LED APPROVAL SHEET

Part No: **AP3221A-C3A**

NOTE:

Green Part

MAKER			CUSTOMER	
SOLIDLITE				
R&D	QA	Sales	Checked	Approved

Prepared	Checked	Approved
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TEL:886-3-5986248 FAX:886-3-5986247 http://www.solidlite.com

Description of P/N No.

AP3221A–C3A

Three chip(R/G/B) + IC Series

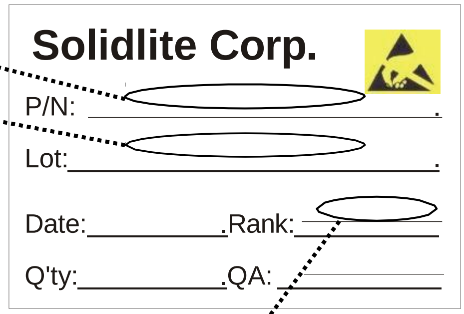
SOLIDLITE LED – TOP 3221-PCB

Descriptionof Lot.

□ □□

Month

NO.



Descriptionof Rank

□ □ □

Absolute Maximum Ratings(unless otherwise specified ,Temperature=25℃)

Characteristic	Symbol	Rating	Unit
Supply Voltage	V_{DD}	6.5	V
Power Dissipation	P_D	<80	mW
Maximum Output Current	I_{LEDOUT}	5.5	mA
Welding Temperature	T_M	300(8S)	℃
Operating Temperature Range	T_{OPR}	-25~85	℃
Storage Temperature Range	T_{STO}	-65~120	℃

Electrical Characteristics(unless otherwise specified ,Temperature=25℃ & V_{DD}=5.0V)

Parameter	Symbol	Min.	Typ.	Max.	Unit	Note
Supply Voltage	VDD	3.3	5	5.5	V	
Operation Current	I_{DD}	-	1	-	mA	R/G/B without load
Sleep Mode Current	I_{sleep}	-	5	-	uA	
Input High "H" of DI、BI	V_{IH}	0.7*VDD	-	VDD+0.4	V	
Input Low "L" of DI、BI	V_{IL}	-0.4	-	0.2*VDD	V	
Output High "H" of DO	V_{OH}	4.5	-	-	V	I_{OH}=3mA
Output Low "L" of DO	V_{OL}	-	-	0.4	V	I_{OL}=3mA
Output Low "L" of KEY	V_{OLK}	-	-	0.4	V	I_{OL}=10mA
R/G/B Sink Current	I_{SK}	2.85	3.00	3.15	mA	Max.3mAoption
		4.75	5.00	5.25	mA	Max.5mAoption
R/G/B Current Gain	Glevel	-	3/17	-	mA/level	Max.3mAoption
		-	5/17	-	mA/level	Max.5mAoption
DI/BI Input Leakage	I_{leak}	-	-	-	uA	V_{DI}=V_{BI}=VDD=5V
R/G/B off Leakage Current	I_{off}	-	-	1	uA	$V_{R/G/B}$=5V,PWMoff

Typical Product Characteristics(Ta=25°C;VDD=5V)

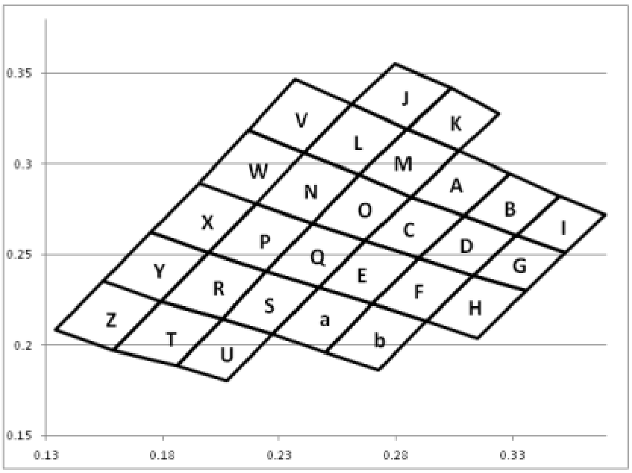
Characteristics	Symbol		Min.	Typ.	Max.	Unit	Test condition
Luminous Intensity	Iv	R	-	150	-	mcd	I_F=5mA
		G	-	320	-		
		B	-	60	-		
		W	-	570	-		
Dominant Wavelength	λd	R	615	-	630	nm	I_F=5mA
		G	520	-	535		
		B	460	-	475		
Color Coordinate	x		-	0.285	-	-	I_F=5mA
	y		-	0.285	-	-	
View Angle	$2\theta_{1/2}$		-	120	-	deg	I_F=5mA

Range of Bins

Luminous Intensity-White(I_F=5mA)

