Light Emitting Diode

Nichia NCSxE17A Discrete Color LEDs

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The Nichia part numbers NCSxE17A, NxSx119B-V1, and NxSx219B-V1 within this document are merely Nichia's part numbers for those Nichia products and are not related nor bear resemblance to any other company's product that might bear a trademark.

1. Overview

In recent years, color LEDs have started to be used in various types of lighting fixtures in the lighting industry. Before color LEDs, floodlights and stage lighting luminaires used white halogen lamps and color filters (i.e. filters that are colored red, green, or blue, etc.) to create colors (see Figure 1). With this method, a color filter was needed for each color to create the required colors. Additionally, two or more luminaires were required to create intermediate colors. With color LEDs, a single luminaire can create any color[1] without external parts and seamlessly change between colors. Color LEDs have greatly expanded the range of color effects far beyond that of conventional lighting fixtures. Color LEDs have various other advantages compared to halogen lamps; for example, reducing the size and weight of a luminaire, energy saving, improving the maintainability of the luminaire due to the long life of the LEDs.

Nichia offers discrete color LEDs[2] for general lighting to meet the needs of its customers. One example of this is the NCSxE17A[3] LEDs (hereinafter referred to as "Nichia E17A Series LEDs"); since this series is very small (i.e. 1.7mm × 1.7mm), the size of a luminaire can be further reduced and a uniform color can be achieved on the illuminated surface. This application note provides the features and the handling precautions for Nichia E17A Series LEDs.

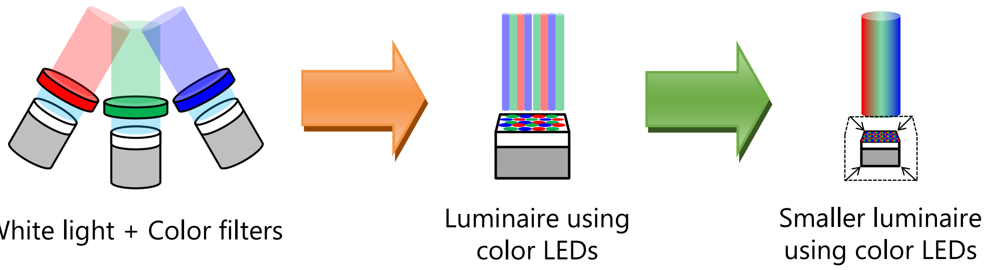


Figure 1. Reference Image of Full-color Luminaires

2. Full-color Luminaires

2.1. Full-color Luminaires Using LEDs

This section provides examples of full-color luminaires that use color LEDs.

2.1.1. Floodlights

Floodlights are used to decoratively illuminate constructions (i.e. a building, bridge, etc.) and landscapes (see Figure 2). Floodlights should have high luminous flux and high luminous intensity to illuminate objects in the distance clearly. With a programmed control, floodlights can be operated to emit a single-colored light, create tunable/gradient colors, and/or flash the light, etc. to provide eye-catching illumination.

Figure 2. Example of a Floodlight Illuminating a Building with a Colored Light

[1] Any color can be created by adjusting the intensities of three or more colors (i.e. usually primary colors). Generally, the additive primary colors are used for general lighting and PC monitors and those are RGB (i.e. red, green, and blue). Regarding how to create required colors, refer to the application note: Design Considerations for Full-Color Luminaires Using Discrete Color LEDs.

[2] The LEDs that emit a single color (i.e. red, blue, etc.); LEDs that emit white light are not included.

[3] The character "x" in the part number "NCSxE17A" described herein refers to the color of the emitted light; each color will have a unique character.

2.1.2. Stage Lighting Luminaires

Stage lighting luminaires are available in a variety of types (e.g. hanging from the ceiling, floor recessed, etc.) to illuminate the stage from many different directions. The greatest advantage that can be achieved by using LEDs for stage lighting is the installation flexibility of the luminaires; luminaires that use LEDs are easier to install and they can be installed in a wider variety of locations than traditional luminaires since the luminaire size and weight can be reduced when using LEDs as the light source.
Additionally, full-color luminaires using LEDs can provide a more even color without casting multiple shadows on the stage since the required color is created inside the luminaire. For comparison, when using the traditional method of creating an intermediate color (i.e. overlapping the colors emitted from multiple luminaires with color filters on the illuminated surface to create a new color), the individual colors may be seen where the colors do not fully overlap (i.e. the outlines of each light).

