3-Channel RGB LED Driver

Description

The SN3101 is a constant current LED driver featuring One Shot Programming mode and Interface Intensity Control mode for RGB lighting effects.

Each output of the SN3101 is a constant current sink pulse width modulated in 256 steps, featuring One Shot Programming mode and Interface Intensity Control mode for RGB lighting effects. The output current is user selectable to be one of 5 levels, 17.5mA, 30.9mA, 42.1mA, 48.2mA or 71.9mA (typical). At 42.1mA the SN3101 outputs require only 0.42V of headroom voltage.

In One Shot Programming mode, the timing characteristics for output current - current rising, holding, falling and off time, can be adjusted individually so that each output can independently maintain a pre-established pattern without requiring any additional interface activity, thus saving valuable system resources.

In Interface Intensity Control mode, the PWM duty cycle of each output can be independently programmed and controlled in 256 steps to simplify color mixing.

Features

- 3 channels of 256 steps PWM RGB LED drivers
- Changing intensity of color LEDs with two modes:
  - −One Shot Programming Mode
  - −Interface Intensity Control Mode
- Programmable output current level settings
- For anode-common LEDs
- SPI interface
- Supply voltage range: 3.0V to 5.5V
- Operating temperature range T_A = −40°C ~ +85°C
- Package: DFN-10, 3mm × 3mm

Application

- Cellular phones
- MP3/MP4/CD/minidiskplayers
- Digital picture frame/toy

Typical Application Circuit

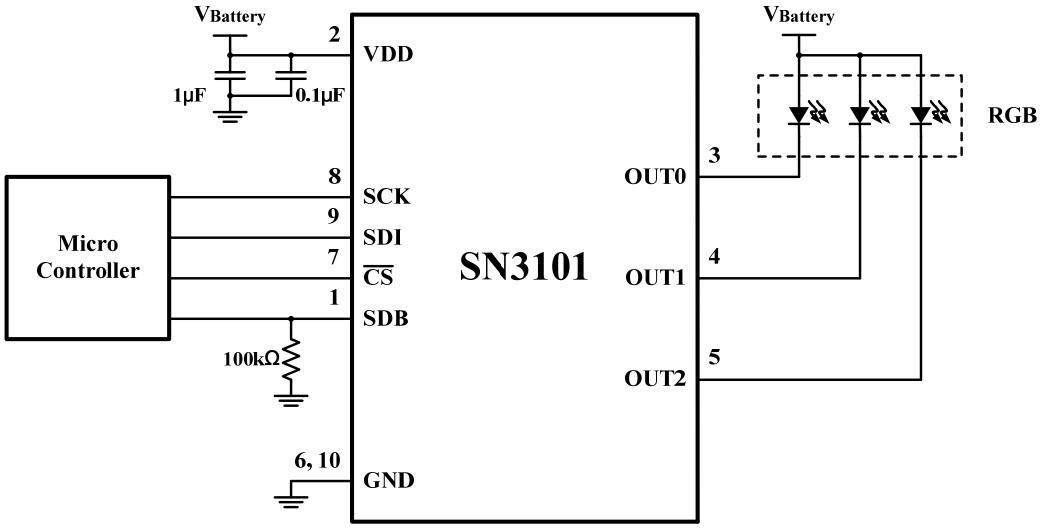
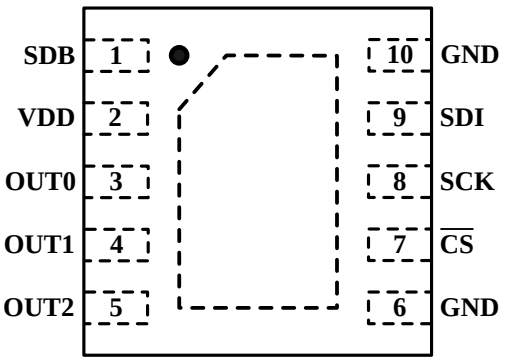


Figure 1 Typical Application Circuit

Pin Configuration

Package	Pin Configurations (Top View)
DFN-10	

Pin Description

No.	Pin	I/O	Description
1	SDB	I	Shutdown, pull to GND in the shutdown mode.
2	VDD	–	Power supply.
3 ~ 5	OUT0 ~ OUT2	O	LED outputs.
6, 10	GND	–	Ground.
7	$\overline{CS}$	I	Active low chip select for serial communications.
8	SCK	I	Input clock for data shift on rising edge.
9	SDI	I/O	Input serial data for data shift resister.
	Thermal Pad	–	Connect to GND.