Bin Code	Min. IV (mcd)	Max. IV (mcd)
1	300	450
2	450	550
3	550	650
4	650	750

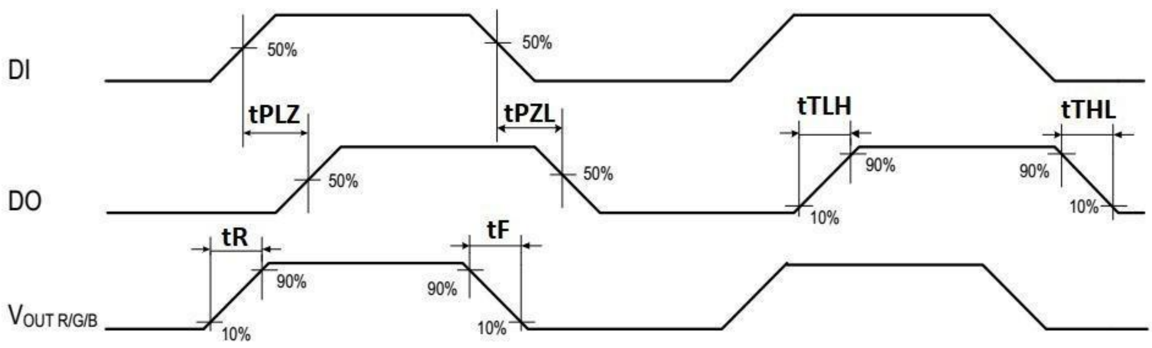
Color Coordinate Comparison-White



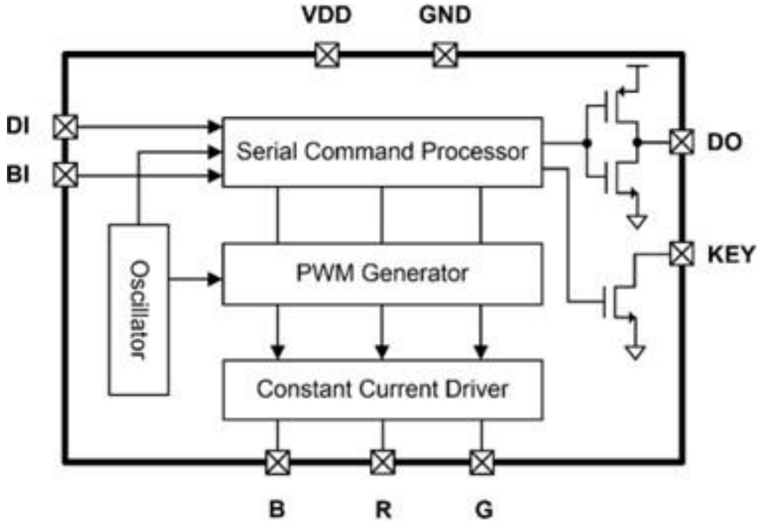
Color Rank

Bin code	X1	Y1	X2	Y2	X3	Y3	X4	Y4	X5	Y5
A	0.307	0.3072	0.3287	0.2948	0.3091	0.2712	0.2865	0.2819	0.307	0.3072
B	0.3287	0.2948	0.3504	0.2824	0.3318	0.2605	0.3091	0.2712	0.3287	0.2948
C	0.2865	0.2819	0.3091	0.2712	0.2899	0.2482	0.2667	0.2578	0.2865	0.2819
D	0.3091	0.2712	0.3318	0.2605	0.3132	0.2387	0.2899	0.2482	0.3091	0.2712
E	0.2667	0.2578	0.2899	0.2482	0.27	0.2227	0.247	0.232	0.2667	0.2578
F	0.2899	0.2482	0.3132	0.2387	0.293	0.2134	0.27	0.2227	0.2899	0.2482
G	0.3318	0.2605	0.3524	0.2513	0.3358	0.2299	0.3132	0.2387	0.3318	0.2605
H	0.293	0.2134	0.3132	0.2387	0.3358	0.2299	0.315	0.204	0.293	0.2134
I	0.3318	0.2605	0.3504	0.2824	0.3695	0.2719	0.3524	0.2513	0.3318	0.2605
J	0.2609	0.3332	0.2797	0.355	0.3036	0.342	0.2849	0.3196	0.2609	0.3332
K	0.2851	0.3196	0.3036	0.342	0.3243	0.328	0.3068	0.3072	0.2851	0.3196
L	0.2406	0.3064	0.2609	0.3332	0.2849	0.3196	0.2643	0.294	0.2406	0.3064
M	0.2643	0.294	0.2849	0.3196	0.3068	0.3072	0.2865	0.2819	0.2643	0.294
N	0.22	0.2783	0.2406	0.3064	0.2643	0.294	0.2444	0.2672	0.22	0.2783
O	0.2444	0.2672	0.2643	0.294	0.2865	0.2819	0.2667	0.2578	0.2444	0.2672
P	0.22	0.2783	0.1996	0.2513	0.2244	0.2407	0.2444	0.2672	0.22	0.2783
Q	0.2444	0.2672	0.2244	0.2407	0.2471	0.232	0.2669	0.2579	0.2444	0.2672
R	0.1996	0.2513	0.1792	0.2243	0.2056	0.2148	0.2244	0.2407	0.1996	0.2513
U	0.2056	0.2148	0.1862	0.1886	0.2075	0.1802	0.2273	0.2061	0.2056	0.2148
X	0.196	0.2894	0.1752	0.2624	0.1996	0.2513	0.22	0.2783	0.196	0.2894
Y	0.1752	0.2624	0.1548	0.2354	0.1792	0.2243	0.1996	0.2513	0.1752	0.2624
Z	0.1548	0.2354	0.1344	0.2084	0.1588	0.1973	0.1792	0.2243	0.1548	0.2354
S	0.2244	0.2407	0.2056	0.2148	0.2273	0.2061	0.2471	0.232	0.2244	0.2407
a	0.2471	0.232	0.2273	0.2061	0.2498	0.1959	0.27	0.2227	0.2471	0.232
b	0.27	0.2227	0.2498	0.1959	0.2728	0.1866	0.293	0.2134	0.27	0.2227
V	0.2169	0.3188	0.2369	0.3468	0.2609	0.3332	0.2406	0.3064	0.2169	0.3188
W	0.1963	0.2907	0.2169	0.3188	0.2406	0.3064	0.22	0.2783	0.1963	0.2907

Parameter	Symbol	Min.	Typ.	Max.	Units	Note
Propagation delaytime	tPLZ	-	-	80	ns	DI→DO, load=30pF
	tPZL	-	-	80	ns	
Rising time	tTHL	-	15	-	ns	
Falling time	tTLH	-	15	-	ns	
Rising time	tR	-	50	-	ns	$I_{SK(R/G/B)}$=3/5mA, load=30pF
Falling time	tF	-	50	-	ns	
Data rate	F_{data}	-	800	-	KHz	



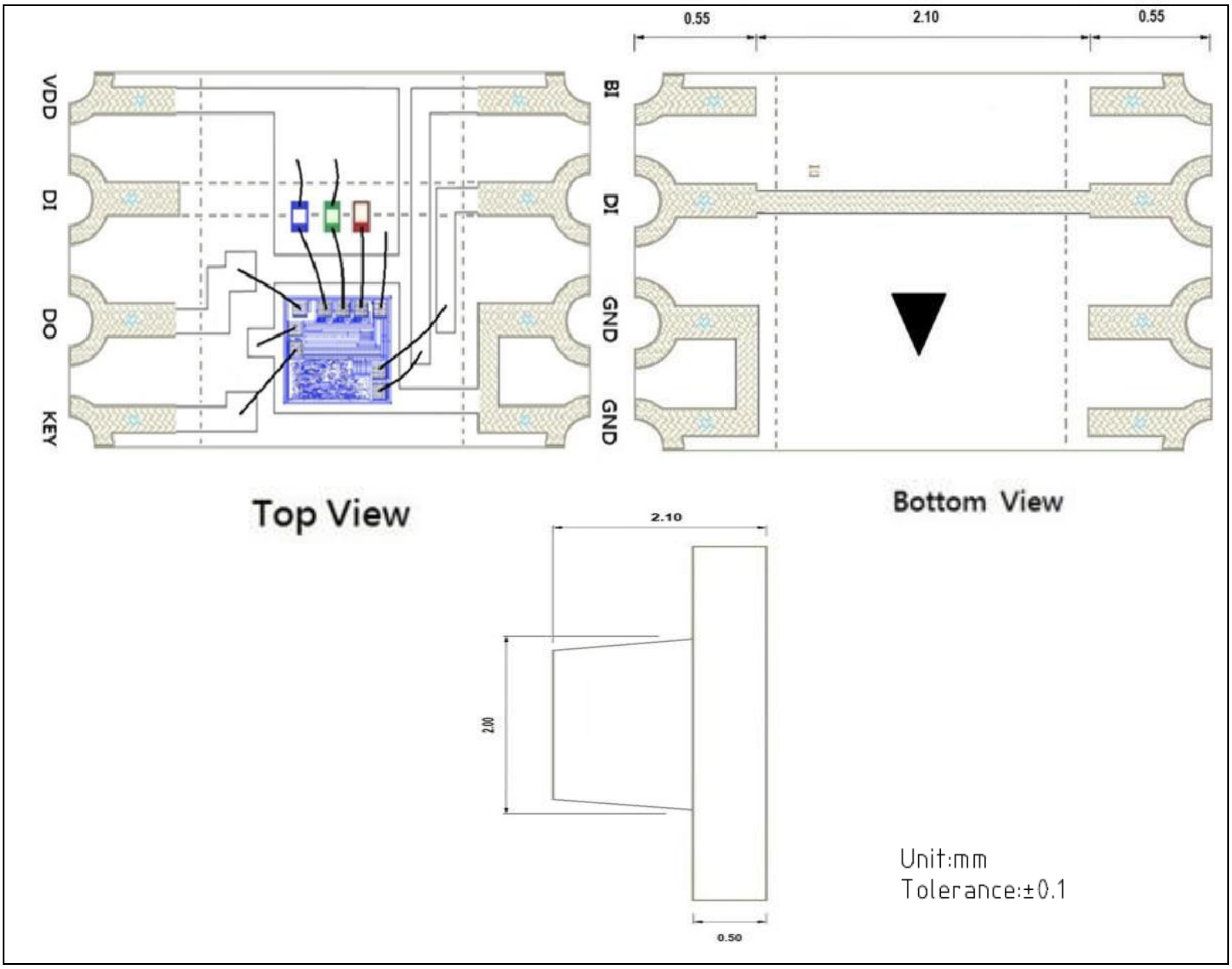
Block Diagram



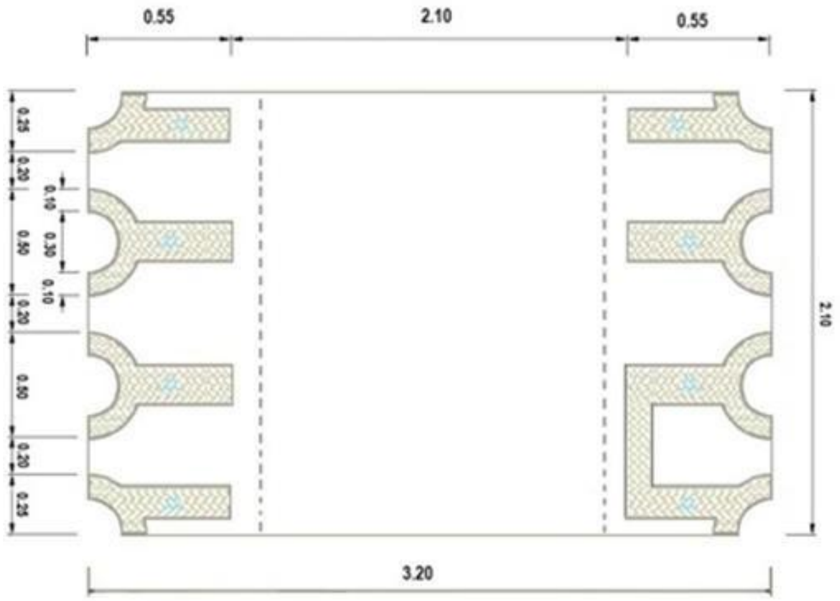
Pin Function Description:

