18 Channel LED Driver

Description

SN3218 is comprised of 18 constant current channels each with independent PWM control, designed for driving LEDs. The output current of each channel can be set at up to 23mA (Max.) by an external resistor. The average LED current of each channel can be changed in 256 steps by changing the PWM duty cycle through an I2C interface.

The chip can be turned off by pulling the SDB pin low or by using the software shutdown feature to reduce power consumption. The slave address is fixed “1010 1000”.

SN3218 is available in QFN-24 (4mm × 4mm). It operates from 2.7V to 5.5V over the temperature range of −40°C to +85°C.

Features

- 2.7V to 5.5V supply
- I2C interface, automatic address increment function
- Internal reset register
- Modulate LED brightness with 256 steps PWM
- Each channel can be controlled independently
- −40°C to +85°C temperature range
- QFN-24 (4mm × 4mm) package

Applications

- Mobile phones and other hand-held devices for LED display
- LED in home appliances

Typical Application Circuit

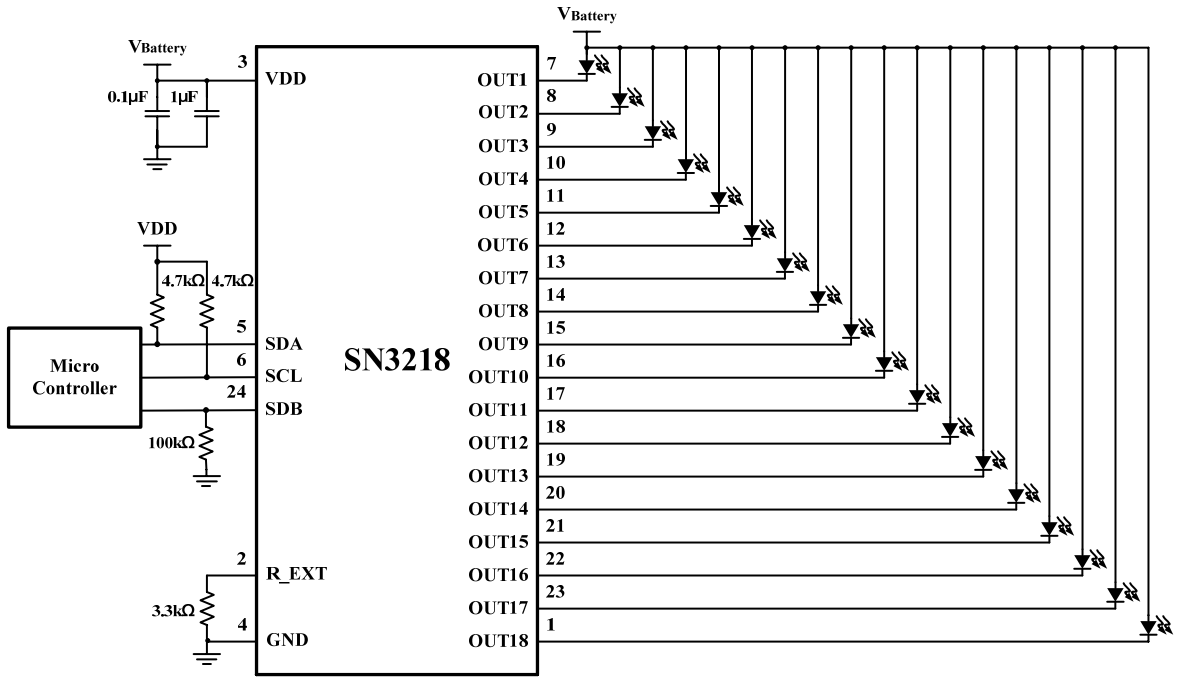
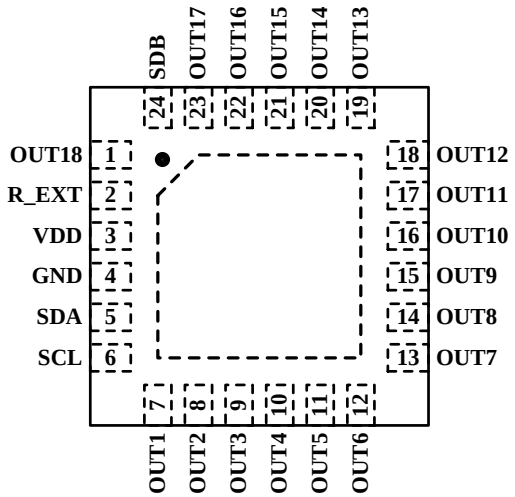


