**AB-PL1515C0I6-5VX0**

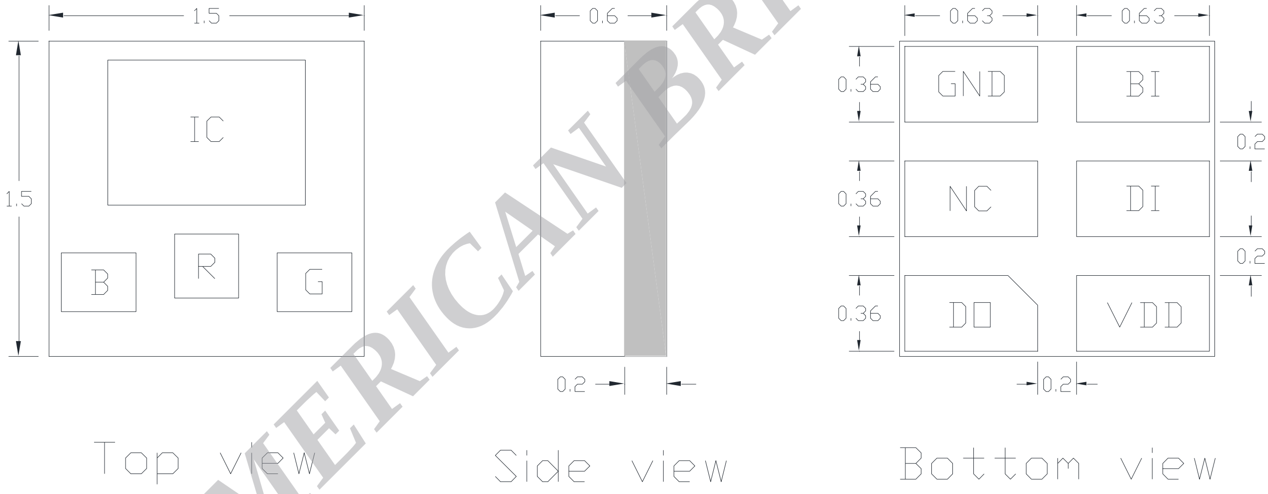
## Features

1. RoHS compliant
2. Support RGB color display and in a single addressable LED
3. Cascading port transmission by dual-wire (clock & data)
4. Built-in current regulator, three-way drive.
5. 256-step gray scale output to allow 16M color display.
6. 32 step dimming control.
7. Built-in oscillator 20MHZ
8. Maximum serial input data / clock frequency 15MHZ
9. Built-in power on reset (2.6V @ VDD=5V)
10. Support sleep and wake up mode for power saving.
11. AEC Q102 Qualified

## Main Applications

- Decorative LED Lighting
- Automotive Interior Ambient lighting

## Mechanical Dimensions



| Pin Name | Function Description |
|---|---|
| VDD | Power supply |
| GND | Ground |
| DI | Serial data input |
| DO | Serial data output |
| BI | Backup data input |
| NC | Empty |

Notes:
1. Drawing not to scale.
2. All dimensions are in millimeters.
3. Unless otherwise indicated, tolerances are ±0.05mm.
4. Please do not use a force of over 0.3kgf impact or pressure on the lens of the LED, otherwise it will cause a catastrophic failure.

## Absolute Maximum Ratings, $T_a$ = 25˚C

**(unless otherwise specified, Temperature=25˚C)**

| Parameter | Symbol | Rating | Unit |
|---|---|---|---|
| Supply Voltage | VDD | 6 | V |
| Maximum Output Current | $I_{OUT}$ | 25 | mA |
| Operating Temperature Range | $T_{OPR}$ | -25~105 | ˚C |
| Storage Temperature Range | $T_{STO}$ | -65~125 | ˚C |

## Electrical / Optical Characteristics, $T_a$ = 25˚C

| Parameter | Symbol | Color | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| Luminous Intensity | IV | Red | 400 | - | 1000 | mcd |
| | | Green | 800 | - | 2000 | |
| | | Blue | 150 | - | 300 | |
| Dominant Wavelength | λd | Red | 620 | - | 630 | nm |
| | | Green | 520 | - | 535 | |
| | | Blue | 460 | - | 475 | |
| View Angle | $2\theta_{1/2}$ | - | 120 | | | deg |

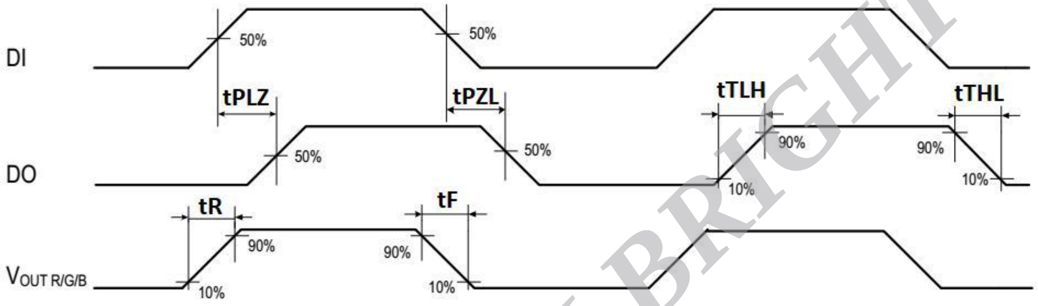
- Luminous intensity is measured with a light sensor and filter combination that approximates the CIE eye-response curve.
- θ1/2 is the off-axis angle at which the luminous intensity is half the axial luminous intensity.
- The dominant wavelength, λd is derived from the CIE chromaticity diagram and represents the single wavelength which defines the color of the device. Peak Emission Wavelength Tolerance is +/- 1nm.