Pin Name	IO	Description
VDD	P	Power Supply
GND	G	Ground
DI	I	Serial data input
BI	I	Secondary serial data input
DO	O	Serial data output
KEY	O	Open-drain output for key scan

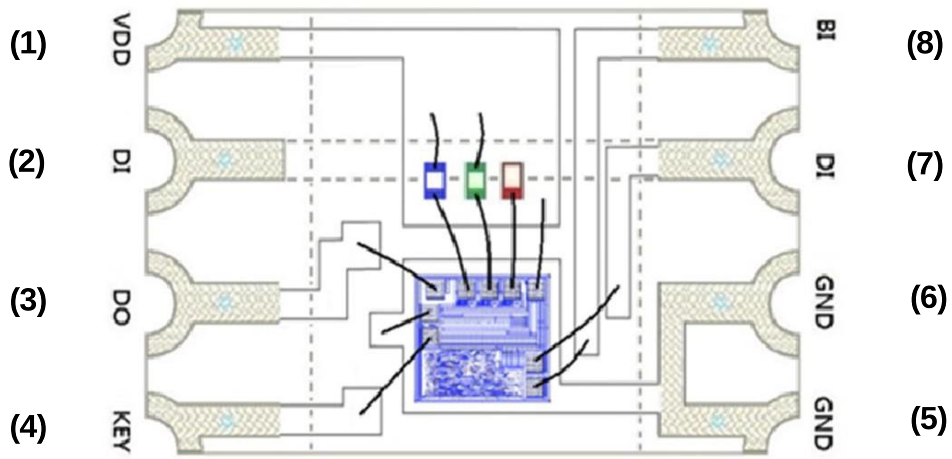
Package Outline Dimensions:



Recommended pad:

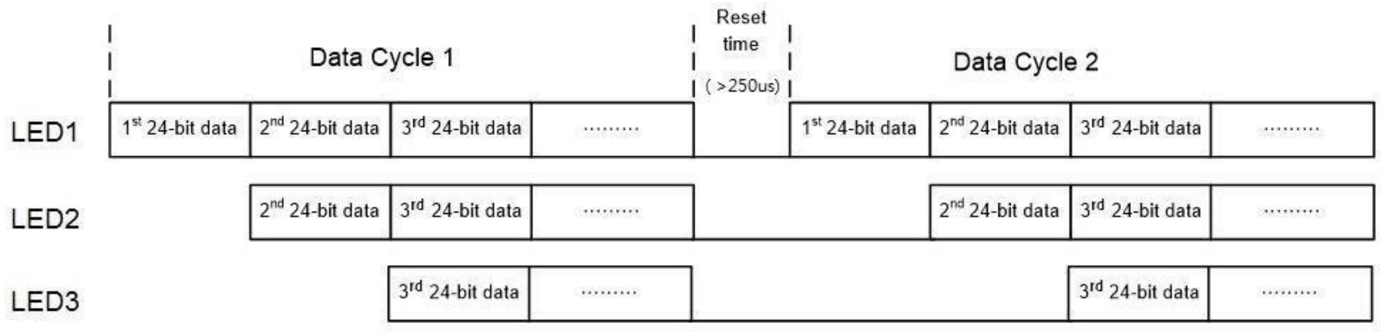


PIN Configuration:



No.	Symbol	Functiondescription
1	VDD	Power Supply
2&7	DI	Serial Data input
3	DO	Serial Data output
4	KEY	Open-Drain output for Key scan
5&6	GND	Ground
8	BI	Secondary serial Data input

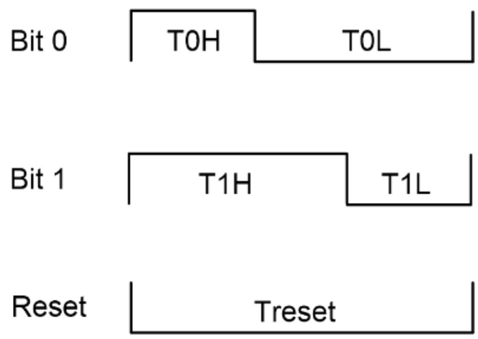
Data Transfer Protocol



The single wire data transfer protocol supports 24-bit data for each LED RGB display data refresh. AP3221A-C3A receives 24-bit data and passes the remaining data to next LED. The 24-bit data consist of green, red and blue data, each with 8-bit width, and are transferred with MSB first. Each of the 8-bit data determines 256-level PWM pulse used to control R/G/B channels.

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

The transferred data are recognized based on the pulse widths received by AP3221A-C3A. A low bit 0 is represented by a 0.3us high pulse followed by a 0.9us low pulse. A high bit 1 is represented by a 0.9us high pulse followed by a 0.3us low pulse. A low pulse ≧ 250us is used to issue a reset command to AP3221A-C3A to start a new cycle of serial commands.



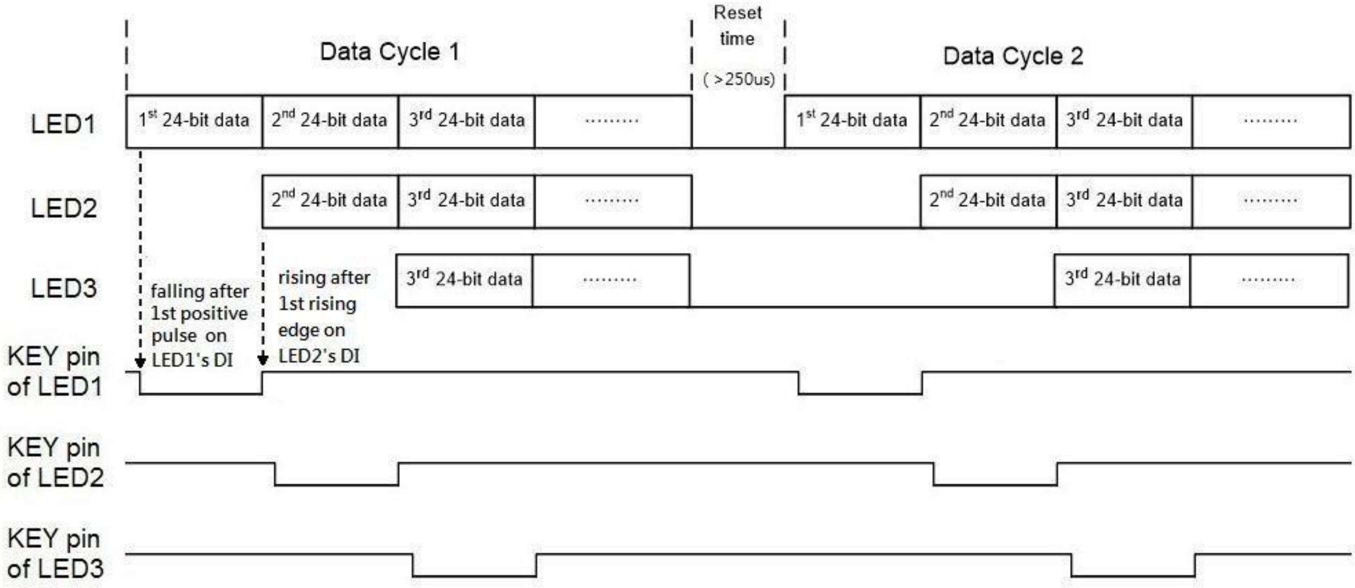
T0H = 0.30us ± 0.10us, T0L = 0.90us ± 0.10us

T1H = 0.90us ± 0.10us, T1L = 0.30us ± 0.10us

Treset ≧ 250us

KEY output during data transfer

AP3221A-C3A supports KeyLED key scan function by forcing open-drain output KEY pin to low state during receiving transferred data. Key pin is wired to an external key switch. Once the responding key is pressed and the switch is ON, the low state is used as a scan signal sent to MCU. The pressed key can then be recognized by the signal. That is, the key with the LED receiving transferred data is pressed. This open-drain output KEY features the scan function during data transfer (patent granted).