Ordering Information

Order Number	Package Type	QTY/Reel	Operating Temperature Range
SN3101I310E	DFN-10	2500	−40°C ~ +85°C

SN3101 □ □ □ □

Lead Free Code
E: Lead Free

Pin Code
10: 10 Pins

Package Type
3: DFN, 3mm × 3mm

Operating Temperature Range
I: Industrial, −40°C ~ +85°C

Absolute Maximum Ratings

Supply voltage, V_{DD} ---------- −0.3V ~ +6.0V
Storage temperature range ---------- −65°C ~ +150°C
Input voltage ---------- −0.3V ~ V_{DD} + 0.3V
Junction temperature ---------- 150°C
Solder information vapor phase (60s) ---------- 215°C
Infrared (15s) ---------- 220°C
Operating temperature range ---------- −40°C ~ +85°C

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other condition beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Electrical Characteristics

The following specifications apply for V_{DD} = 5V, unless otherwise noted. Limits apply for T_A = 25°C. *(Note 1)*

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
V_{DD}	Supply voltage		3.0		5.5	V
I_{DD}	Quiescent power supply current	$V_{SDB} = V_{DD}$		1.4	2.0	mA
I_{SD}	Shutdown current	V_{SDB} = GND		0.1	1.0	μA
	Software shutdown			1.7	3.0	μA
I_{OUT}	Average output current	Interface Intensity Control Mode PWM Bytes = 0xFF, V_{DS} = 0.6V OUT0 ~ OUT2		42.1		mA
V_{HR}	Current sink headroom voltage	I_{LED} = 42.1mA		420		mV
SCK, SDI, $\overline{CS}$, SDB Logic Electrical Characteristics						
$V_{IN(0)}$	Logic "0" input voltage	V_{DD} = 3.0V ~ 5.5V			0.4	V
$V_{IN(1)}$	Logic "1" input voltage	V_{DD} = 3.0V ~ 5.5V	1.4			V
$I_{IN(0)}$	Logic "0" input current			5.0		nA *(Note 2)*
$I_{IN(1)}$	Logic "1" input current			5.0		nA *(Note 2)*

Digital Input Switching Characteristics *(Note 2)*

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
f_{CK}	SCK rrequency				1.0	MHz
t_{CH}	SCK high time		200			ns
t_{CL}	SCK low time		200			ns
t_{DH}	SDI setup time		50			ns
t_{DS}	SDI high time		50			ns
t_{CSS}	$\overline{CS}$ to SCK rise setup time		250			ns
t_{CSCP}	$\overline{CS}$ rising edge to SCK rising edge		200			ns
t_{CSH}	$\overline{CS}$ pulse high time		300			ns

Note1: Production testing of the device is performed at 25°C. Functional operation of the device and parameters specified over other temperature range, are guaranteed by design, characterization and process control.

Note2: Guaranteed by design.

Application Information

SPI Interface

The SN3101 contains a 16bit SPI interface to access the internal data and control registers of the device (see Registers Definitions). This module is used to receive the commands transmitted by MCU. The 16-bit serial interface uses three pins, SDI and SCK to enter data. Data read is not available and data entered must be 16 bits. The description of three pins is shown in table 1.

Table 1 Serial Pins

Signal Name	Attribute	Direction	Description
SCK	Edge Triggered	MCU-> SN3101	Serial bus clock
SDI	Level	MCU -> SN3101	Serial data
$\overline{CS}$	Active Low	MCU -> SN3101	SPI bus selection

Table 2 shows the structure of the 16-bit command word and Figure 2 shows the timing diagram of this serial interface. When the SPI block is idle, the MCU must maintain HIGH. For the MCU to transmit data to the SN3101, must be pulled LOW and remain LOW for the duration of the transmission. The first 8 bits are address bits and the remaining 8 bits are data bits.

Initial Power-Up

On initial power-up, the SN3101 registers are reset to their default values, OUT0~OUT2 need to be turned on thru **SDRGB** bit in Configuration Register (00h).