# Electrical Characteristics

**(unless otherwise specified, Temperature=25˚C & VDD=5.0V)**

| Parameter | Symbol | Min. | Typ. | Max. | Unit | Note |
|---|---|---|---|---|---|---|
| Supply Voltage | VDD | 3.3 | 5 | 5.5 | V | |
| Operation Current_1 | IDD | - | 0.3 | - | mA | R/G/B PWM=0x00 |
| Operation Current_2 | IDD | - | 0.45 | - | mA | R/G/B PWM=0xff |
| Sleep Mode Current | Isleep | - | - | 5 | uA | |
| Input High “H” of DI、BI | VIH | 0.7*VDD | - | VDD+0.4 | V | |
| Input Low “L” of DI、BI | VIL | -0.4 | - | 0.2*VDD | V | |
| Output High “H” of DO | VOH | 4.4 | - | - | V | IOH=3mA |
| Output Low “L” of DO | VOL | - | - | 0.3 | V | IOL=3mA |
| R/G/B Sink Current | ISK | 19 | 20 | 21 | mA | VDD-VFLED≧0.7V |
| R/G/B Current Gain | Glevel | - | 20/31 | - | mA/level | |
| DI / BI Input Leakage | Ileak | - | - | 1 | uA | VDI=VBI=VDD=5V |
| R/G/B off Leakage Current | Ioff | - | - | 1 | uA | VR/G/B=5V, PWM off |

| Parameter | Symbol | Min. | Typ. | Max. | Unit | Note |
|---|---|---|---|---|---|---|
| Propagation delay time | tPLZ | - | - | 80 | ns | DI → DO, load=30pF |
| Rising time | tTHL | - | 15 | - | ns | |
| Falling time | tTLH | - | 15 | - | ns | |
| Rising time | tR | - | 50 | - | ns | ISK(R/G/B) =20mA, load=30pF |
| Falling time | tF | - | 50 | - | ns | |
| Data rate | Fdata | - | 800 | - | KHz | |



## Luminous Intensity Bin Structure at 20mA

| Color | Bin Code | Min. | Max. | Unit |
|---|---|---|---|---|
| Red | A | 400 | 1000 | mcd |
| Green | A | 800 | 2000 | |
| Blue | A | 150 | 300 | |

- AB maintains a tolerance of ±10% on flux and power measurements.
- The flux bin of the product may be modified for improvement without notice.

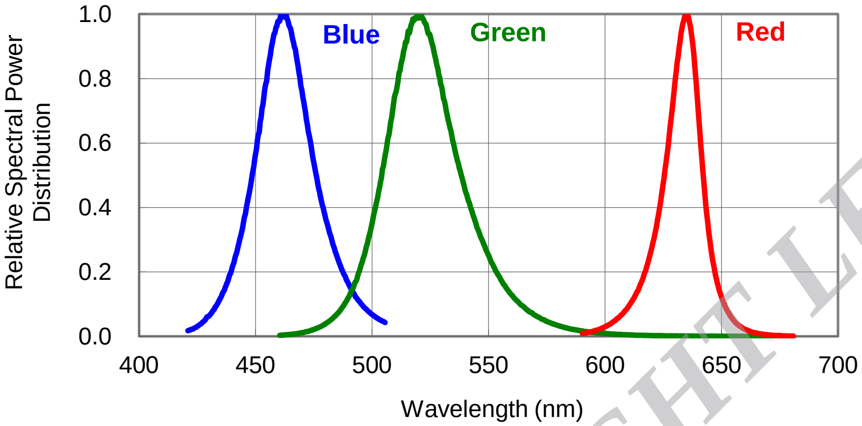
## Dominant Wavelength Bin Structure at 20mA

| Color | Bin Code | Min. | Max. | Unit |
|---|---|---|---|---|
| Red | 4 | 620 | 630 | nm |
| Green | 1 | 520 | 535 | |
| Blue | A | 460 | 475 | |