Figure 1 Typical application circuit

Pin Configuration

Package	Pin Configuration (Top View)
QFN-24	

Pin Description

No.	Pin	I/O	Description
1	OUT18	O	Output channel for LEDs.
2	R_EXT	I	Input terminal used to connect an external resistor. This regulates the output current.
3	VDD	–	Power supply.
4	GND	–	Ground.
5	SDA	I/O	I2C serial data.
6	SCL	I	I2C serial clock.
7~23	OUT1 ~ OUT17	O	Output channel for LEDs.
24	SDB	I	Shutdown the chip when pulled low.
	Thermal Pad	–	Connect to GND.

Ordering Information

Order Number	Package Type	QTY/Reel	Operating Temperature Range
SN3218I424E	QFN-24	2500	−40°C ~ +85°C

SN3218 □ □ □ □

Environmental Code
E: Lead Free

Pin Code
24:24 pins

Package Type
4: QFN, 4mm × 4mm

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

Absolute Maximum Ratings

Supply voltage, V_{DD} ---------- −0.3V ~ 6.0V
Voltage at SCL, SDA, SDB ---------- −0.3V ~ V_{DD} +0.3V
Voltage at OUT1 to OUT18 ---------- +5V
Operating temperature range ---------- −40°C ~ +85°C
Storage temperature range ---------- –55°C ~ +150°C
Thermal resistance, θ_{JA} (QFN-24) ---------- 30°C/W
ESD HBM ---------- 4kV

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

T_A = −40°C ~ +85°C, V_{DD} = 2.7V ~ 5.5V, unless otherwise noted. Typical values are T_A = 25°C, V_{DD} = 3.6V.

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
V_{DD}	Supply voltage		2.7		5.5	V
I_{MAX}	Maximum output current of each channel	V_{OUT} = 0.6V, R_{EXT} = 3.3kΩ *(Note 1)*		23		mA
I_{DD}	Quiescent power supply current	R_{EXT} = 3.3kΩ		5.25		mA
I_{SD}	Shutdown current	V_{SDB} = 0V or software shutdown		3.1		μA
I_{OZ}	Output leakage current	V_{SDB} = 0V or software shutdown, V_{OUT} = 5V			1	μA
V_{EXT}	Output voltage of R-EXT pin			1.3		V
Logic Electrical Characteristics (SDA, SCL, SDB)						
V_{IL}	Logic "0" input voltage	V_{DD} = 2.7V			0.4	V
V_{IH}	Logic "1" input voltage	V_{DD} = 5.5V	1.4			V
I_{IL}	Logic "0" input current			5 *(Note 2)*		nA
I_{IH}	Logic "1" input current			5 *(Note 2)*		nA

Digital Input Switching Characteristics *(Note 2)*

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
f_{SCL}	Serial-Clock frequency				400	kHz
t_{BUF}	Bus free time between a STOP and a START condition		1.3			μs
$t_{HD, STA}$	Hold time (repeated) START condition		0.6			μs
$t_{SU, STA}$	Repeated START condition setup time		0.6			μs
$t_{SU, STO}$	STOP condition setup time		0.6			μs
$t_{HD, DAT}$	Data hold time				0.9	μs
$t_{SU, DAT}$	Data setup time		100			ns
t_{LOW}	SCL clock low period		1.3			μs
t_{HIGH}	SCL clock high period		0.7			μs
t_R	Rise time of both SDA and SCL signals, receiving	*(Note 3)*		20+0.1Cb	300	ns
t_F	Fall time of both SDA and SCL signals, receiving	*(Note 3)*		20+0.1Cb	300	ns

Note 1: The recommended minimum value of R_{EXT} is 3.3kΩ, or it may cause a large current.