Shutdown Mode

The SN3101 device features a shutdown mode. Shutdown mode is entered via a write to the Configuration Register (see Table 4). In shutdown mode all of the output current sources are switched off. Shutdown mode can either be used as a means to reduce power consumption or for generating a flashing display (repeatedly entering and leaving shutdown mode).

Note: During shutdown mode the Digit-Registers maintain their data.

Table 2 16-Bit Serial Data Format

A7	A6	A5	A4	A3	A2	A1	A0	D7	D6	D5	D4	D3	D2	D1	D0
MSB		Register Address (see Table 3)					LSB	MSB			Data				LSB

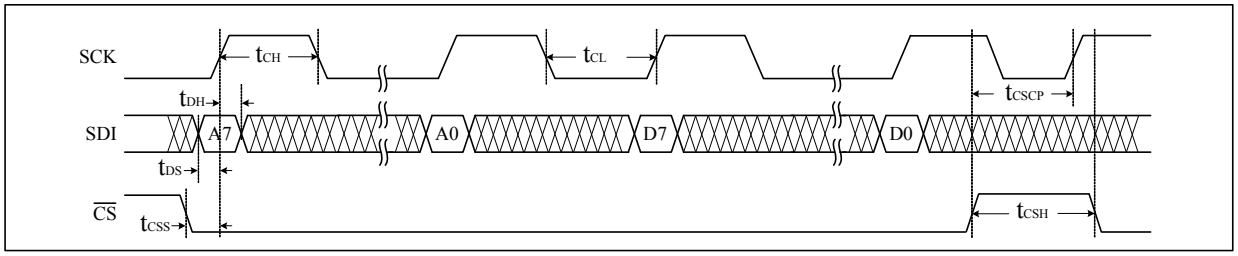


Figure 2 Interface Timing

Registers

The SN3101 device contains 18 Registers, which are listed in Table 3. Communication to the SN3101 via the serial interface consists of an 8-bit address word followed by an 8-bit data word.

Table 3 Register Function Map

Address	Name	Function	Table	Default
00h	Configuration	Configure the operation mode	4	0000 0001
02h	RGB mode	Set RGB mode	5	0000 0000
03h	RGB current	Set RGB current	6	
04h	OUT0_PWM	Set OUT0 PWM duty cycle	7	0000 0000 *(Note 1)*
05h	OUT1_PWM	Set OUT1 PWM duty cycle	7	
06h	OUT2_PWM	Set OUT2 PWM duty cycle	7	
0Ah	OUT0_T0	OUT0 holdoff time	8	0000 0000 *(Note 2)*
0Bh	OUT1_T0	OUT1 holdoff time	8	
0Ch	OUT2_T0	OUT2 holdoff time	8	
10h	OUT0_T1&T2	OUT0 rising time and hold time	9	
11h	OUT1_T1&T2	OUT1 rising time and hold time	9	
12h	OUT2_T1&T2	OUT2 rising time and hold time	9	
16h	OUT0_T3&T4	OUT0 falling time and off time	10	
17h	OUT1_T3&T4	OUT1 falling time and off time	10	
18h	OUT2_T3&T4	OUT2 falling time and off time	10	
1Ch	Update	Update data of Time registers	-	xxxx xxxx *(Note 3)*
1Dh	OUT2-0_EN	Enable OUT2~ OUT0	11	xxxx x111 *(Note 4)*
20h	RGB Current2	Set RGB current	12	0000 0000 *(Note 5)*

Note:

1. In Interface Intensity Control mode, the PWM duty cycle is defined by input data set in register 04h-06h.

2. In One Shot Programming mode, the PWM duty cycle is defined by T0-T4.T0 is start time.T1 is rising time.T2 is hold time.T3 is falling time.T4 is off time. (See in figure 3)

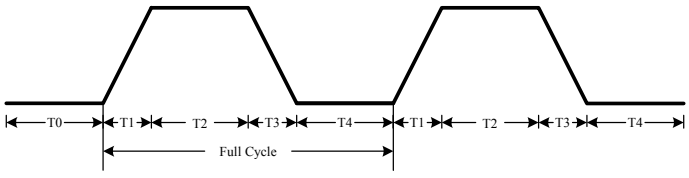


Figure 3 Sketch Map of Time Parameters

3. Write any 8 bit data to the update register after set the value of T0~T4 to update the value of them.

4. In OUT2-0_EN register, only the three LSBs are effective, OUT0 is controlled by the LSB. For example, we send 11111 110 to OUT2-0_EN register to disable OUT0，but other output channel are enabled.