2.1.3. Other Luminaires that use LEDs

As discussed above, LEDs increase the design flexibility for luminaires. Full-color tuning is now possible for a wider variety of locations and for various purposes/situations with luminaires that use LEDs. Nichia expects that full-color luminaires using LEDs will become more widely used in residential homes in the future.

2.2. How to Change Colors with Full-color Luminaires

In a full-color luminaire, a required color is created by changing the brightness of each primary color (i.e. RGB); a luminaire needs to be able to control three or more channels simultaneously for full-color tuning[4]. This section discusses some of the communication methods generally used to control the brightness and colors of a luminaire.

2.2.1. Infrared Communication

The infrared communication is mainly used for general lighting for residential homes. A luminaire using this communication method has an infrared receiving sensor on it. The brightness and colors are controlled with an infrared remote controller supplied with the luminaire. With this communication method, each luminaire needs a corresponding remote controller; therefore, this method is not suitable for situations where controlling multiple luminaires at once or a more complicated program control (e.g. automatic timing control) are needed.

[4] Generally, three primary colors (i.e. RGB) are used for full-color tuning; these three colors need to be controlled separately.

2.2.2. Digital Addressable Lighting Interface (DALI)

DALI is an international standard for digital lighting control that was developed mainly by European luminaire manufacturers. Since DALI is a standard, DALI compliant products are interoperable between manufacturers; this applies not only to luminaires, but also when connecting devices like sensors and switches to a DALI control system.
As shown in Figure 3, one device (i.e. DALI controller) can control up to sixty-four devices (i.e. luminaires). Each luminaire has its own unique address and it allows for the luminaires to be controlled individually or arranged into groups (sixteen groups maximum) to be controlled together. In addition, a DALI system is a two-way communication system; it can monitor the state of the luminaires (e.g. on or off), the power consumed, etc. and control the luminaires automatically based on the feedback provided. This feature makes DALI suitable to control multiple luminaires in a large-scale lighting system (e.g. office building) together with a single communication system.

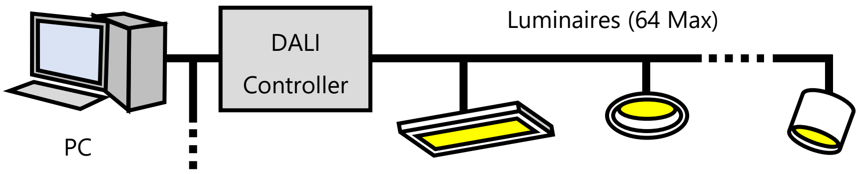


Figure 3. Illustrated Image of a DALI Control System

2.2.3. DMX512 and DMX512-A

DMX512 was originally established by the United States Institute for Theatre Technology (USITT) for controlling stage lighting dimmers and effects. It was revised to be DMX512-A and approved by the American National Standards Institute (ANSI). Since the digital signal transmission method in DMX512 and DMX512-A is simpler than the other standards and the cables used to connect the devices are robust, it can offer stable communication even in severe environments. The DMX controller and its controlled devices are connected in a daisy chain; see Figure 4. Up to 512 channels can be used with a single DMX controller and 8 bits (i.e. 256 levels of control are available) per channel. In addition to dimming the light, it is also possible to control the devices mechanically (e.g. panning, tilting, etc.). In most applications, once a starting address is configured for each device, corresponding addresses (i.e. channels) are automatically assigned per control.
DMX512 and DMX512-A systems are usually not used for general lighting for residential homes. They are widely used for full-color luminaires such as floodlights and stage lighting luminaires to provide eye-catching illumination.
It should be noted that the DMX512 system is not a two-way communication system; if a problem (e.g. a data reception failure, an electrical connection failure in a connected device) occurs, the system cannot detect it and therefore a DMX512 system it is not recommended for safety-critical applications such as a fireworks ignition system. Two-way communication is available with DMX512-A (i.e. Remote Device Management, RDM).