Suppose there are 140 keys in a keyboard set, the worst case response time of a pressed key event during data transfer is calculated as below.

Worst response time=single_bit_transfer_time*24_bits*140_keys

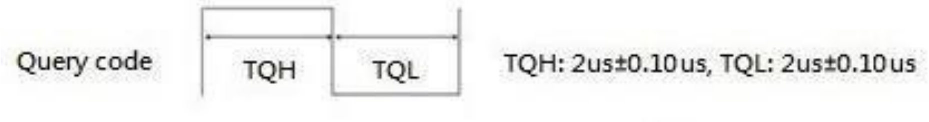
=1.2us* 24 *140

=4.032ms

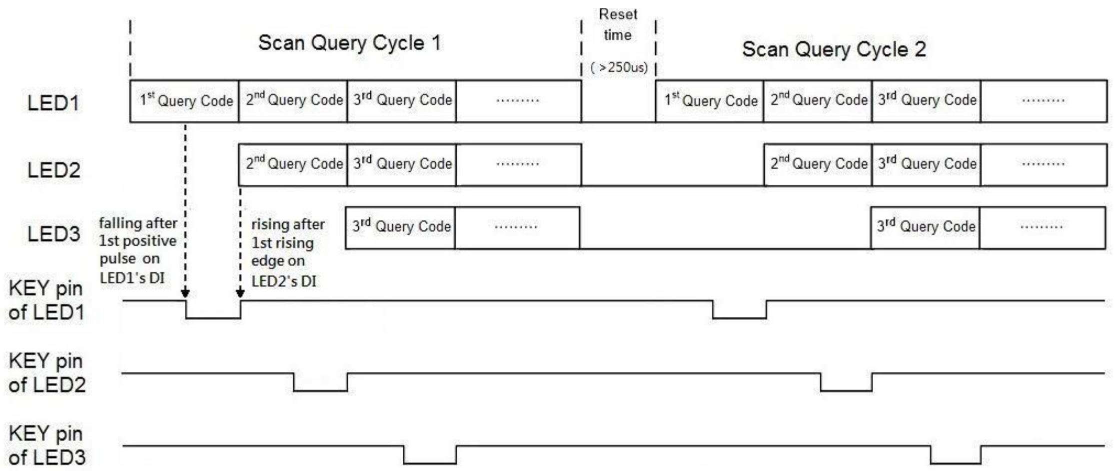
Please note that the low pulse on KEY pin falls after the first positive pulse of 24-bit data, and rises after the first rising edge of next 24-bit data. This timing enables MCU to check if the key with the LED receiving 24-bit data is pressed before issuing next 24-bit data.

Key scan query protocol

AP3221A-C3A's KeyLED feature supports key scan query protocol for MCU to accelerate key scan timing. Instead of 24-bit data, MCU sends a query code to each LED to scan key press status with the specific LED. A query code is represented by a 2us high pulse followed by a 2us low pulse.



When an LED receives a query code, the KEY pin of the LED is forced to low state. Hence, the low state triggers a low pulse event to MCU if the responding key is pressed.



Because the wave length of a query code (4us) is much shorter than that of 24-bit data (28.8us), the worst case response time of a pressed key event in key scan query mode is better than that in data transfer mode. Suppose there are 140 keys in a keyboard set, the worst case response time of a pressed key event in key scan mode is calculated as below.

Worst response time=single_query_code_time*140_keys

=4us*140

=0.56ms.

Please note that the low pulse on KEY pin falls after the first positive pulse of a query code, and rises after the rising edge of the positive pulse in next query code. This timing enables MCU to check if the key with the LED receiving the query code is pressed before issuing next query code.

Sleep and wake-up mode

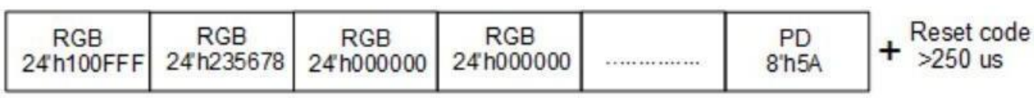
AP3221A-C3A supports sleep/wake-up modes for power-saving purpose. When receiving 24-bit 0's RGB data, 8-bit0x5Aspecialdata, and a reset command, AP3221A-C3A will enter sleep mode. In sleep mode, the built-in oscillator and associated circuitry is disabled. The quiescent current of AP3221A-C3A is less than 2uA (typ) in sleep mode.

A sleeping AP3221A-C3A wakes up from sleep mode when detecting an input rising edge on DI or BI pin. Normally a positive pulse on DI or BI pin can be used as a wake-up trigger. After waking up, all sleeping circuits in AP3221A-C3A return to normal working mode within 1ms.To wake-up the next cascaded AP3221A-C3A, the received positive pulse on DI pin is passed to DO pin, which connected to DI pin of the next AP3221A-C3A, and in turn wakes up the next AP3221A-C3A. Hence, all cascaded sleeping AP3221A-C3A can wake up successively.

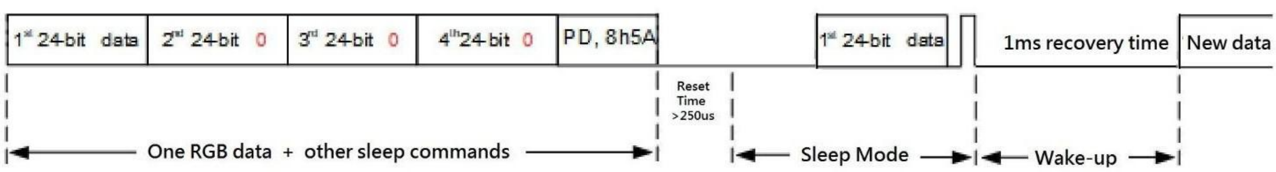
Since it takes 1ms for a sleeping AP3221A-C3A returning to normal functioning mode, it is recommended for MCU to wait for 1ms to send display data and commands after issuing a wake-up pulse.

In case a mal-functioned AP3221A-C3A exists in an LED strip, the one next to the mal-functioned AP3221A-C3A determines the sleep/wake-up mode through BI pin, instead of DI pin.

In an LED strip, it is possible to set certain AP3221A-C3A active, while the others in sleep mode. As an example, the following commands are for two leading active AP3221A-C3A and other sleeping AP3221A-C3A.



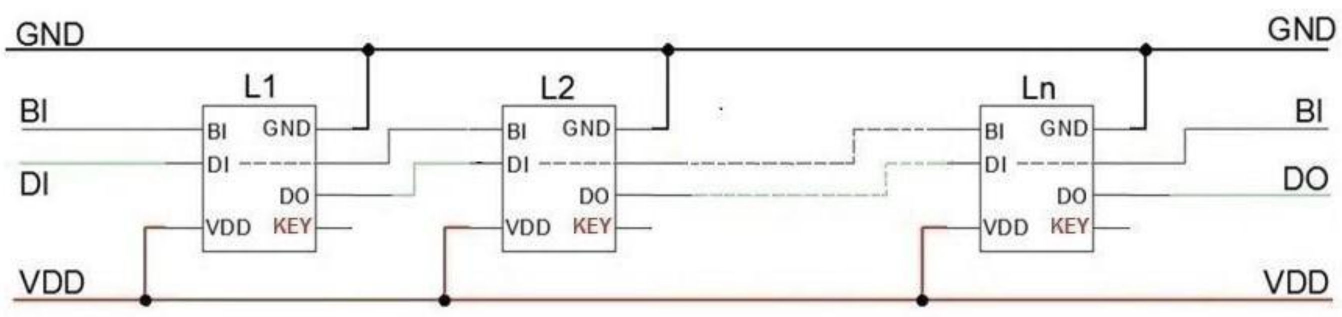
As an example of sleep/wake-up commands shown below, the first AP3221A-C3A is kept active and the remaining AP3221A-C3As enter sleep mode by 24-bit 0's and an ending 0x5A byte. Later on, a positive pulse wakes up all sleeping AP3221A-C3A.