Note 2: Guaranteed by design.

Note 3: Cb = total capacitance of one bus line in pF. $I_{SINK} \leq 6mA$. t_R and t_F measured between $0.3 \times V_{DD}$ and $0.7 \times V_{DD}$.

Detailed Description

I2C Interface

The SN3218 uses a serial bus, which conforms to the I2C protocol, to control the chip's functions with two wires: SCL and SDA. The SN3218's slave address is "1010 1000". It only supports write operations.

The SCL line is uni-directional. The SDA line is bi-directional (open-collector) with a pull-up resistor (typically 4.7kΩ). The maximum clock frequency specified by the I2C standard is 400kHz. In this discussion, the master is the microcontroller and the slave is the SN3218.

The timing diagram for the I2C is shown in Figure 2. The SDA is latched in on the stable high level of the SCL. When there is no interface activity, the SDA line should be held high.

The "START" signal is generated by lowering the SDA signal while the SCL signal is high. The start signal will alert all devices attached to the I2C bus to check the incoming address against their own chip address.

The 8-bit chip address is sent next, most significant bit first. Each address bit must be stable while the SCL level is high.

After the last bit of the chip address is sent, the master checks for the SN3218's acknowledge. The master releases the SDA line high (through a pull-up resistor). Then the master sends an SCL pulse. If the SN3218 has received the address correctly, then it holds the SDA line low during the SCL pulse. If the SDA line is not low, then the master should send a "STOP" signal (discussed later) and abort the transfer.

Following acknowledge of SN3218, the register address byte is sent, most significant bit first. SN3218 must generate another acknowledge indicating that the register address has been received.

Then 8-bit of data byte are sent next, most significant bit first. Each data bit should be valid while the SCL level is stable high. After the data byte is sent, the SN3218 must generate another acknowledge to indicate that the data was received.

The "STOP" signal ends the transfer. To signal "STOP", the SDA signal goes high while the SCL signal is high.

Address Auto Increment

To write multiple bytes of data into SN3218, load the address of the data register that the first data byte is intended for. During the SN3218 acknowledge of receiving the data byte, the internal address pointer will increment by one. The next data byte sent to SN3218 will be placed in the new address, and so on. The auto increment of the address will continue as long as data continues to be written to SN3218 (Figure 5).