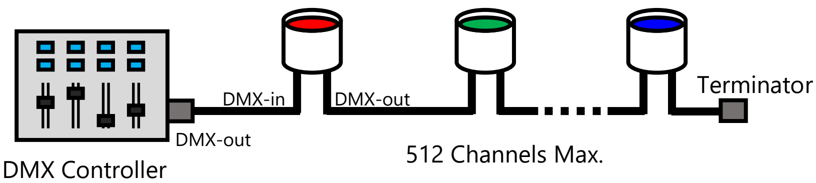


Figure 4. Illustrated Image of a DMX512/DMX512-A system

3. Color Options for the Nichia E17A Series LEDs

3.1. Part Numbers and Characteristics of the Nichia E17A Series LEDs

Table 1 shows the characteristics of each LED in the Nichia E17A Series; the white LED is not included.
Figure 5 shows the wavelengths of the Nichia E17A Series LEDs.
Figure 6 shows the chromaticity of the Nichia E17A Series LEDs.

Table 1. Characteristics of the Nichia E17A Series LEDs (i.e. Typical Characteristics at T_C=25°C)

Part Number[5]	Appearance	Emitted Color	Dominant Wavelength	Outline Dimensions	Forward Voltage (I_F=350mA)	Luminous Flux (I_F=350mA)	Chromaticity Coordinates (I_F=350mA)		Absolute Max. Rating Current	Absolute Max. Rating Temp.
			(nm)	(mm)	V_F(V)	φv(lm)	x	y	I_{F_max} (mA)	T_{J_max} (°C)
NCSCE17A		Royal Blue	451	1.7×1.7×0.35	3.0	18	0.157	0.021	700	135
NCSBE17A		Blue	472	1.7×1.7×0.35	3.0	42	0.126	0.078	700	135
NCSEE17A		Azure	486	1.7×1.7×0.35	3.0	132	0.188	0.268	700	135
NCSGE17A		Green	539	1.7×1.7×0.35	3.0	208	0.252	0.651	550	135
		Lime	567	1.7×1.7×0.35	3.0	212	0.414	0.543	700	135
NCSAE17A		Amber	590	1.7×1.7×0.35	3.0	124	0.567	0.419	700	135
NCSRE17A		Brilliant Red	612	1.7×1.7×0.35	3.0	58	0.669	0.328	700	135
		Red	618	1.7×1.7×0.35	3.0	31	0.683	0.313	700	135

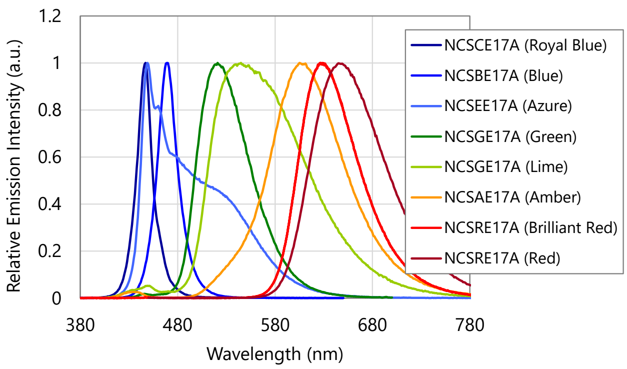


Figure 5. Wavelength

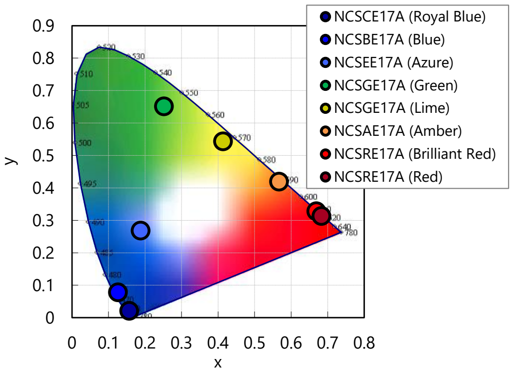


Figure 6. Chromaticity Coordinates

[5] The 4th character of the part numbers refers to the color of the light as follows: C: blue (royal blue), B: blue, E: bluish green, G: green, A: amber, R: red.