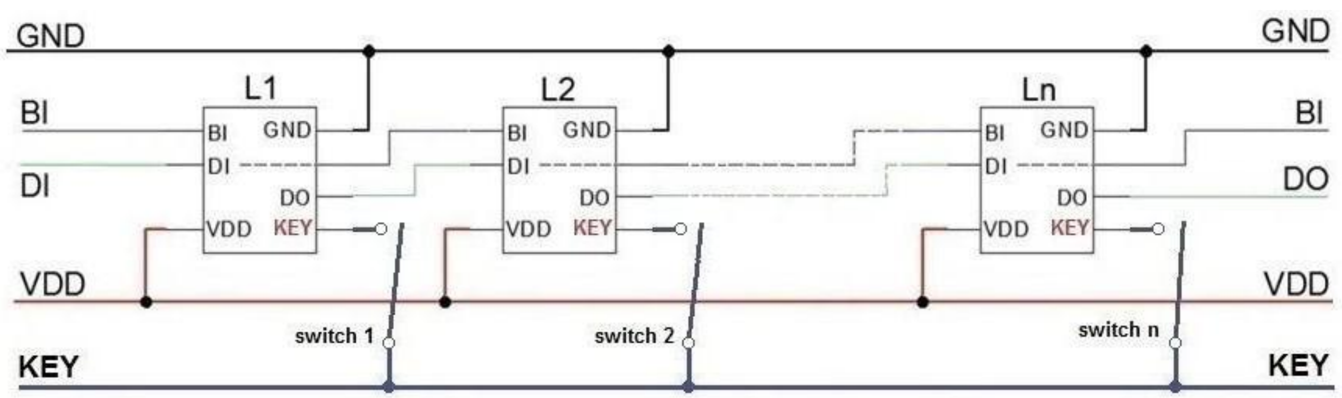
Note that KEY pin of a sleeping AP3221A-C3A outputs a low state which can be used as a trigger of wake-up interrupt to MCU in case any key with a sleeping AP3221A-C3A is pressed.

Typical Application Circuit

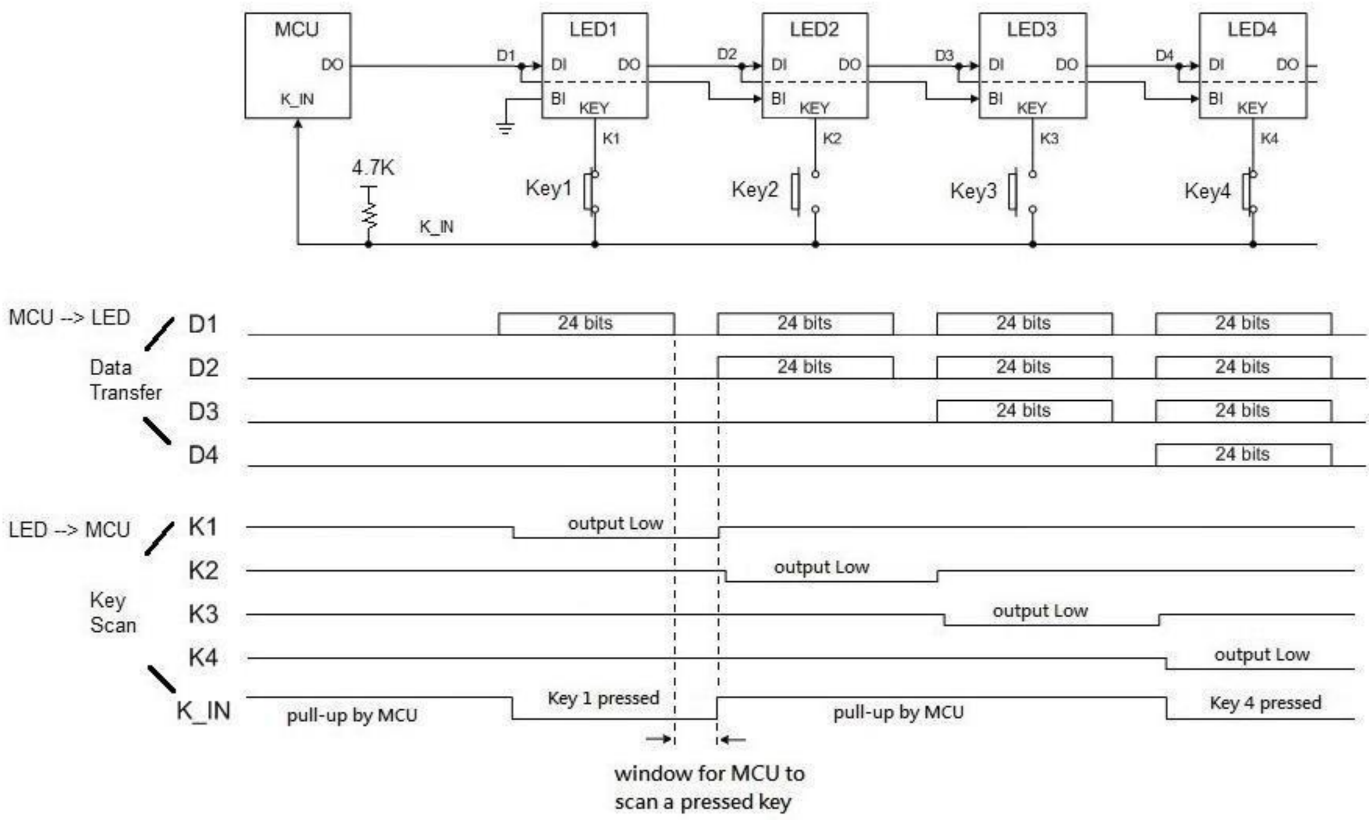
Single-wire LED strip application circuit with malfunction bypass feature is shown below. The circuit can be implemented in a single layer PCB layout easily.



Single-wire LED strip and key scan application circuit with malfunction bypass feature is shown below. With appropriate PCB layout, it is possible to realize the circuit in a single layer PCB layout.