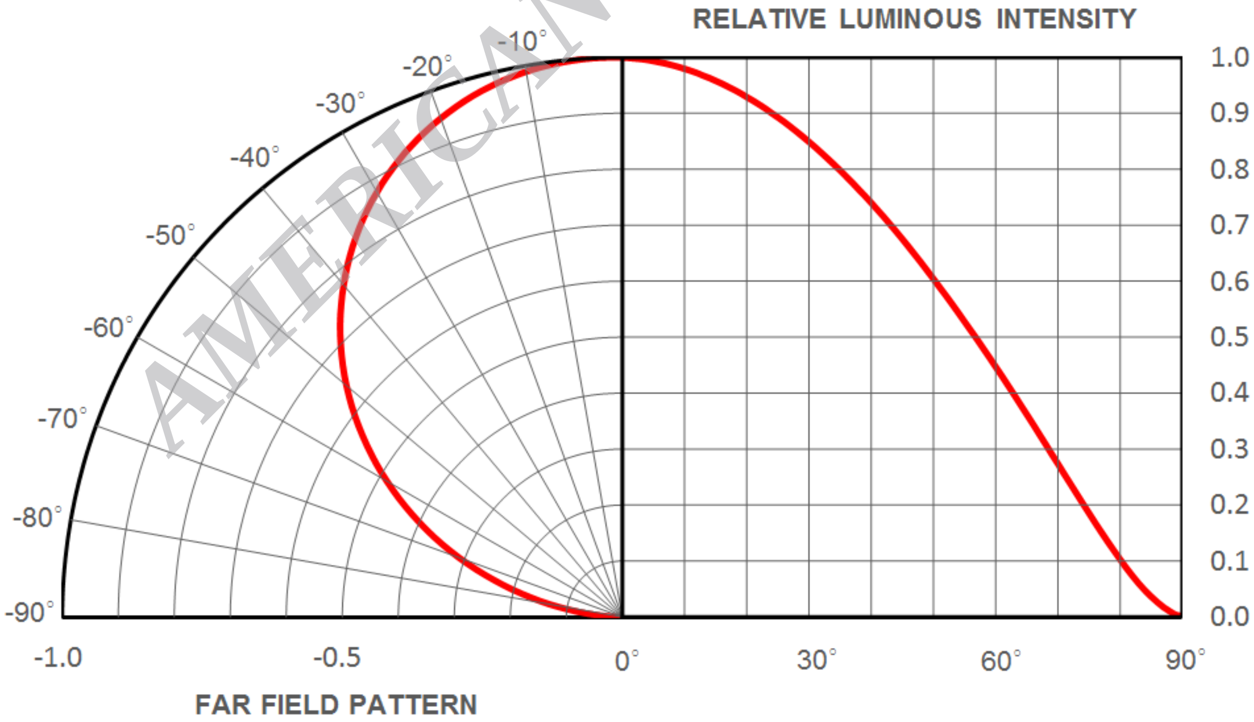
- AB maintains a tolerance of ±1nm for dominant wavelength measurements.

**AB-PL1515C0I6-5VX0**

## Color Spectrum, $T_a$ = 25˚C



## Typical Representative Spatial Radiation Pattern



# Reliability testing in accordance with AEC-Q102

The development of this product included extensive operational life-time testing and environmental testing. Table 1 summarizes the tests applied and cumulative test results obtained from testing performed in accordance with AEC-Q102.

**Table 1. Operating life, mechanical and environmental tests performed on it's package in accordance with AEC-Q102.**

| # | STRESS | ABV | Conditions | Duration | Failure Criteria | Rejects |
|---|---|---|---|---|---|---|
| 1 | Pre- and Post-Stress Electrical Test | TEST | Test is performed as specified in the applicable stress reference at room temperature. | N/A | See notes [2] | 0 |
| A1 | Pre-conditioning | PC | Soak Tamb = 85 °C, RH = 85%<br>Reflow soldering | N/A | See notes [2] | 0 |
| A2a | Wet High Temperature Operating Life | WHTOL 1 | Tambient = 85 °C / 85% RH<br>IF = max. DC [1] | 1000 hours | See notes [2] | 0 |
| A3a | Power Temperature Cycling | PTC | -40°C to 85°C, 10 minutes dwell, 20 minutes transfer (1 hour cycle),<br>2 minutes ON/2 minutes OFF,<br>IF = max. DC [1] | 1000 hours | See notes [2] | 0 |
| A4 | Temperature Cycling | TC | -40°C to 110°C,15 minutes dwell | 1000 cycles | See notes [2] | 0 |
| C10 | Solderability | SD | 245 °C ± 5 °C | 3s | See notes [3] | 0 |
| B1b | High Temperature Operating Life | HTOL2 | Maximum specified Tsolder,<br>IF = max. DC [1] | 1000 hours | See notes [2] | 0 |
| G2 | Vibration Variable Frequency | VVF | 10-2000-10 Hz, log or linear sweep rate,<br>20 G about 1 min., 1.5 mm, 3X/axis | | See notes [3] | 0 |
| G3 | Mechanical Shock | MS | 1500 G, 0.5 msec. pulse,<br>5 shocks each 6 axis | | See notes [3] | 0 |

