output current deviation: ±1 % between channels in a single chip, ±3% between chips;
- 2) Advanced circuit construction results in constant current when output voltage is higher than saturation voltage. As the advantageous line regulation the I/V diagram of output current between voltage is nearly a horizontal straight line , which means output current is nearly independent with output voltage.

**Power Dissipation of INK1003**

The MAX power dissipation of INK1003 is determined by:  $PD(max)=(Tj-Ta)/R_{th(j-a)}$ ,when all 3 channel is on the power dissipation is :  $P_d(act) = (I_{DD} \times V_{DD}) + (I_{OUT} \times Duty \times V_{DS} \times 3)$  . In order to guarantee:

$PD(act) \leq PD(MAX)$ , the formula translation between output current and duty is :

$$I_{OUT} = \left( \frac{T_j - T_a}{R_{th(j-a)}} - I_{CC} \times V_{CC} \right) / V_{DS} / Duty / 3$$

When ambient temperature rises, the MAX power dissipation falls.

**Load Voltage (V<sub>LED</sub>)**

The design value of V<sub>DS</sub> is 0.4~5V. Ensuring PD(ACT)>PD(MAX), the V<sub>DS</sub> could be higher.. V<sub>DS</sub>=V<sub>LED</sub>-V<sub>F</sub> when V<sub>LED</sub>=12V. V<sub>LED</sub> is load voltage, which can be set lower, which is just higher than the lowest voltage allowed. A voltage divider can be used when necessary to produce a V<sub>DROP</sub> for a lower power dissipation in IC, the formula can be described as: V<sub>DS</sub>=(V<sub>LED</sub>-V<sub>F</sub>)-V<sub>DROP</sub>

As the picture shows, resistors and zener diodes are suitable to reduce power dissipation of INK1003.

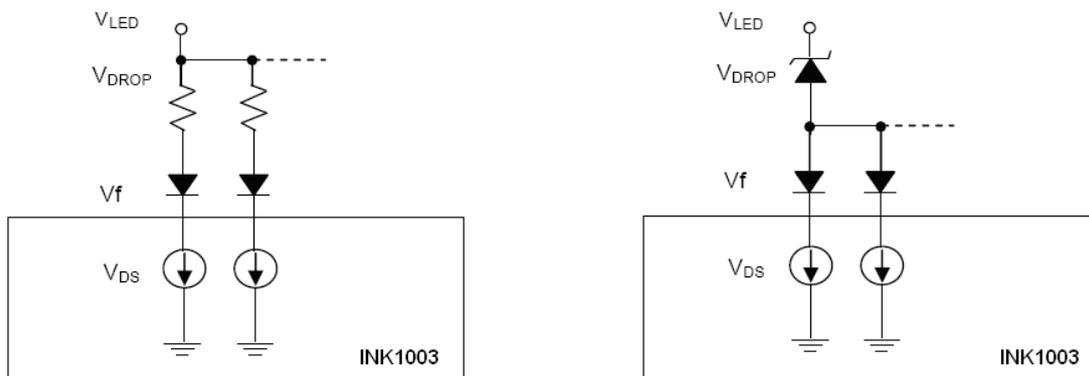


Fig 3, the voltage divider design of INK1003

**Gray Scale Data Word Format**

INK1003 uses the one-line communication mode, with return to zero code gray scale data transport. When the SDI node receives total 24 bit data, SDO node begins to send data to the next chip (set low before sending) . After that the IC no longer receives data, 3 PWM output named ROUT、GOUT、BOUT outputs signal with different duty according to the data received. The period of output signal is 3.2mS.The chip receives data again until RESET signal is sent to SDI node of the IC. Then the SDI node receives total 24 bit data, SDO node begins to send data to the next IC again. The output of ROUT、ROUT、BOUT will not change until receiving RESET signal. After the RESET signal( more than 24uS low signal) , 24 bit PWM data received newly will output to ROUT、GOUT、BOUT.