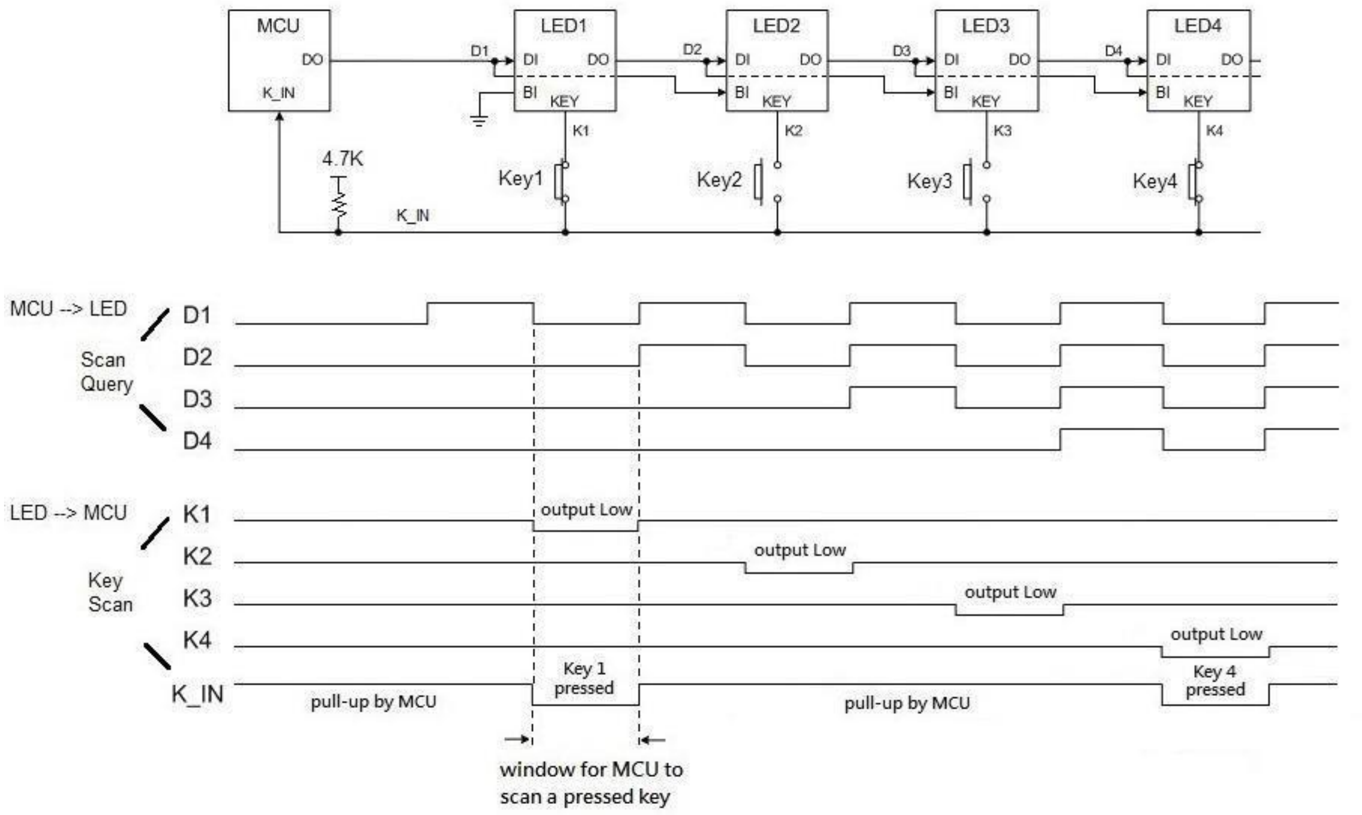


Typical KeyLED Waveform Controlwith MCU (during Data Transfer)



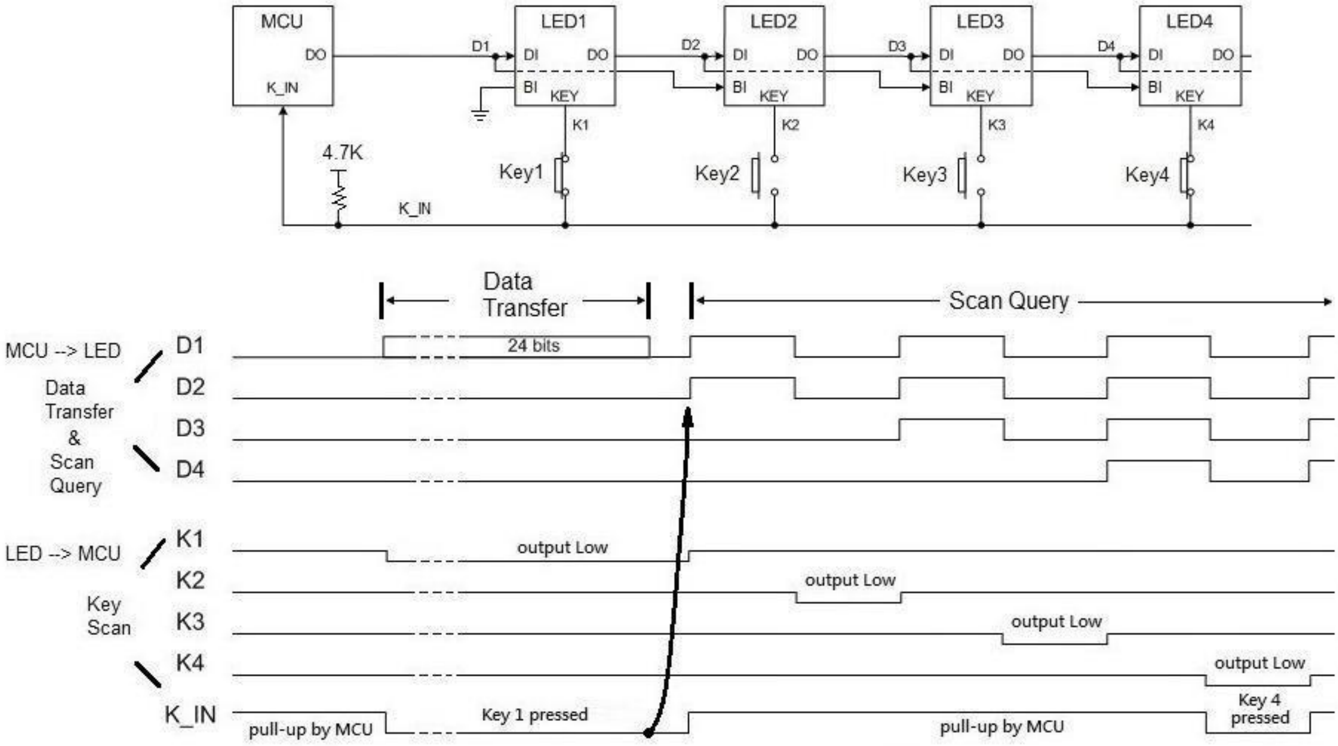
As an example of KeyLED control waveform shown above, a global net K_IN is wired to one terminal of all key switches. K_IN net is weakly pulled up to VDD level by an MCU input port. While a certain LED is receiving 24-bit RGB data, its KEYport will output a low level pulse. If the key associated with the LED is pressed and the switch is ON, the low level pulse is then passed to K_IN net. MCU can determine the exact key being pressed by the sequential order of transferred data.

Typical KeyLED Waveform Controlwith MCU (during Data Query)



As an example of KeyLED control waveform shown above, a global net K_IN is wired to one terminal of all key switches. K_IN net is weakly pulled up to VDD level by an MCU input port. While a certain LED is receiving a scan query code, its KEY port will output a low level pulse. If the key associated with the LED is pressed and the switch is ON, the low level pulse is then passed to K_IN net. MCU can determine the exact key being pressed by the sequential order of query codes. Since wave length of a query code is much shorter than 24-bit RGB data, the key press response time in scan query mode is much faster than in data transfer mode.

Typical KeyLED Waveform Controlwith MCU (mixed Data Transferwith Scan Query)

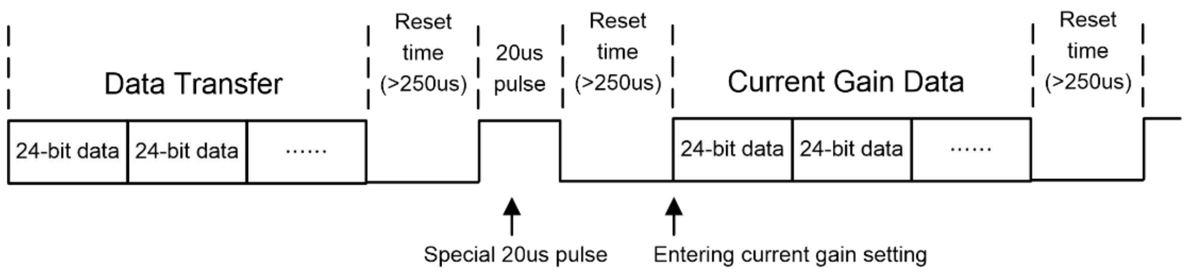


As an example of KeyLED control waveform shown above, if MCU treats the key press event with higher priority than data transfer, MCU can change data transfer mode into scan query mode immediately after a24-bit data transfer is done. This allows MCU to response the key press event efficiently. The data transfer can be resumed while query scan is complete (after 0.56ms for 140-key application).

Dimming Control

AP3221A-C3A supports an 18-level current gain control to adjust sink current of R/G/B channels. This feature enables dimming control of LED lighting. Each of the red, green and blue channels can be controlled individually, which in turn not only to save power consumption, but also to fine-tune the color temperature of R/G/B LEDs.