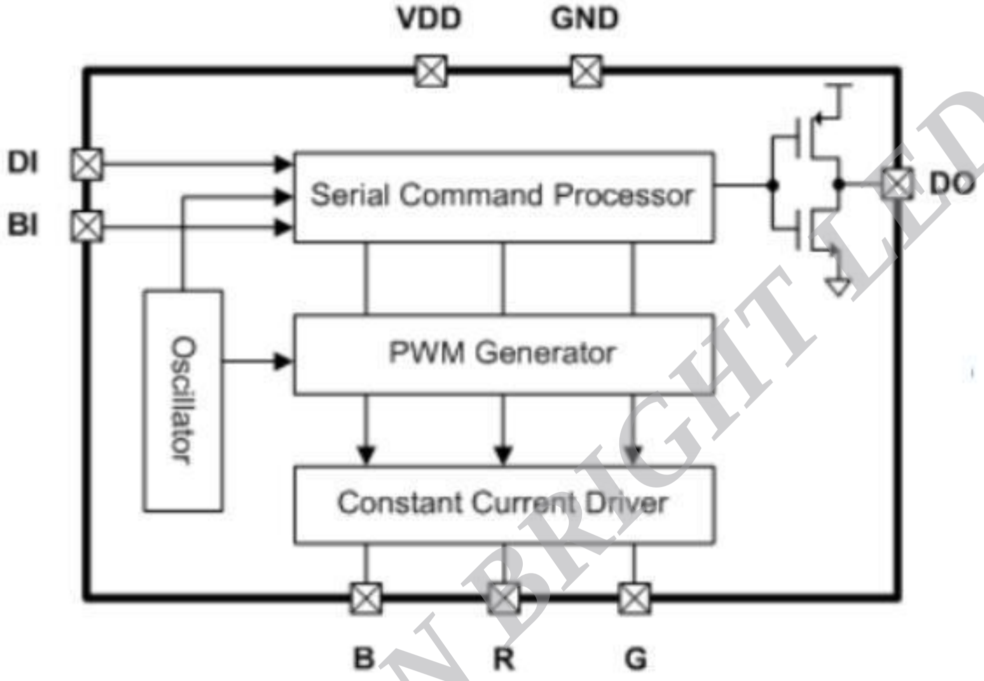
Notes:
1. Depending on the maximum derating curve.
2. Criteria for judging failure

| Item | Test Condition | Criteria for Judgement | |
|---|---|---|---|
| | | Min. | Max. |
| Forward Voltage ($V_F$) | $I_F$ = max DC | -- | Initial Level x 1.1 |
| Luminous Flux or Radiometric Power ($\Phi_V$) | $I_F$ = max DC | Initial Level x 0.8 | -- |
| Reverse Current ($I_R$) | $V_R$ = 5V | -- | 50 μA |

* The test is performed after the LED is cooled down to the room temperature.

3. A failure is an LED that is open or shorted.

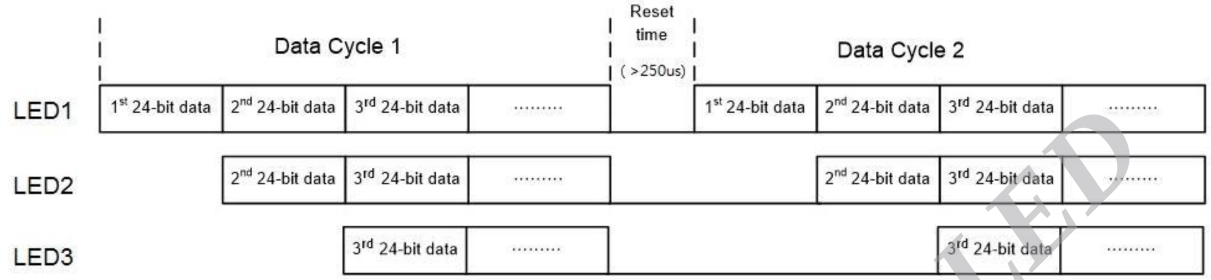
## Block Diagram



## Pin Function Description

| Pin Name | IO | Description |
|---|---|---|
| **VDD** | P | Power Supply |
| **GND** | G | Ground |
| **DI** | I | Serial data input |
| **BI** | I | Backup serial data input |
| **DO** | O | Serial data output |
| **R** | O | Red LED output driver |
| **G** | O | Green LED output driver |
| **B** | O | Blue LED output driver |

# Data Transfer Protocol

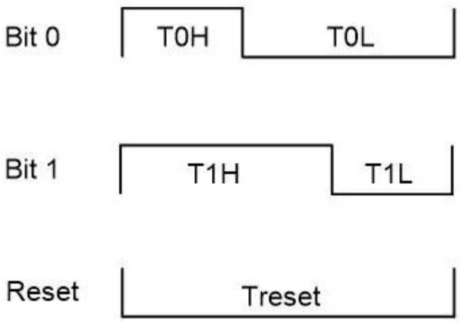


- The single wire data transfer protocol supports 24-bit data for each LED RGB display data refresh. AB-PL1515C0I6-5VX0 receives 24-bit data and passes the remaining data to next LED. The 24-bit data consist of red, green and blue data, each with 8-bit width, and are transferred with MSB first. Each 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 | B7 | B6 | B5 | B4 | B3 | B2 | B1 | B0 | G7 | G6 | G5 | G4 | G3 | G2 | G1 | G0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