5. This register is used to set the maximum output current level to 17.5mA.

Table 4 00h Configuration Register

Bit	D7:D6	D5	D4:D1	D0
Name	–	SDRGB	–	SSD
Default	00	0	0000	1

The Configuration Register controls SN3101 a group RGB outputs and shutdown mode. Notice **SDRGB** bit should be set to 1 to ensure that the outputs are turned on.

SDRGB All Outputs Enable
0 Disable
1 Enable

SSD Software Shutdown Mode Enable
0 Chip Enable
1 Chip Shutdown

Table 5 02h RGB Mode Register

Bit	D7:D6	D5	D4:D0
Name	–	M_RGB	–
Default	00	0	00000

The RGB Mode Register selects the operation mode.

M_RGB All outputs mode selection
0 Interface Intensity Control Mode
1 One Shot Programming Mode

Table 6 03h RGB Current Register

Bit	D7:D4	D3	D2	D1:D0
Name	–	RGB_MAX		–
Default	0000	0	0	00

Default the outputs each with 42.1mA current capability, they are adjustable. The RGB current register allows the maximum output current to be scaled as indicated in Table above. The SN3101 provides for a maximum current ranging as high as 71.9mA and as low as 30.9mA. Care must be taken so as not to exceed the maximum allowable power dissipation for the device. If setting the maximum output current level to 17.5mA is needed, please refer to Table 12 and set the register 20h.

RGB_MAX Maximum Current for All Outputs(Typ.)
00 42.1mA
01 48.2mA
10 71.9mA
11 30.9mA

Table 7 04h~06h OUTx_PWM Register

Bit	D7:D0
Name	PWM
Default	0000 0000

In Interface Intensity Control mode, the PWM duty cycle is defined by input data set in register 04h-06h.

OUT0_PWM register acts when D5 of RGB mode register is set to 0, the value of OUT0_PWM register decides the average output current of OUT0, the average output current may be computed using the formula,

$$I_{OUT} = \frac{42.1mA}{256} * \sum_{n=0}^{7} 2^n$$

Where n stands for the set bit sequence number, for D4, n=4. An example: D7~D0=10110101,

I_{OUT} = 42.1mA×(2^0+2^2+2^4+2^5+2^7)/256
= 29.8mA

See Table 13 in Application Information for more.

OUT1 ~ OUT2 PWM register are the same as OUT0 PWM register.

Time Registers

In One Shot Programming mode, the PWM duty cycle is defined by T0~T4.

By programming different values of T0~T4 for the different outputs, OUT0~OUT2, many different combinations LED effects can be created.

The complete waveform period consists of the summation of all times T1~T4.

Table 8 0Ah~0Ch OUTx_T0 Register

Bit	D7:D4	D3:D0
Name	T0	–
Default	0000	0000

T0 is the hold off delay before the waveform (described by the values of T1~T4) begins as shown in Figure 3. The hold off delay occurs only after 1) any 8-bit value is written to the update register, or 2) turn on the One Shot Programming mode by programming the RGB Mode Register (02h).

All output T0 registers (0Ah~0Ch) are programmed in the same manner.

T0	Time Delay of Output Current		
0000	0s	0001	0.13s
0010	0.26s	0011	0.52s
0100	1.04s	0101	2.08s
0110	4.16s	0111	8.32s
1000	16.64s	1001	33.28s
1010	66.56s		

Table 9 10h~12h OUTx_T1&T2 Register

Bit	D7:D5	D4:D1	D0
Name	T1	T2	–
Default	000	0000	0

T1: T1 is the time that the output current ramps up to its final value. For example, if the maximum output current is set to 42.1mA, it is the amount of time required for the output to change from 0mA to 42.1mA.

T2: T2 is the time the output holds its maximum current.

All output T1, T2 registers (10h~12h) are programmed in the same manner.