Automatic shaping forwarding technology is utilized, so the number of cascade is not affected by the signal transmission, but only affected by refresh speed. A n example of 1024 cascade, whose refresh time is 1024X0.4X2=0.8192ms, There will be no flicker phenomenon.

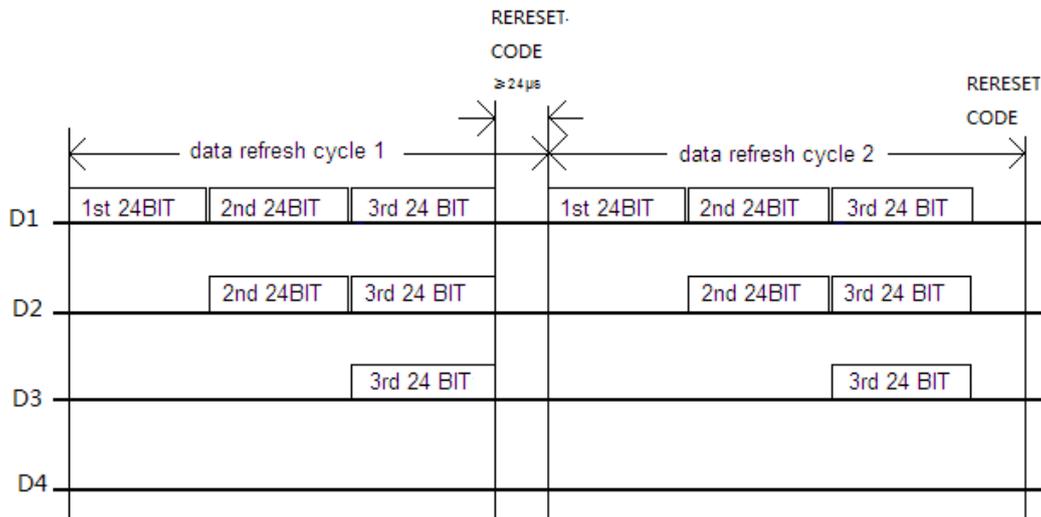
During data transfer, the first bit is the MSB of the ROUT channel, the last one transferred into the data shift register is the LSB of the BOUT channel.

The current duty of each channel of as bellow:

$$D_{xOUT} = \frac{L[7]*2^7 + L[6]*2^6 + L[5]*2^5 + L[4]*2^4 + L[3]*2^3 + L[2]*2^2 + L[1]*2^1 + L[0]}{256} \dots\dots (7)$$

Where L[x]="0" or "1", which is R、G、B[x], x=0,1,2.....7 in the gray scale data. Gray scale data 0000 0000 is for the minimum 0 duty ratio, and 1111 1111 is for the maximum duty ratio.

**INK1003 Communication Protocol**

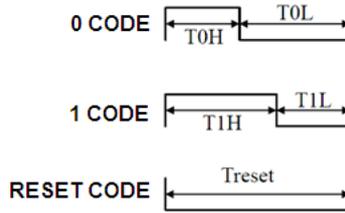


**24 BIT DATA FORMATE**

|    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| R7 | R6 | R5 | R4 | R3 | R2 | R1 | R0 | G7 | G6 | G5 | G4 | G3 | G2 | G1 | G0 | B7 | B6 | B5 | B4 | B3 | B2 | B1 | B0 |
|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|

NOTE: MSB is sent first, LSB is sent last. In order to send data ROUT, GOUT, BOUT.