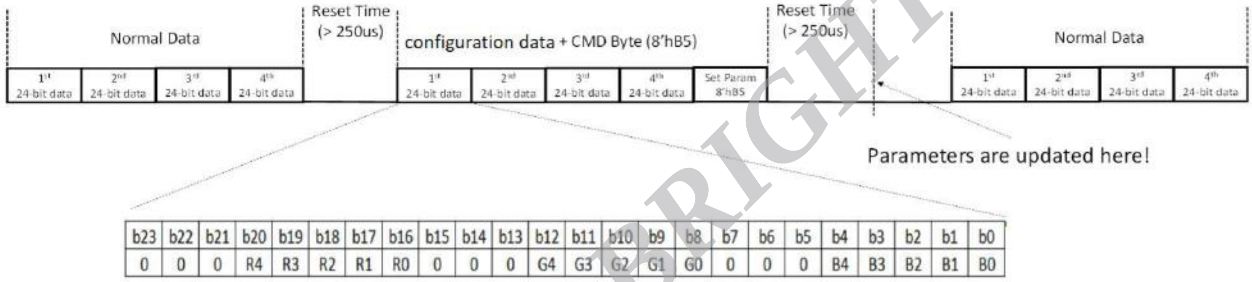
- The transferred data are recognized based on the pulse widths received by AB-PL1515C0I6-5VX0. A low bit 0 is represented by a 0.3us high pulse followed by a 0.9us low pulse. A high bit 1 is represented by a 0.9us high pulse followed by a 0.3us low pulse. A low pulse >= 250us is used to issue a reset command to AB-PL1515C0I6-5VX0 to start a new cycle of serial commands.

| Item | Min | Tpy. | Max | Unit |
|---|---|---|---|---|
| **T0H** | 200 | 300 | 400 | ns |
| **T0L** | 800 | 900 | 1000 | |
| **T1H** | 800 | 900 | 1000 | |
| **T1L** | 200 | 300 | 400 | |
| **T1_Width** | 1150 | - | - | |
| **Reset** | 250 | - | - | us |



# Dimming Control (Current Gain)

- Supports an 32-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 the R/G/B channel, the controller should issue the dimming configuration data of each LED first, then the 8-bit digits only with 8‘hB5 and the reset command are followed, the current gain command will take effect immediately.



| b23 | b22 | b21 | b20 | b19 | b18 | b17 | b16 | b15 | b14 | b13 | b12 | b11 | b10 | b9 | b8 | b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | R4 | R3 | R2 | R1 | R0 | 0 | 0 | 0 | G4 | G3 | G2 | G1 | G0 | 0 | 0 | 0 | B4 | B3 | B2 | B1 | B0 |

R[4:0]: R dimming set value (default: 'h1F), G[4:0]: G dimming set value (default:'h1F)
B[4:0]: B dimming set value (default: 'h1F)

- The maximum output current of each R/G/B channels is then determined as below (ISK=20mA).

Rsink = ISK * (R[[4]*16/31+R[3]*8/31 + R[2]*4/31 + R[1]*2/31 + R[0]*1/31)
Gsink = ISK * (G[[4]*16/31+G[3]*8/31+ G[2]*4/31 + G[1]*2/31 + G[0]*1/31)
Bsink = ISK * (B[[4]*16/31+ B[3]*8/31 + B[2]*4/31 + B[1]*2/31 + B[0]*1/31)

By default, R[4:0] = G[4:0] = B[4:0] = 0x1F.

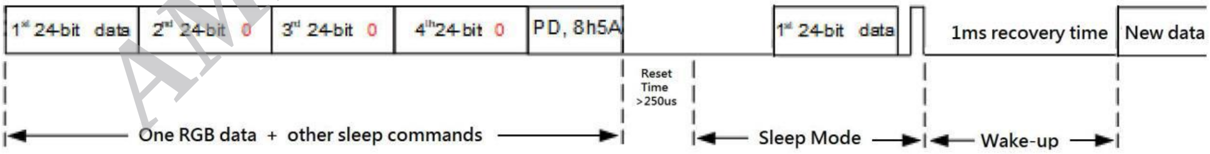
## Recommended programming flow:

**After system power-on, MCU should send data 0 first (dark mode) for all LEDs in the strip, then MCU can deliver normal display data or execute current gain (dimming) command to LEDs.**