3.2. How the Nichia E17A Series LEDs Create Colors

There are two ways to create a colored light for an LED. One of them is to use an LED chip that emits the required color. The Nichia NxSx119B-V1 and NxSx219B-V1 Series LEDs[6] (hereinafter referred to as "the Nichia 19B-V1 Series LEDs") use this method. The other one is to use a colored phosphor with the LED chip; the phosphor is excited by the light emitted from the chip and emits the required color. The Nichia E17A Series LEDs use this method. See Figure 7 for examples of the structure of these two LED series.
In the method used for the Nichia 19B-V1 Series LEDs, an LED chip with the wavelength of the required color is used. Since the required color can be created with the chip itself, these LEDs do not need a phosphor. While the colored light created with this method has a narrower distribution range for the wavelength and a higher color purity than the light created with a phosphor, the characteristics of the LED may greatly vary depending on the color of the chip since the structure of the chip is different for each color. This difference in characteristics should be considered when designing the circuit for a color tunable luminaire; see section 4.2.
In the method used for the Nichia E17A Series LEDs, a phosphor that emits the required color is used; the phosphor is excited by the blue LED chip[7] to create the required colored light. The difference in the characteristics between the colors can be reduced with this method since all of the colors use a blue chip.

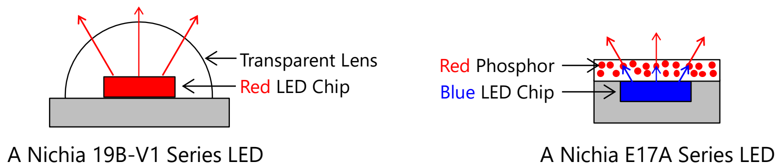


Figure 7. How the Nichia 19B-V1/E17A Series LEDs Create a Red Light

4. Features of the Nichia E17A Series LEDs

This section provides the key features of the Nichia E17A Series LEDs.

4.1. High Light Output and Small Emitting Area

The most remarkable feature of the Nichia E17A Series LEDs is its very compact package size. While the rated power consumption of both the Nichia E17A and 19B-V1 Series LEDs are the same, more than three times as many E17A Series LEDs can fit in the same area (see Figure 8). This allows the E17A Series LEDs to have a light output per area that is significantly greater than that of the 19B-V1 Series LEDs[8].

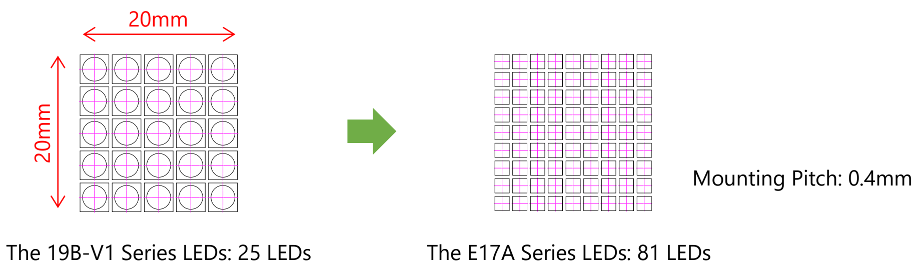


Figure 8. Number of 19B-V1 and E17A Series LEDs that can be Mounted in the Same Area

[6] The "x" in the part numbers NxSx119B-V1 and NxSx219B-V1 provided herein is an arbitrary character; it varies depending on the color of the emitted light.
[7] The blue (i.e. royal blue and blue) LEDs do not use a colored phosphor; the color of the light of these LEDs is the color of the light emitted by the LED chip. These LEDs have a transparent resin to protect the chip instead of a phosphor.
[8] The difference in the light output per area between the Nichia E17A and 19B-V1 series LEDs varies depending on the emitted color.

If the light output required for the chosen luminaire using the E17A Series LEDs is the same as the luminaire using the 19B-V1 Series LEDs, the area of the total emitting surface can be greatly reduced. A smaller total emitting surface has advantages when optical components (e.g. lens, reflector) are used with the LEDs in the luminaire. For example, when the light is collimated to produce a parallel light (e.g. a floodlight), the smaller the total emitting surface is, the narrower the beam angle will be (see Figure 9), and if the beam angle and the luminous intensity required for the luminaire are the same as when using the Nichia 19B-V1 Series LEDs, the size of the optical components can be reduced.
However, the heat dissipation needs to be taken into consideration when designing the chosen luminaire using the Nichia E17A Series LEDs since the power dissipation will be in a smaller area compared to the 19B-V1 Series LEDs. Ensure that the absolute maximum rated junction temperature is not exceeded for any of the LEDs in the luminaire; note that the junction temperature of the LEDs mounted in the middle of the PCB tends to be higher than the other LEDs.