T1	Rising Time		
000	0.13s	001	0.26s
010	0.52s	011	1.04s
100	2.08s	101	4.16s
110	8.32s	111	16.64s

T2	Holding Full Current Time		
0000	0s	0001	0.13s
0010	0.26s	0011	0.52s
0100	1.04s	0101	2.08s
0110	4.16s	0111	8.32s
1000	16.64s		

Table 10 16h~18h OUTn_T3&T4 Register

Bit	D7:D5	D4:D1	D0
Name	T3	T4	–
Default	000	0000	0

T3: T3 is the time that the output current ramps down from the maximum value to zero. For example, if the maximum output current is set to 42.1mA, it is the amount of time required for the output to change from 42.1mA to 0mA.

T4: T4 is the time delay before repeating the next cycle.

All output T3, T4 registers (16h~18h) are programmed in the same manner.

T3	Falling Time		
000	0.13s	001	0.26s
010	0.52s	011	1.04s
100	2.08s	101	4.16s
110	8.32s	111	16.64s

T4	Holding Off Time		
0000	0s	0001	0.13s
0010	0.26s	0011	0.52s
0100	1.04s	0101	2.08s
0110	4.16s	0111	8.32s
1000	16.64s	1001	33.28s
1010	66.56s		

1Ch Update Register

Once configured, the timing parameters, T0 thru T4, may only be changed by modifying the values stored in the timing registers, followed by writing any 8-bit value to the update register. The new timing parameters will take effect following the write to the update register.

Table 11 1Dh OUTx_EN Register

Bit	D7:D3	D2	D1	D0
Name	–	OUT2_EN	OUT1_EN	OUT0_EN
Default	00000	1	1	1

The OUTx_EN Registers control the on or off state of each output.

OUTx_EN	Output States
0	Output Off
1	Output On

Table 12 RGB Current2 Register (20h)

Bit	D7:D2	D1	D0
Function	–	RGB_C	–
Default	000000	0	0

RGB Currnet2 Register makes RGB current on the fifth setting at 17.5mA.

D1	RGB Current Setting
1	RGB Current is Set to 17.5mA
0	RGB Current is Set by REG 03h

Application Information

Constant Current

The maximum current of OUT0 ~ OUT2 are internally set to one of 5 constant current levels (17.5mA, 30.9mA, 42.1mA, 48.2mA or 71.9mA (typical)). The constant current sinks maintain the output current at the programmed level when sinking current.

When set to sink 42.1mA, if the voltage at the output pin falls below 0.42V, because of a large LED forward voltage (V_F) or falling supply voltage, then the output current will begin to fall off as shown in Figure 3. The selection for the constant current level is made by programming the RGB current register as shown in Table 6.

Interface Intensity Control Mode

When configuration register (00h) D5 is set high, the maximum current of outputs is selected via RGB current register (03h) bits D3~D2. Outputs operate in Interface Intensity Control mode when you clear the RGB mode register bit D5. In this control mode, you must send data if you want to change the PWM intensity of the RGB LEDs.

The SN3101's PWM LED outputs can be used to drive individual color LEDs or RGB LED modules. When driving an RGB LED module, the intensity of each LED in the module is programmable allowing the RGB LED module to be set to many different colors, based on the value of the PWM byte.

When Interface Intensity Control mode is enabled, the average output current of OUT0~OUT2 is dependent upon the PWM duty cycle. LEDs driven with a higher duty cycle results in a higher luminous intensity. For example, if the maximum output current is 42.1mA, the table below gives some average I_{OUT} values controlled by PWM bytes. The average output current can be adjusted in 256 steps of PWM control.

Table 13 256 Steps Output Current

PMW byte	I_{OUT} (mA)
0x00	0
0x01	0.14
0x02	0.33
0x03	0.49
… …	… …
0xff	42.1

One Shot Programming Mode

Outputs work in One Shot Programming mode when you set RGB mode register bit D5 to '1'. When the SN3101 is operating in One Shot Programming mode, the output waveform is user configurable by the selection of T0~T4. New values written to T0~T4 will take effect after writing any 8 bits of data to the Update register.

In One Shot Programming mode, the PWM duty cycle is defined by T0-T4.

T0: T0 is the holdoff delay before the waveform (described by the values of T1~T4) begins as shown in Figure 3. The holdoff delay occurs only after 1) any 8-bit value is written to the update register, or 2) turn on the One Shot Programming mode by programming the RGB Mode Register (02h).