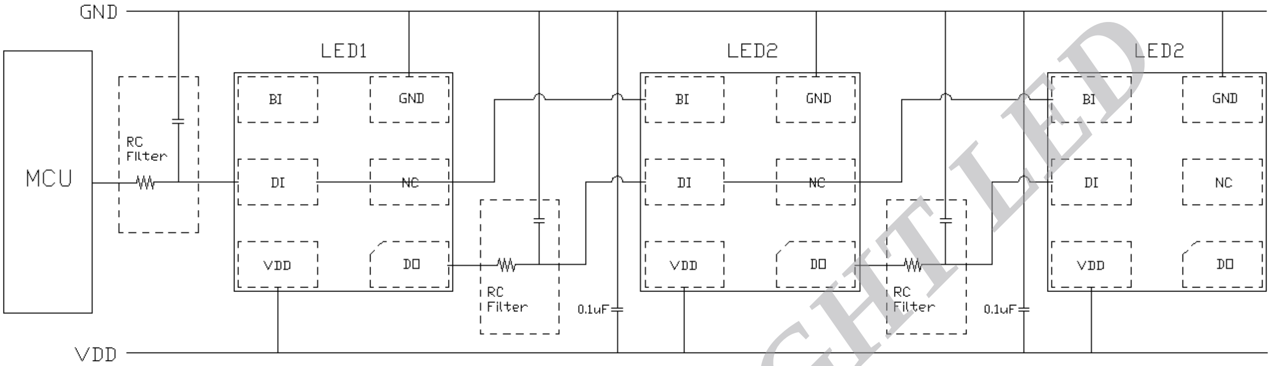
## Sleep and wake-up mode

- Supports sleep/wake-up modes for power-saving purpose. When receiving 24-bit 0's RGB data, 8-bit 0x5A special data, and a reset command, AB-PL1515C0I6-5VX0 will enter sleep mode. In sleep mode, the built-in oscillator and associated circuitry is disabled. The quiescent current is less than 5uA (typ) in sleep mode.
- A sleeping AB-PL1515C0I6-5VX0 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 return to normal working mode within 1ms. To wake-up the next cascaded LED, the received positive pulse on DI pin is passed to DO pin, which connected to DI pin of the next the LED, and in turn wakes up the next LED. Hence, all cascaded sleeping AB-PL1515C0I6-5VX0 can wake up successively.
- Since it takes 1ms for a sleeping AB-PL1515C0I6-5VX0 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 AB-PL1515C0I6-5VX0 exists in an LED strip, the one next to the mal-functioned LED determines the sleep/wake-up mode through BI pin, instead of DI pin. In an LED strip, it is possible to set certain AB-PL1515C0I6-5VX0 active, while the others in sleep mode. As an example, the following commands are for two leading active LED and other sleeping LED.

- As an example of sleep/wake-up commands shown below, the first AB-PL1515C0I6-5VX0 is kept active and the remaining AB-PL1515C0I6-5VX0 enter sleep mode by 24-bit 0's and an ending 0x5A byte. Later on, a positive pulse wakes up all sleeping LEDs.



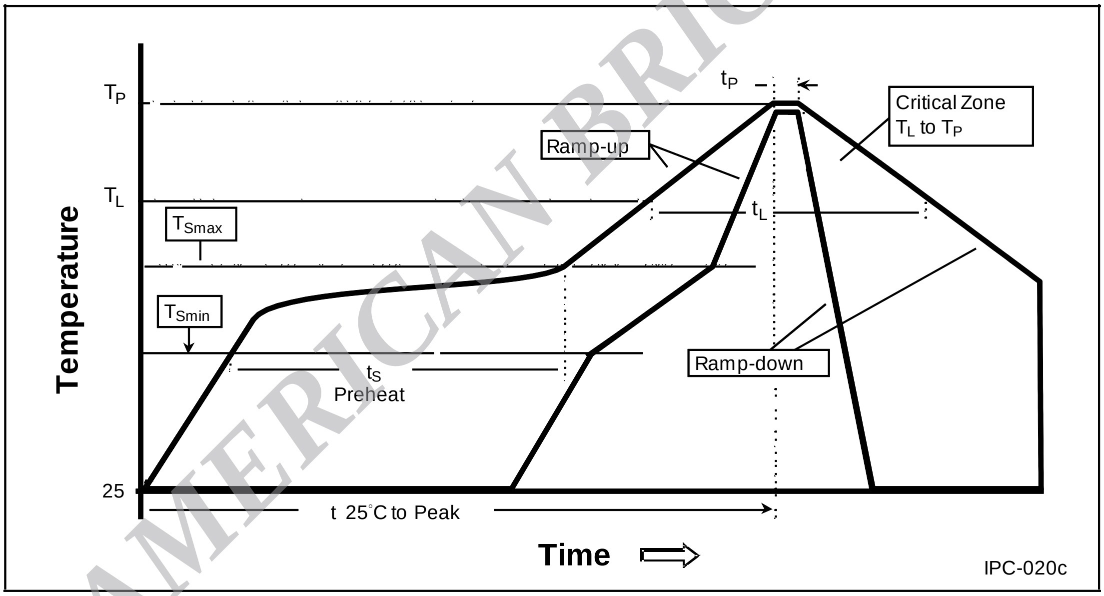
## Typical Application Circuit



- RC Filter must be added on PCB to ensure the stable waveform of signal in different applications. The value of RC is subject to the practical system environment.
- The bypass capacitor on VDD pin of each IC is necessary to be added on board for the stability of chip operation. The suggested value of capacitor is 0.1uF.