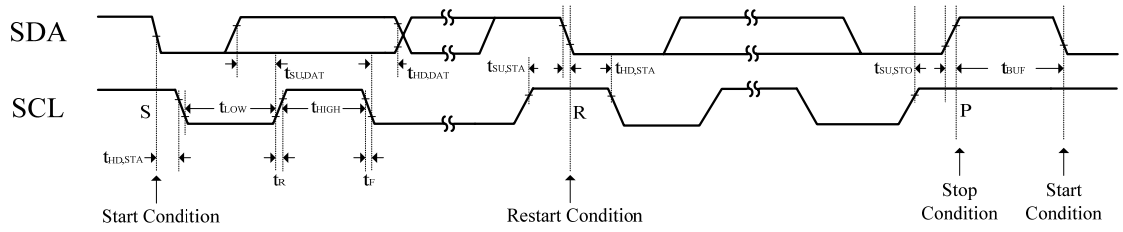


Figure 2 Interface timing

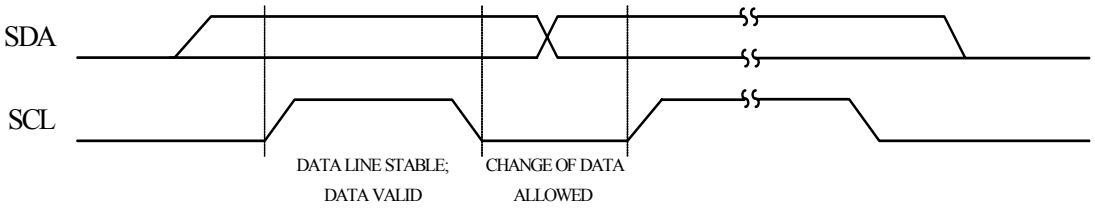


Figure 3 Bit transfer

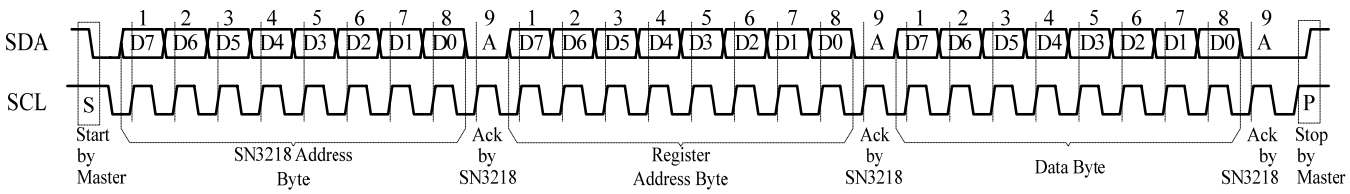


Figure 4 Writing to SN3218(Typical)

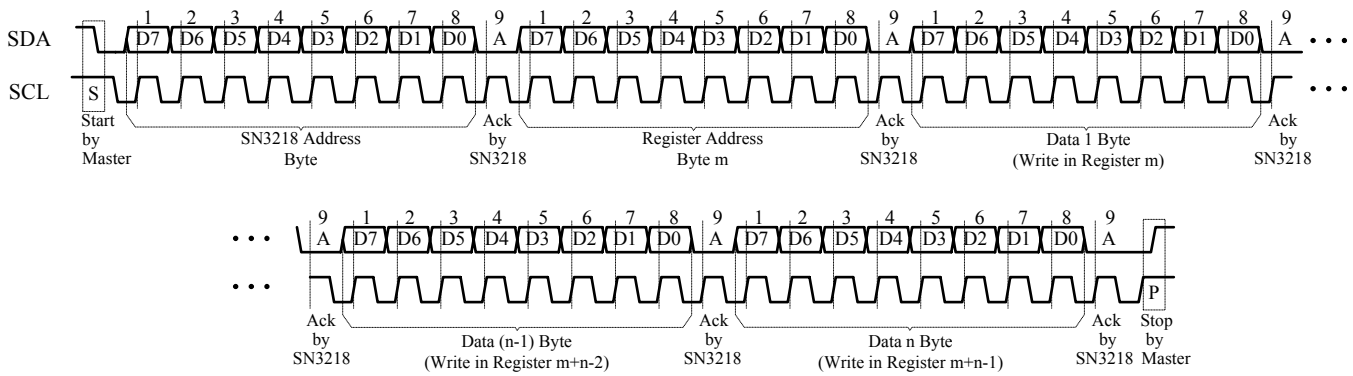


Figure 5 Writing to SN3218(Automatic address increment)

Registers Definitions

Table 1 Register Function

Address	Name	Function	Table	Default
00h	Shutdown Register	Set software shutdown mode of SN3218	2	0000 0000
01h~12h	PWM Register	18 channels PWM duty cycle data register	3	
13h	LED Control Register1	Channel 1 to 6 enable bit	4	
14h	LED Control Register2	Channel 7 to 12 enable bit	5	
15h	LED Control Register3	Channel 13 to 18 enable bit	6	
16h	Update Register	Load PWM Register and LED Control Register's data	–	XXXX XXXX
17h	Reset Register	Reset all registers into default	–	

Table 2 00h Shutdown Register

Bit	D7:D1	D0
Name	Reserved	SSD
Default	000000	0

The Shutdown Register sets software shutdown mode of SN3218.