T1: T1 is the time that the output current ramps up to its final value. For example, if the maximum output current is set to 42.1mA, it is the amount of time required for the output to change from 0mA to 42.1mA.

T2: T2 is the time the output holds its maximum current.

T3: T3 is the time that the output current ramps down from the maximum value to zero. For example, if the maximum output current is set to 42.1mA, it is the amount of time required for the output to change from 42.1mA to 0mA.

T4: T4 is the time delay before repeating the next cycle.

By programming different values of T0~T4 for the different outputs, OUT0~OUT2, many different combinations LED effects can be created.

The complete waveform period consists of the summation of all times T1~T4.

Classification Reflow Profiles

Profile Feature	Pb-Free Assembly
Preheat & Soak Temperature min (Tsmin) Temperature max (Tsmax) Time (Tsmin to Tsmax) (ts)	150°C 200°C 60-120 seconds
Average ramp-up rate (Tsmax to Tp)	3°C/second max.
Liquidous temperature (TL) Time at liquidous (tL)	217°C 60-150 seconds
Peak package body temperature (Tp)*	Max 260°C
Time (tp)** within 5°C of the specified classification temperature (Tc)	Max 30 seconds
Average ramp-down rate (Tp to Tsmax)	6°C/second max.
Time 25°C to peak temperature	8 minutes max.

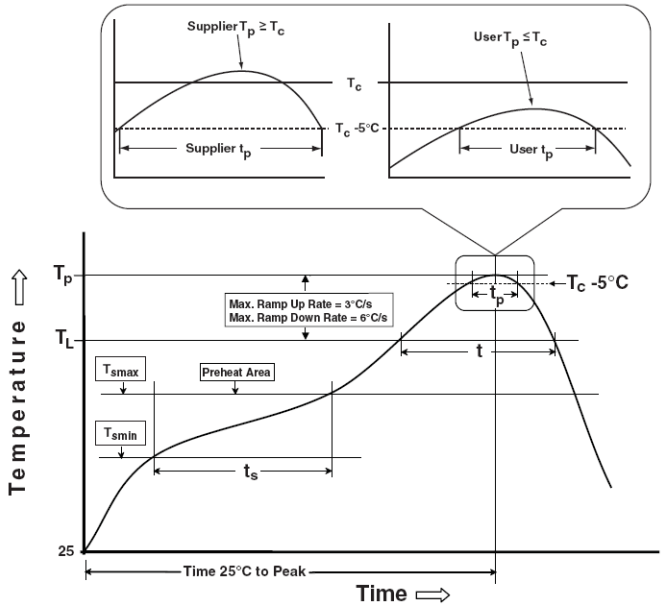
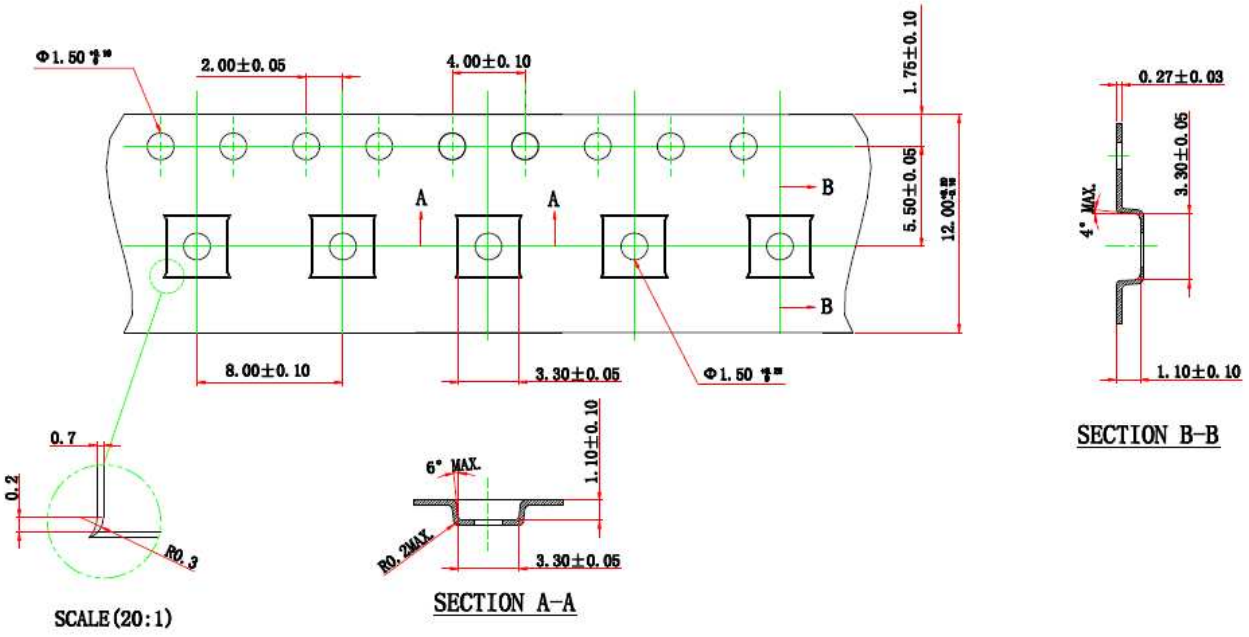