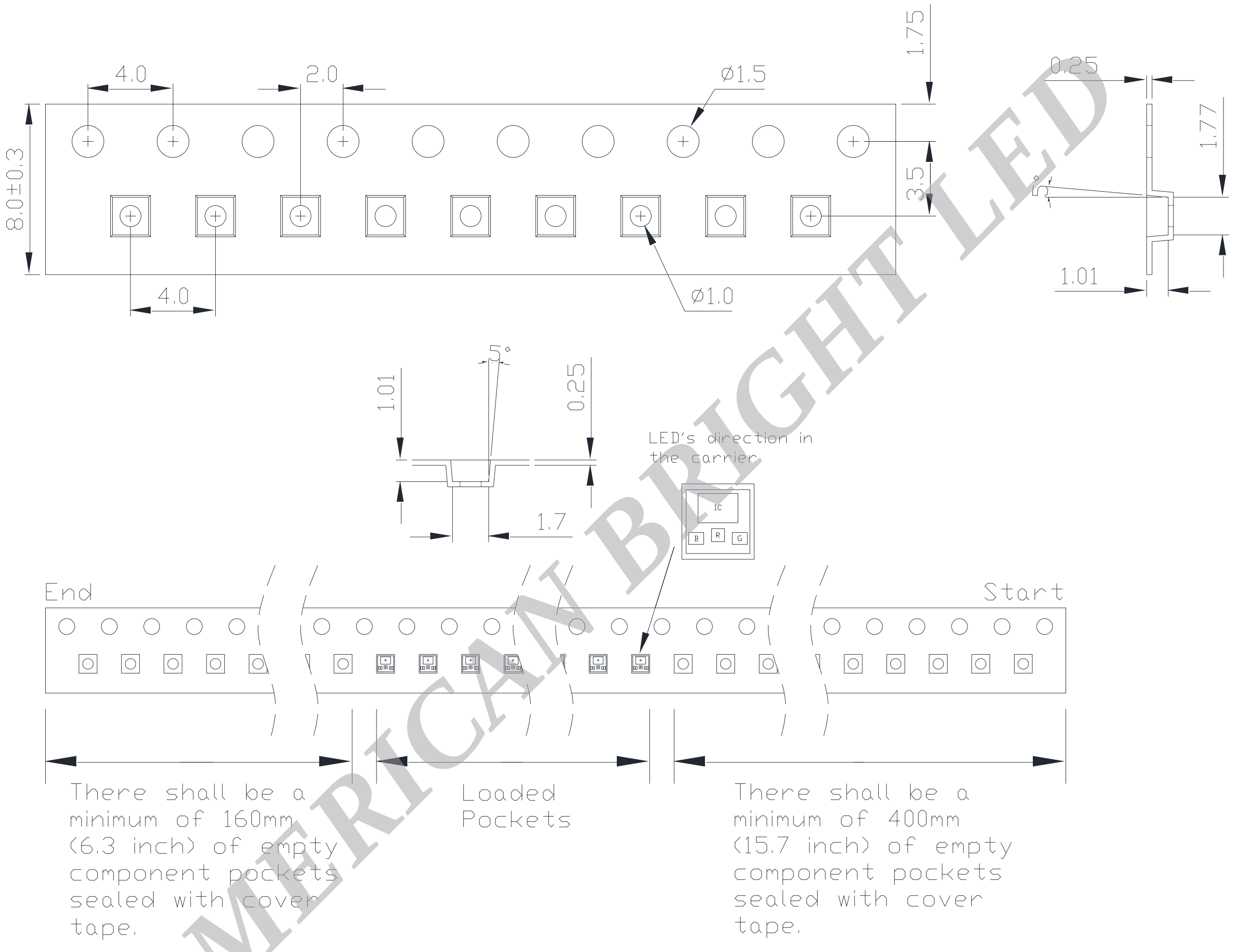
# Reflow Soldering Condition

| Profile Feature | Sn-Pb Eutectic Assembly | Pb-Free Assembly |
|---|---|---|
| Average Ramp-Up Rate ($T_{Smax}$ to $T_P$) | 3°C / second max. | 3°C / second max. |
| Preheat<br>– Temperature Min ($T_{Smin}$)<br>– Temperature Max ($T_{Smax}$)<br>– Time ($t_{Smin}$ to $t_{Smax}$) | <br>100°C<br>150°C<br>60-120 seconds | <br>150°C<br>200°C<br>60-180 seconds |
| Time maintained above:<br>– Temperature ($T_L$)<br>– Time ($t_L$) | <br>183°C<br>60-150 seconds | <br>217°C<br>60-150 seconds |
| Peak/Classification Temperature ($T_P$) | 240°C | 260°C |
| Time Within 5°C of Actual Peak Temperature ($t_P$) | 10-30 seconds | 20-40 seconds |
| Ramp-Down Rate | 6°C/second max. | 6°C/second max. |
| Time 25°C to Peak Temperature | 6 minutes max. | 8 minutes max. |



- We recommend using the M705-RGS800HF Type5 solder paste from SMIC (Senju Metal Industry Co., Ltd.) for lead-free soldering.
- Do not use solder pastes with post reflow flux residue>47%. (58Bi-42Sn eutectic alloy, etc) This kind of solder pastes may cause a reliability problem to LED.
- All temperatures refer to topside of the package, measured on the package body surface.
- Repairing should not be done after the LEDs have been soldered. When repairing is unavoidable, a double-head soldering iron should be used. It should be confirmed beforehand whether the characteristics of the LEDs will or will not be damaged by repairing.
- Reflow soldering should not be done more than three times.
- When soldering, do not put stress on the LEDs during heating.
- After soldering, do not warp the circuit board.

# Emitter Reel Packaging



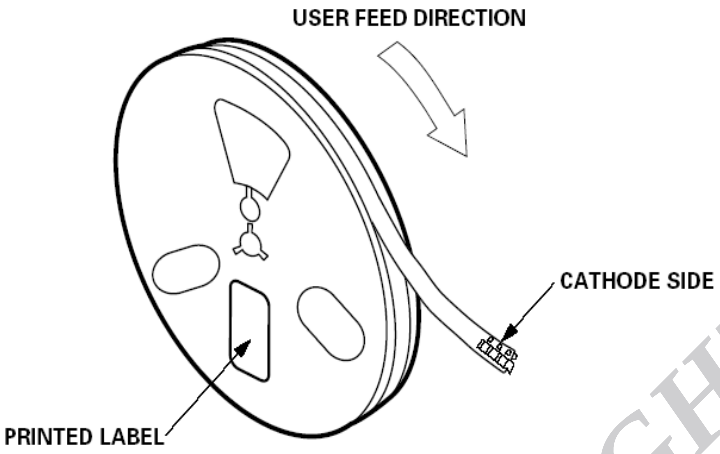
There shall be a minimum of 160mm (6.3 inch) of empty component pockets sealed with cover tape.