SSD Software Shutdown Enable

0 Software shutdown mode

1 Normal operation

Table 3 01h~12h PWM Register(OUT1~OUT18)

Bit	D7:D0
Name	PWM
Default	0000 0000

The PWM Registers adjusts LED luminous intensity in 256 steps.

The value of a channel's PWM Register decides the average output current for each output, OUT1~OUT18.

The average output current may be computed using the Formula (1):

$$I_{OUT} = \frac{I_{MAX}}{256} \cdot \sum_{n=0}^{7} D[n] \cdot 2^n \qquad (1)$$

Where "n" indicates the bit location in the respective PWM register.

For example: D7:D0 = 10110101,

$I_{OUT} = I_{MAX} (2^0+2^2+2^4+2^5+2^7)/256$

See Formula (2) in Page 9 to calculate the I_{MAX}.

Table 4 13h LED Control Register1(OUT1~OUT6)

Bit	D7:D6	D5:D0
Name	Reserved	OUT6:OUT1
Default	00	000000

Table 5 14h LED Control Register2(OUT7~OUT12)

Bit	D7:D6	D5:D0
Name	Reserved	OUT12:OUT7
Default	00	000000

Table 6 15h LED Control Register3(OUT13~OUT18)

Bit	D7:D6	D5:D0
Name	Reserved	OUT18:OUT13
Default	00	000000

The LED Control Registers store the on or off state of each column LED.

OUTx	LED State
0	LED off
1	LED on

16h PWM Update Register

The data sent to the PWM Registers and the LED Control Registers will be stored in temporary registers. A write operation of any 8-bit value to the Update Register is required to update the registers (01h~15h).

17h Reset Register

Once user writes any 8-bit data to the Reset Register, SN3218 will reset all registers to default value. On initial power-up, the SN3218 registers are reset to their default values for a blank display.

Typical Application

PWM Control

The PWM Registers (01h~12h) can modulate LED brightness of 18 channels with 256 steps. For example, if the data in PWM Register is "0000 0100", then the PWM is the fourth step.

Writing new data continuously to the registers can modulate the brightness of the LEDs to achieve a breathing effect.

R_{EXT}

The maximum output current of OUT1~OUT18 can be adjusted by the external resistor, R_{EXT}, as described in Formula (2).

$$I_{MAX} = x \cdot \frac{V_{EXT}}{R_{EXT}} \qquad (2)$$

x = 58.5, V_{OUT} = 0.6V, V_{EXT} = 1.3V.

The recommended minimum value of R_{EXT} is 3.3kΩ.

Gamma Correction

In order to perform a better visual LED breathing effect we recommend using a gamma corrected PWM value to set the LED intensity. This results in a reduced number of steps for the LED intensity setting, but causes the change in intensity to appear more linear to the human eye.

Gamma correction, also known as gamma compression or encoding, is used to encode linear luminance to match the non-linear characteristics of display. Since the SN3218 can modulate the brightness of the LEDs with 256 steps, a gamma correction function can be applied when computing each subsequent LED intensity setting such that the changes in brightness matches the human eye's brightness curve.

Table 7 32 gamma steps with 256 PWM steps

C(0)	C(1)	C(2)	C(3)	C(4)	C(5)	C(6)	C(7)
0	1	2	4	6	10	13	18
C(8)	C(9)	C(10)	C(11)	C(12)	C(13)	C(14)	C(15)
22	28	33	39	46	53	61	69
C(16)	C(17)	C(18)	C(19)	C(20)	C(21)	C(22)	C(23)
78	86	96	106	116	126	138	149
C(24)	C(25)	C(26)	C(27)	C(28)	C(29)	C(30)	C(31)
161	173	186	199	212	226	240	255