To set the current gain of AP3221A-C3A's R/G/B channels, a special pulse must be issued by MCU before setting the current gain levels, as shown below



After a reset pulse following normal data transfer, if a 20us positive pulse is issued with another reset pulse, AP3221A-C3A is forced into a special mode to interpret following 24-bit data as current gain setting data. Each of the 24-bit data comprises 4-bit gain values of R/G/B channels, as shown below.

S23	S22	S21	S20	S19	S18	S17	S16	S15	S14	S13	S12	S11	S10	S9	S8	S7	S6	S5	S4	S3	S2	S1	S0
0	0	0	0	R[3]	R[2]	R[1]	R[0]	0	0	0	0	G[3]	G[2]	G[1]	G[0]	0	0	0	0	B[3]	B[2]	B[1]	B[0]

The maximum output current of each R/G/B channels is then determined as below(I_{SK}=3mAor5mA).

$$Rsink=I_{SK}*(R[3]*10/17+R[2]*4/17+R[1]*2/17+R[0]*1/17)$$

$$Gsink= I_{SK}* (G[3]*10/17 + G[2]*4/17 + G[1]*2/17 + G[0]*1/17)$$

$$Bsink = I_{SK}* (B[3]*10/17 + B[2]*4/17 + B[1]*2/17 + B[0]*1/17)$$

By default, R[3:0]=G[3:0]=B[3:0]=0x0F.

Surface Mounting Condition

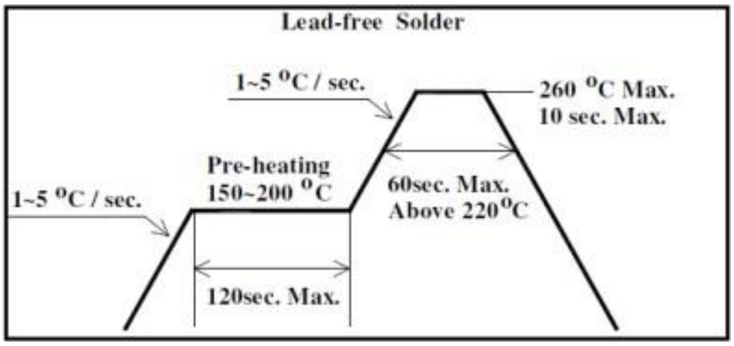
In automatic mounting of the SMD LEDs on printed circuit boards, any bending , expanding and pulling forces or shock against the SMD LEDs shall be kept min. to prevent them from electrical failures and mechanical damages of the devices .

Soldering Reflow

Soldering of the SMD LEDs shall conform to the soldering condition in the individual specifications.
SMD LEDs are designed for Reflow Soldering .
In the reflow soldering , too high temperature and too large temperature gradient such as rapid heating / cooling may cause electrical & optical failure and damages of the devices .
Solidlite can not quarantee the LED after they have been assembled using the solder dipping method .

Recommended Soldering Temperature_Time Profile (Reflow Soldering)

Lead Free Solder	
Pre-heat	150~200℃
Pre-heat time	120 sec. Max.
Peak-Temperature	260℃ Max.
Soldering time Condition	10 sec. Max.



Reliability TestItemand Conditions

・Results of Reliability Test *Test (Note)Thevaluesarebasedon1-dieperformance.

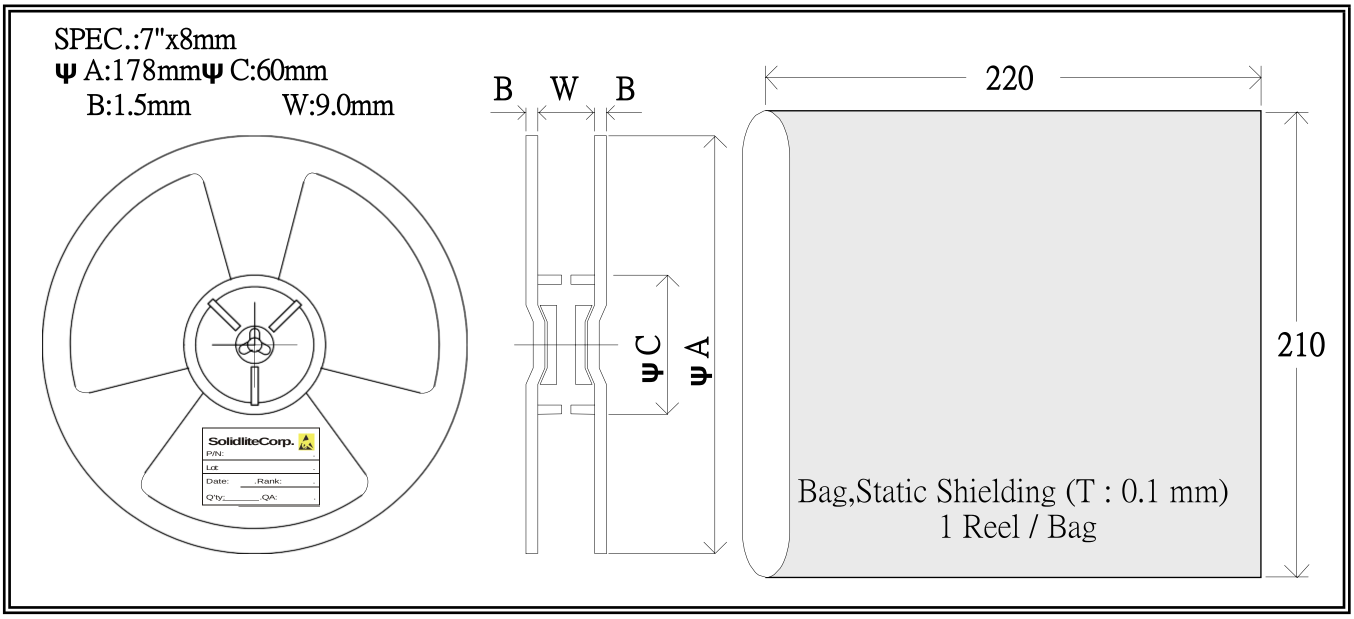
No	Item	Test Condition	Test Hours/Cycles	Sample No	Ac/Re
1	DC Operating Life	RN/GN/BN~I_F: 5mA	1,000HRS	50 PCS	0 /1
2	High Temperature Storage	Temp:100℃	1,000HRS	50 PCS	0 /1
3	Low Temperature Storage	Temp:-55℃	1,000HRS	50 PCS	0 /1
4	Thermal Shock Test	-40˚C ←→ 80℃ 5min 8secs5min	100 CYCLES	50 PCS	0 /1
5	Temperature Cycle	-40℃~25℃~100℃~25℃ 30min5min30min5min	300 CYCLES	50 PCS	0 /1
6	Temp. & Humidity bias	T_A=85℃,RH=85%,I_F=5mA*	1,000HRS	50 PCS	0 /1