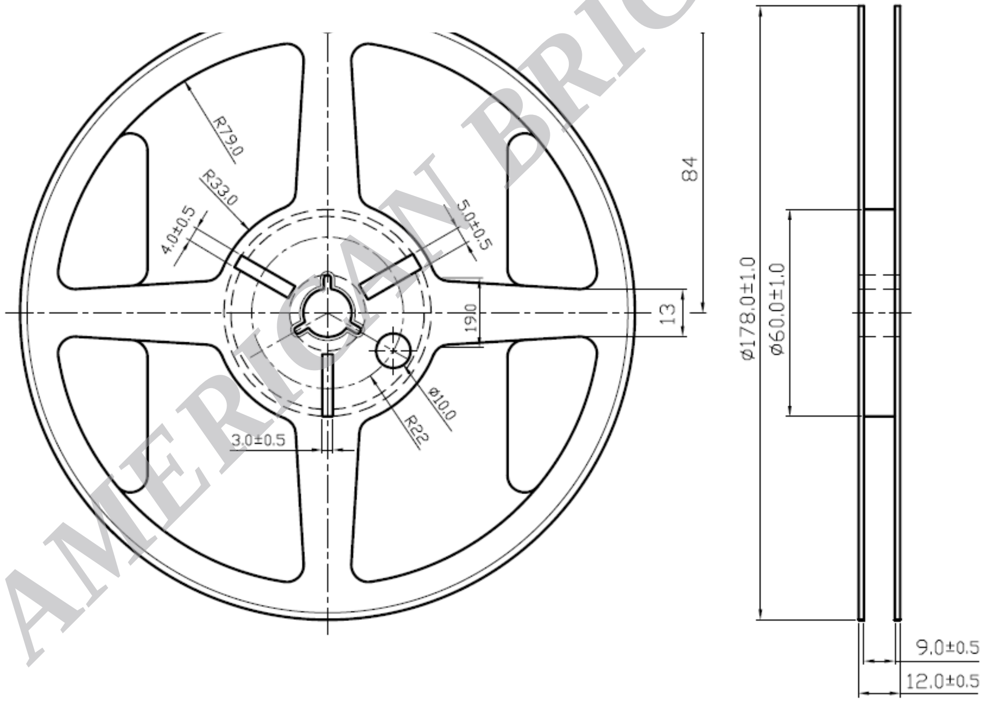
Loaded Pockets

There shall be a minimum of 400mm (15.7 inch) of empty component pockets sealed with cover tape.

Notes:
1. Drawing not to scale.
2. All dimensions are in millimeters.
3. Unless otherwise indicated, tolerances are ± 0.1mm.

# Emitter Reel Packaging





Notes:
1. Empty component pockets sealed with top cover tape.
2. 5,000 pieces per reel.
3. Drawing not to scale.
4. All dimensions are in millimeters.

# Precaution for Use

- Storage
  Please do not open the moisture barrier bag (MBB) more than one week. This may cause the leads of LED discoloration. We recommend storing in a dry box after opening the MBB. The recommended storage conditions are temperature 5 to 30 ° C and humidity less than 40% RH. It is also recommended to return the LEDs to the MBB and to reseal the MBB.
- We recommend using the M705-RGS800HF Type5 solder paste from SMIC (Senju Metal Industry Co., Ltd.) for lead-free soldering.
- Do not use solder pastes with post reflow flux residue>47%. (58Bi-42Sn eutectic alloy, etc) This kind of solder pastes may cause a reliability problem to LED.
- Any mechanical force or any excess vibration shall not be accepted to apply during cooling process to normal temperature after soldering.
- Please avoid rapid cooling after soldering.
- Components should not be mounted on warped direction of PCB.
- Repairing should not be done after the LEDs have been soldered. When repairing is unavoidable, a heat plate should be used. It should be confirmed beforehand whether the characteristics of the LEDs will or will not be damaged by repairing.
- This device should not be used in any type of fluid such as water, oil, organic solvent and etc. When cleaning is required, isopropyl alcohol should be used.
- When the LEDs are illuminating, operating current should be decide after considering the package maximum temperature.

# Handling of Lens LEDs

Notes for handling of lens LEDs

- Please do not use a force of over 0.3kgf impact or pressure on the lens, otherwise it will cause a catastrophic failure.
- The LEDs should only be picked up by making contact with the sides of the LED body.
- Avoid touching the lens especially by sharp tools such as Tweezers.
- Avoid leaving fingerprints on the lens.
- Please store the LEDs away from dusty areas or seal the product against dust.
- When populating boards in SMT production, there are basically no restrictions regarding the form of the pick and place nozzle, except that mechanical pressure on the lens must be prevented.
- Please do not mold over the lens with another resin. (epoxy, urethane, etc)