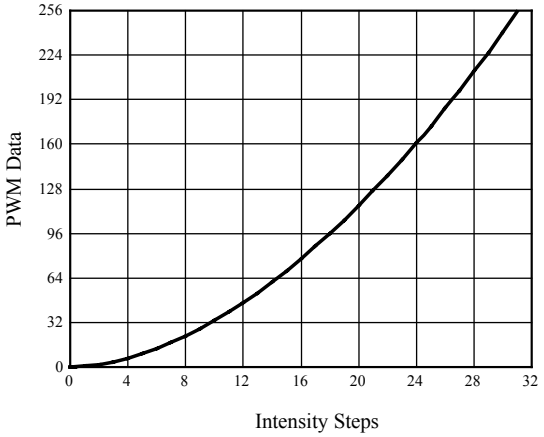


Figure 6 Gamma correction(32 steps)

Choosing more gamma steps provides for a more continuous looking breathing effect. This is useful for very long breathing cycles. The recommended configuration is defined by the breath cycle T. When T=1s, choose 32 gamma steps, when T=2s, choose 64 gamma steps. The user must decide the final number of gamma steps not only by the LED itself, but also based on the visual performance of the finished product.

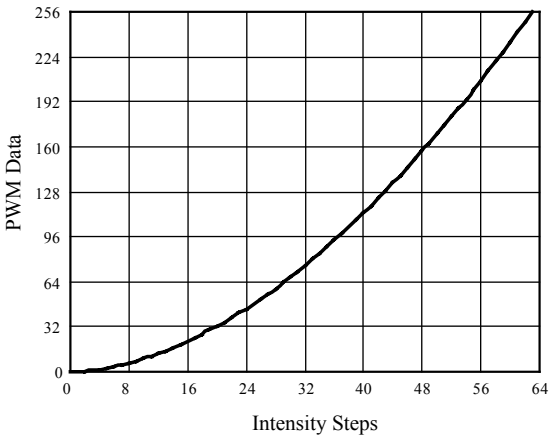


Figure 7 Gamma correction(64 steps)

Shutdown Mode

Shutdown mode can either be used as a means of reducing power consumption or generating a flashing display (repeatedly entering and leaving shutdown mode). During shutdown mode all registers retain their data.

Software Shutdown

By setting SSD bit of the Configuration Register (00h) to "0", the SN3218 will operate in software shutdown mode, wherein they consume only 3.1μA (typ.) current. When the SN3218 is in software shutdown mode, all current sources are switched off.

Hardware Shutdown

The chip enters hardware shutdown mode when the SDB pin is pulled low.

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.