Figure 4 Classification Profile

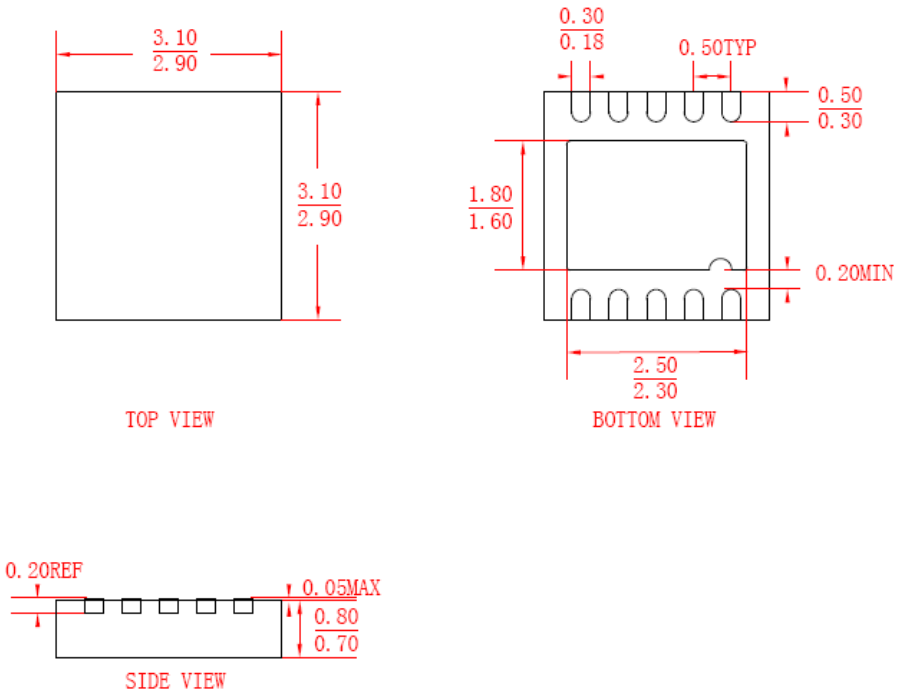
Tape and Reel Information



NOTES:[技术要求]:
1.CARRIER TAPE COLOR:BLACK[载带颜色为黑色]
2.COVER TAPE WIDTH:9.50±0.10 [配盖9.5宽盖带]
3.COVER TAPE COLOR:TRANSPARENT[盖带颜色无色透明]
4. SURFACE ANTISTATIC COATED 10^{9}～10^{11} OHMS/SQ.
[单位面积表面阻抗 10^{9}～10^{11}Ω/□]
5.10 SPROCKET HOLE PITCH CUMULATIVE TOLERANCE ±0.20MAX.
[10个传送定位孔间距累积公差0.20MAX.]
6.CAMBER NOT TO EXCEED 1 MM IN 100 MM[载带直线弯曲度：≤1mm/100mm.]
7.MOLD# W8FSP(3×3)[载带模腔W8FSP(3×3)]
8.ALL DIMS IN mm.[所有单位为mm]
9.BAN TO USE THE ENVIRONMENT-RELATED SUBSANCES OF JCET PRESCRIBING.
[禁止使用长电科技规定的一级环境管理物质]
10.THE DERECTION OF VIEW: [视图方向：]

Package Information

DFN-10



Note: All dimensions in millimeters unless otherwise stated.