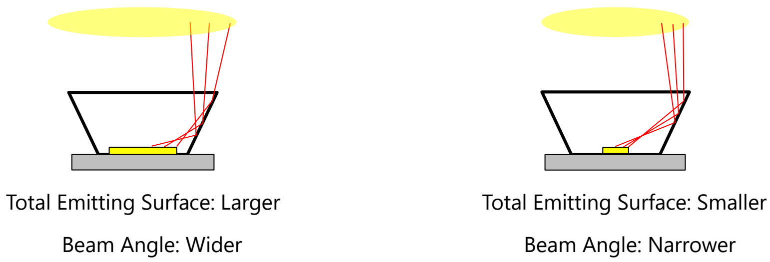


Figure 9. Difference in the Beam Angle Depending on the Size of the Total Emitting Surface

4.2. Same Forward Voltage across all Colors

The forward voltage of an LED varies depending on the emitted color of the chip. For example, for the Nichia 19B-V1 Series LEDs, the forward voltage is significantly different among the part numbers since this series of LEDs uses different colored chips. This needs to be considered when designing a circuit using LEDs of different colors.
Figure 10 shows an example of a circuit that has LEDs with different colored chips. The voltage applied to Constant Current Circuit R1 in Circuit 1 is calculated by subtracting the forward voltage of LED 1 from the input voltage Vin: 4V - 2.5V ＝ 1.5V. If the current of 100mA flows through LED 1, the same amount of current flows to Constant Current Circuit R1; the electric power consumed in R1 is calculated as 1.5V × 100mA = 0.15W. These calculations also apply to Circuits 2 and 3: as done for R1, if the current of 100mA flows to Constant Current Circuits R2 and R3, the electric power consumed in R2 is 0.05W and that in R3 is 0.1W. The power that is consumed in R1, R2, and R3 is the energy that becomes heat, etc. instead of being converted into light; the power loss of the luminaire is calculated as the sum of the consumed power in R1, R2, and R3: 0.15W + 0.05W + 0.1W = 0.3W.
Next, assume a case where the difference in the forward voltage between the LEDs in the circuit is greater. If the forward voltage for Circuit 1 is changed from 2.5V to 2.0V, the electric power consumed in R1 will increase from 0.15W to 0.2W. As a result, the power loss of the luminaire will increase from 0.3W to 0.35W. This means that the greater the difference in the forward voltage between the LEDs is, the power loss in a circuit with a lower operating voltage will be greater, causing the luminaire efficacy to decrease and the heat generated in Constant Current Circuits to increase.
For the Nichia E17A Series LEDs, the forward voltage of each color is almost the same since all of the LEDs in this series use a blue chip. This reduces the difference in the voltage among the circuits, a decrease in the luminaire efficacy, and the heat generation in the circuits.

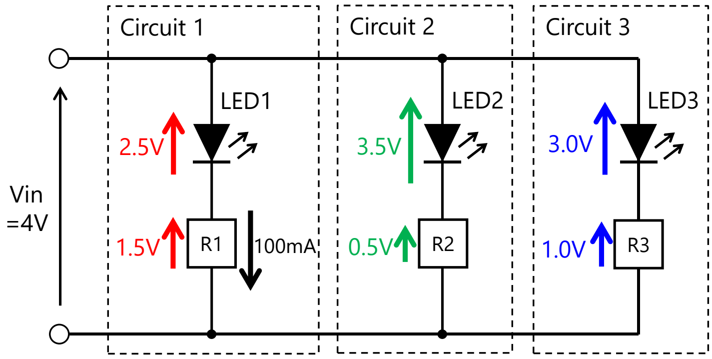


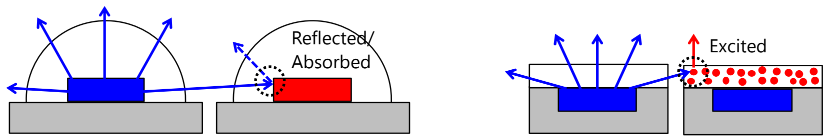
Figure 10. Example Circuit for a Color Tunable Luminaire