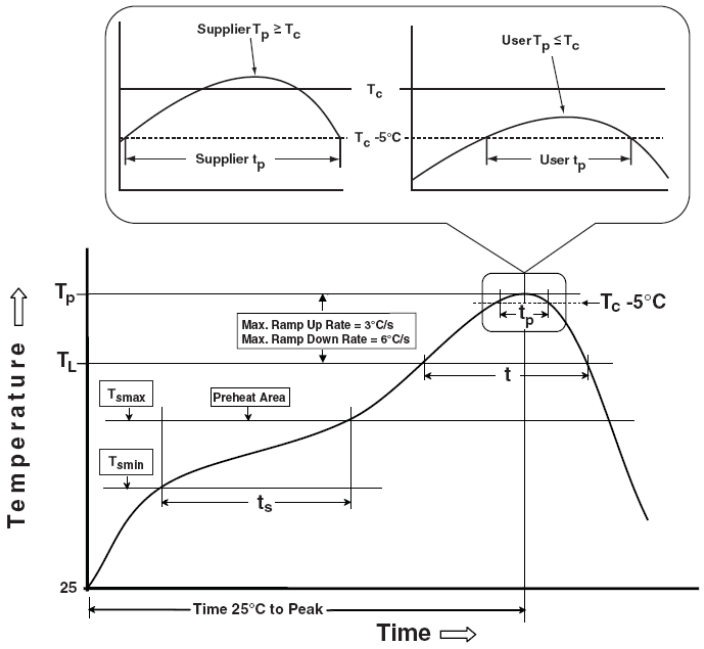
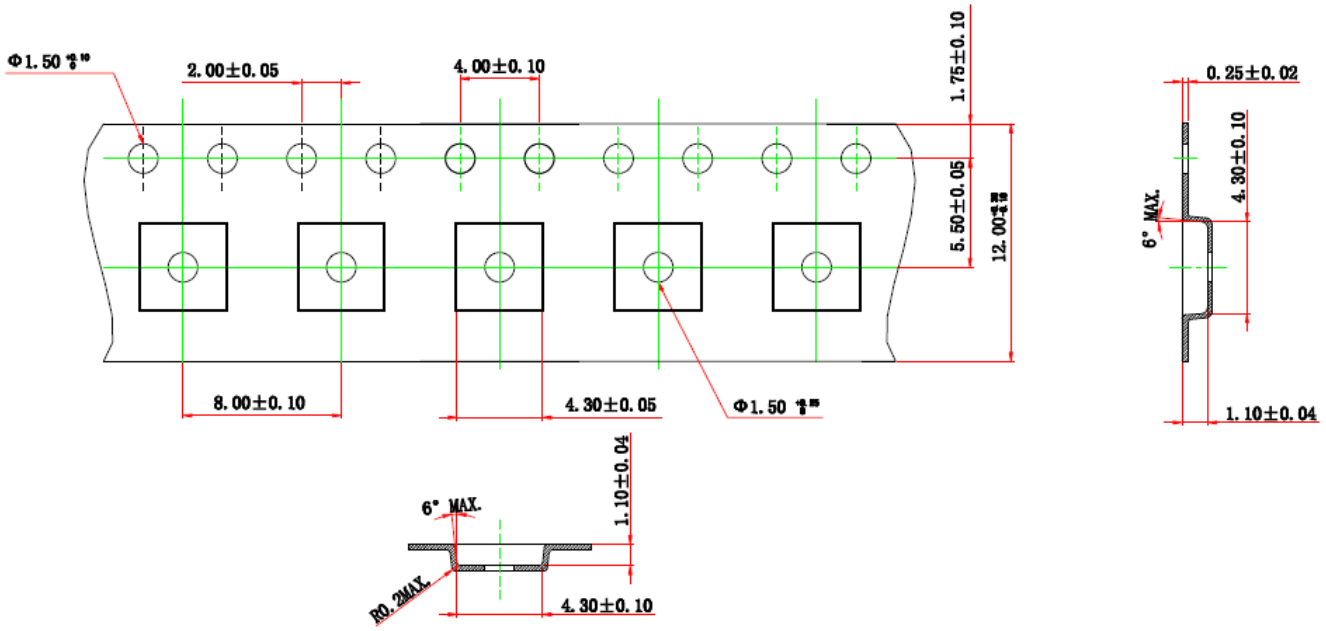


Figure 8 Classification profile

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 [配套9.5±0.10宽盖带]
3.COVER TAPE COLOR:TRANSPARENT[盖带颜色无色透明]
4. ANTISTATIC COATED 10^{8}～ 10^{11}OHMS/SQ.[单位面积表面阻抗为$10^{8}\Omega$/□～$10^{11}\Omega$/□]
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.SUPPLIER:3M[供应商3M]
7.MOLD# W8FBP(4×4×0.75/0.85)[载带规格W8FBP(4×4×0.75/0.85)]
8.ALL DIMS IN mm.[所有单位为mm]
9.BAN TO USE THE LEVEL 1 ENVIRONMENT-RELATED SUBSTANCES 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:]
11.SPECIAL FOR CUSTOMER SI-EN [矽恩客户专用]

Package Information

QFN-24