1) INPUT CODE



2) THE DATA SIGNAL LEVEL TIME

| NAME | DISCRIPTION               | TYPICAL      | PERMISSIBLE ERROR |
|------|---------------------------|--------------|-------------------|
| T0H  | 0 code of high level time | 0.25 $\mu$ s | $\pm$ 75ns        |
| T1H  | 1 code of high level time | 1.0 $\mu$ s  | $\pm$ 75ns        |
| T0L  | 0 code of low level time  | 1.0 $\mu$ s  | $\pm$ 75ns        |
| T1L  | 1 code of low level time  | 0.25 $\mu$ s | $\pm$ 75ns        |

Fig 4, data of INK1003

5V APPLICATION

Inner power supply circuit clamps VCC at 5.4V. The clamp circuit will not work at 5V voltage supply, but at some abnormal condition of supply voltage such as the recovery time of short-circuit protection, the output voltage could be as high as 9V, which results in damage of IC. INK1003 could be permanent damaged if the Lamp power supply is reversely connected. In order to avoid such damage, bellow circuit is recommended:

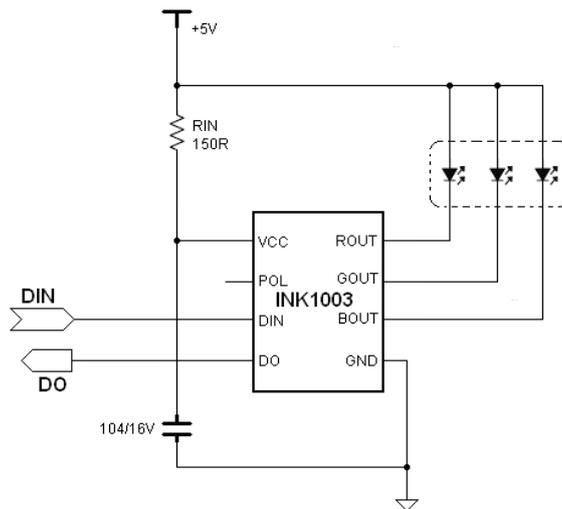


Fig5, typical application circuit of 5V

Such 5V typical application circuit can be widely used in 5V lamp strip, full color exposed lamp and all kinds of small video point light sources.

**INK 1003 APPLICATION IN HIGH POWER PWM CONTROLLER.**

Polarity reverse function is integrated in INK1003, when 7PIN is connected ground or none connect, IC will gray output normal. When 7PIN is connect VCC, the PWM signal of R/G/B channel reverses. The original 0 duty changes to 100%.With such function external power NPN switches or constant current driver can be used to driving the LED lamps in high voltage/power lighting application, and zero gray control can be easily realized. A capacitor connected between VIN and GND is necessary in high power LED lamps