・The Reliability Criteria of SMD LED

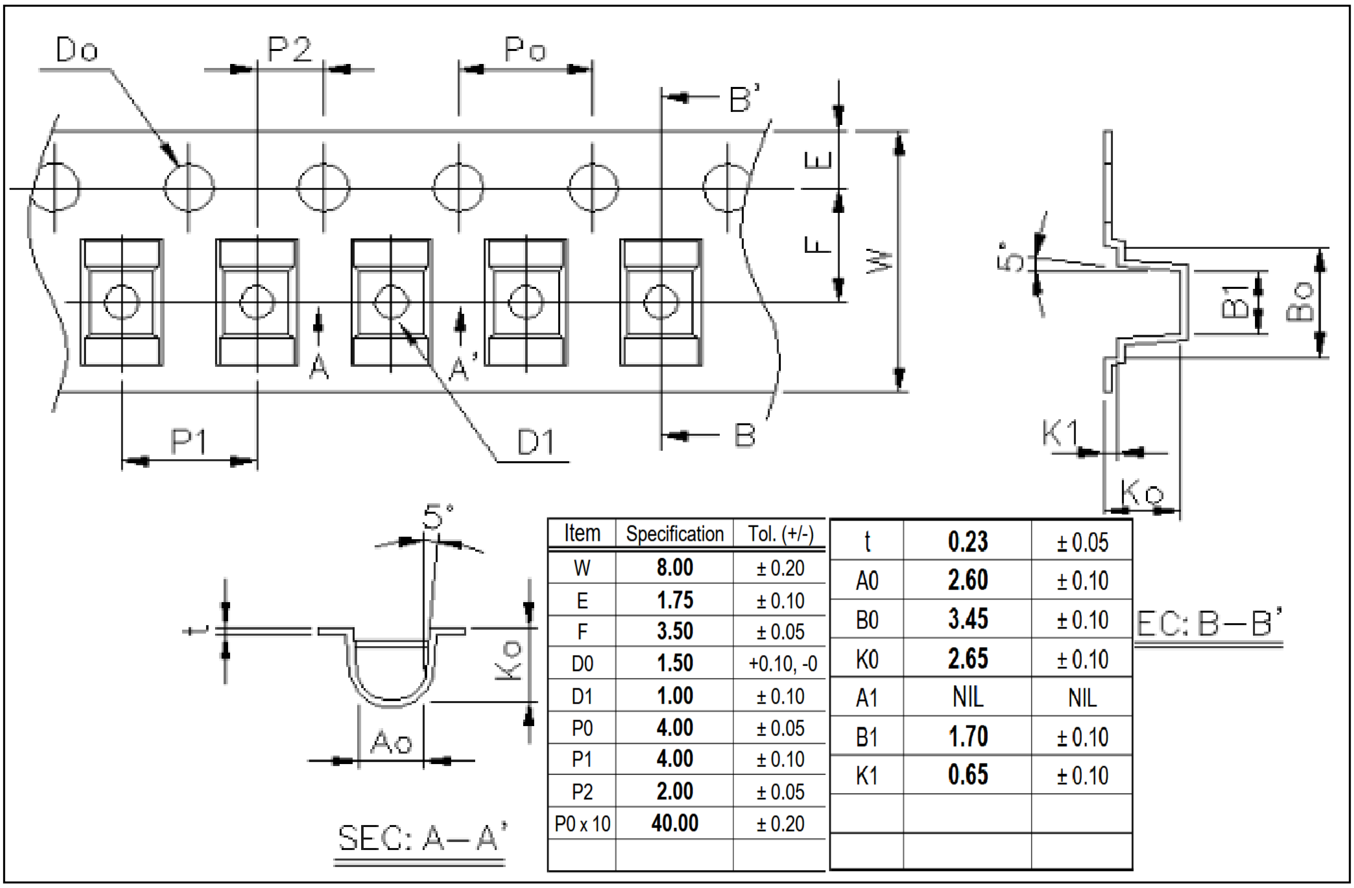
Item	Symbol	Test Condition	Limit	
			Min.	Max.
Forward Voltage	V_F	I_F:5mA	-	U.S.L*1.2
Reverse Current	I_R	V_R:5V	-	U.S.L*2
Power	P_O	I_F :5mA	L.S.L.*0.5	

*U.S.L.: Upper Standard Level *L.S.L.: Lower Standard Level

Package Reel & Static Shielding Bag Dimensions: (Unit: mm)



Package Carrier Tape Dimensions: (Unit: mm)



Item	Specification	Tol. (+/-)
W	8.00	± 0.20
E	1.75	± 0.10
F	3.50	± 0.05
D0	1.50	+0.10, -0
D1	1.00	± 0.10
P0	4.00	± 0.05
P1	4.00	± 0.10
P2	2.00	± 0.05
P0 x 10	40.00	± 0.20

t	0.23	± 0.05
A0	2.60	± 0.10
B0	3.45	± 0.10
K0	2.65	± 0.10
A1	NIL	NIL
B1	1.70	± 0.10
K1	0.65	± 0.10

Cautions :

1. Storage

*Storage Conditions

Before opening the package:

The LEDs should be kept at 30℃ or less and 90%RH or less. The LEDs should be used within a year. When storing the LEDs, moisture proof packaging with absorbent material (silica gel) is recommended.

After opening the package:

The LEDs should be kept at 30℃ or less and 70%RH or less. The LEDs should be soldered within 168 hours (7days) after opening the package. If unused LEDs remain, they should be stored in moisture proof packages, such as sealed containers with packages of moisture absorbent material (silica gel). It's also recommended to return the LEDs to the original moisture proof bag and to reseal the moisture proof bag again.

*If the moisture absorbent material (silica gel) has faded away or the LEDs have exceeded the storage time, baking treatment should be performed using the following condition.

Baking treatment: more than 24 hours at 65+/-5℃

*Solidlite LED electrode sections are comprised of a silver plated copper alloy. The silver surface may be affected by environments which contain corrosive gases and so on. Please avoid conditions which may cause the LED to corrode, tarnish or discolor. This corrosion or discoloration may cause difficulty during soldering operations. It is recommended that the user use the LEDs as soon as possible.

*Please avoid rapid transitions in ambient temperature, especially in high humidity environments where condensation can occur.

2. Moisture Proof Package

*When moisture is absorbed into the SMT package it may vaporize and expand during soldering. There is a possibility that this can cause exfoliation of the contacts and damage to the optical characteristics of the LEDs. For this reason, the moisture proof package is used to keep moisture to a minimum in the package.

*The moisture proof package is made of an aluminum moisture proof bag whit a zipper. A package of a moisture absorbent material (silica gel) is inserted into the aluminum moisture proof bag. The silica gel changes its color from blue to pink as it absorbs moisture.

3. Heat Generation

*Thermal design of the end product is of paramount importance. Please consider the heat generation of the LED when making the system design. The coefficient of temperature increase per input electric power is affected by the thermal resistance of the circuit board and density of LED placement on the board, as well as other components. It is necessary to avoid intense heat generation and operate within the maximum ratings given in this specification.

*The operating current should be decided after considering the ambient maximum temperature of LEDs.

4. Static Electricity

*Static electricity or surge voltage damages the LEDs.
It is recommended that a wrist band or an anti-electrostatic glove be used when handling the LEDs.

*All devices, equipment and machinery must be properly grounded.
It is recommended that measures be taken against surge voltage to the equipment that mounts the LEDs.

*When inspecting the final products in which LEDs were assembled, it is recommended to check whether the assembled LEDs are damaged by static electricity or not. It is to find static-damaged LEDs by a light-on or a VF test at a lower current (below 1mA is recommended) .

*Damaged LEDs will show some unusual characteristics such as the leak current remarkably increases, the forward voltage becomes lower, or the LEDs do not light at the low current.
Criteria:(VF>2.0 V at IF=0.5mA)

5. Cleaning

*It is recommended that isopropyl alcohol be used as a solvent for cleaning the LEDs. When using other solvents, it should be confirmed beforehand whether the solvents will dissolve the package and the resin or not. Freon solvents should not be used to clean the LEDs because of worldwide regulations.

*Do not clean the LEDs by the ultrasonic. When it is absolutely necessary, the influence of ultrasonic cleaning on the LEDs depends on factors such as ultrasonic power and the assembled condition. Before cleaning, a pre-test should be done to confirm whether any damage to the LEDs will occur.

6. Other

*Care must be taken to ensure that the reverse voltage will not exceed the absolute maximum rating when using the LEDs with matrix drive.

*The LED light output is strong enough to injure human eyes. Precaution must be taken to prevent looking directly at the LEDs with unaided eyes for more than a few seconds

*Flashing lights have been known to cause discomfort in people. You can prevent this by taking precautions during use. Also, people should be cautious when using equipment that has had LEDs incorporated into it.

*The LEDs described in this brochure are intended to be used for ordinary electronic equipment (such as office equipment, communications equipment, measurement instruments and household appliances). Consult Solidlite's sales staff in advance for information on the applications in which exceptional quality and reliability are required, particularly when the failure or malfunction of the LEDs may directly jeopardize life or health (such as for airplanes, aerospace, submersible repeaters, nuclear reactor control systems, automobiles, traffic control equipment, life support systems and safety devices).

*User shall not reverse engineer by disassembling or analysis of the LEDs without having prior written consent from Solidlite. When defective LEDs are found, the user shall inform Solidlite directly before disassembling or analysis.

*The formal specifications must be exchanged and signed by both parties before large volume purchased begins.

*The appearance and specifications of the product may be modified for improvement without notice