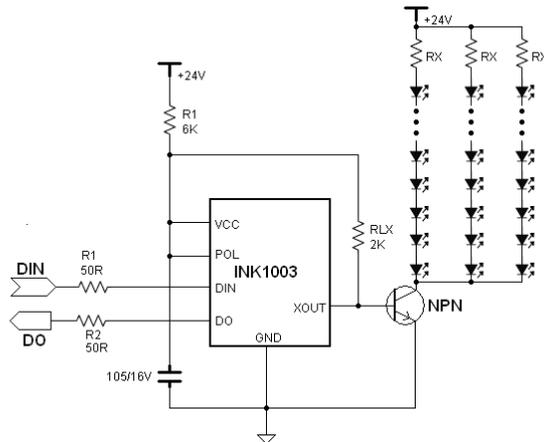


Fig6. Typical high voltage application

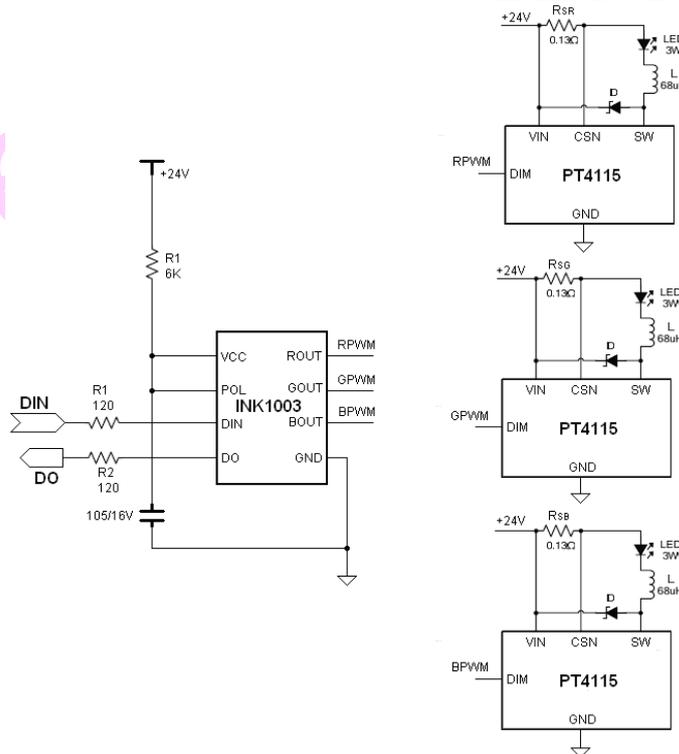


Fig7. typical high power constant current application

NOTE: A capacitor connected between VIN and GND is necessary

**NOTE:**

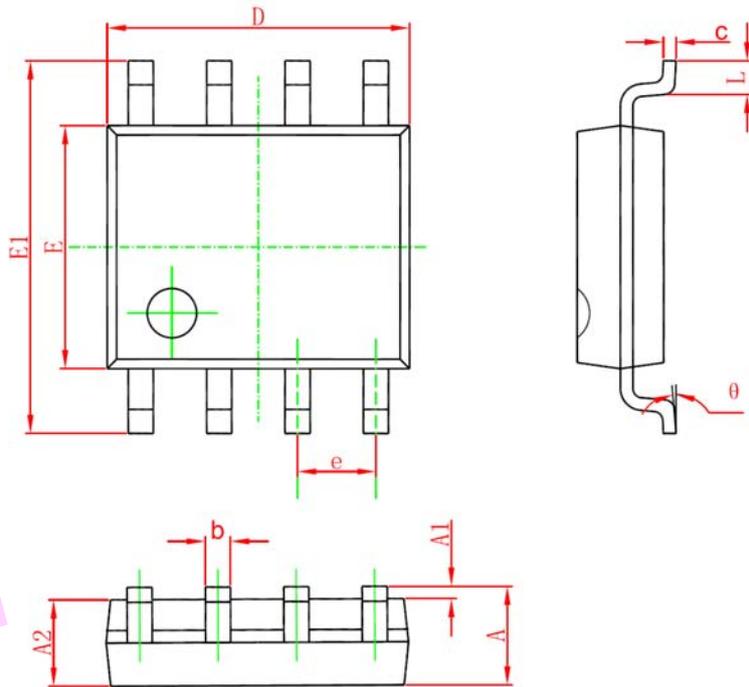
When POL is high as a PWM controller, do not set to “reverse output” in the controller software.

**INK1003 Cascading Applications**

Push-pull output stage is integrated in INK1003 to realize strong driving ability, signal can be transmit very long with cascade application. 20 meters can be realized at the 800 KHz clock frequency in laboratory. A series connected 50ohm resistor is needed to guarantee impedance matching and avoid signal reflection. Meanwhile, damage to the IC is avoid when signal line and power line is misconnected.

**Package Information**

SOP8



| SIGN  | mm         |       |
|-------|------------|-------|
|       | MIN        | MAX   |
| A     | 1.350      | 1.750 |
| A1    | 0.100      | 0.250 |
| A2    | 1.350      | 1.550 |
| b     | 0.330      | 0.510 |
| c     | 0.170      | 0.250 |
| D     | 4.700      | 5.100 |
| E     | 3.800      | 4.000 |
| E1    | 5.800      | 6.200 |
| e     | 1.270(BSC) |       |
| L     | 0.400      | 1.270 |
| theta | 0°         | 8°    |