4.3. Temperature Characteristics of Red LEDs

When the LED temperature (i.e. the junction temperature) is increased, the luminous flux is reduced in most cases: generally, this reduction in the luminous flux is greater for a red LED chip than LED chips of another color. When using an LED that has a red chip there is a concern that the designed value of the luminous flux may not be obtained due to this temperature characteristic, causing color tunable luminaires that use this type of LED to not create the required colors.
The Nichia E17A Series LEDs use a blue LED chip for all of the colors. Blue LED chips have more stable temperature characteristics than red chips; using the E17A Series LEDs offers the following advantages for luminaires: the reduction in the luminous flux due to an increase of the junction temperature is smaller, and the color shift is smaller.

4.4. Optical Effects Caused by Adjacent LEDs

When LEDs are mounted with a small pitch, the light emitted from an LED may interfere with an adjacent LED resulting in optical effects on both of the LEDs (i.e. a reduction in the luminous flux, color shift, etc.). This issue is likely to occur especially for the Nichia E17A Series LEDs due to their structure. Refer to Figure 11 for how an adjacent LED may affect the luminous flux/color for the Nichia 19B-V1 Series and E17A Series LEDs.
For the 19B-V1 Series LEDs, the light emitted from an LED will hit the substrate and/or the chip of an adjacent LED causing the light to be reflected or absorbed by the adjacent LED. It may result in a reduction in the luminous flux of the LED. However, a color shift may not be as likely to occur since this series of LEDs does not contain phosphor, which may be excited by an adjacent LED and emit light.
For the E17A Series LEDs, the light emitted from an LED will hit the phosphor layer of an adjacent LED causing the phosphor to be excited and emit a low light; it may result in a color shift of the luminaire using these LEDs. Since most types of phosphors are excited by light whose wavelength is shorter than that of the color of the light the phosphor emits, the color shift may be more likely to occur when a blue LED of this series is illuminated. This means the possibility for a color shift to occur will depend on the combination of LEDs and LED pitch that are used for the luminaire. Nichia performed evaluations on how much color shift would occur for different mounting conditions. This section provides the evaluation results.



The Nichia 19B-V1 Series LEDs The Nichia E17A Series LED

Figure 11. How an Adjacent LED Affects the Luminous Flux/Color

4.4.1. Evaluation Method

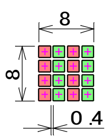
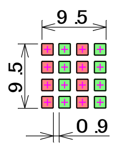
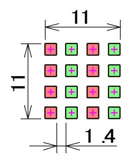
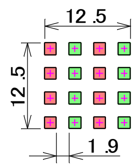
Evaluated LEDs:

R: NCSRE17A (Red)
G: NCSGE17A (Green)
B: NCSCE17A (Royal Blue)
A: NCSAE17A (Amber)
W: NCSWE17A (Cool White, Rank: sm50/R70)
L: NCSLE17A (Warm White, Rank: sm30/R9050)
All combinations using two colors from the above list were evaluated.

LED Pitch:

The evaluated LEDs were mounted with four different pitches between 0.4mm and 1.9mm. See Table 2.

Table 2. How the Evaluated LEDs were Mounted

	LED Pitch			
	0.4mm	0.9mm	1.4mm	1.9mm
: Color No.1 : Color No.2				

Operating Current:

The evaluated LEDs were operated at the sorting current of 350mA in pulse mode[9] to reduce the effect of the self-heating of the LEDs on the evaluations.

Evaluation Method:

For each evaluated PCB with the evaluated LEDs mounted per condition, only the LEDs of Color No. 1 were illuminated (i.e. the adjacent LEDs of Color No. 2 were not illuminated); the chromaticity was measured with an integrating sphere.

[9] For more information on the operation in pulse mode, refer to the applicable specification.

The obtained chromaticity coordinates were compared to the average chromaticity coordinates of the LEDs that were measured before the LEDs were mounted on the PCB to verify the amount of the color shift.

4.4.2. Evaluation Results

Figures 12-17 show the evaluation results.

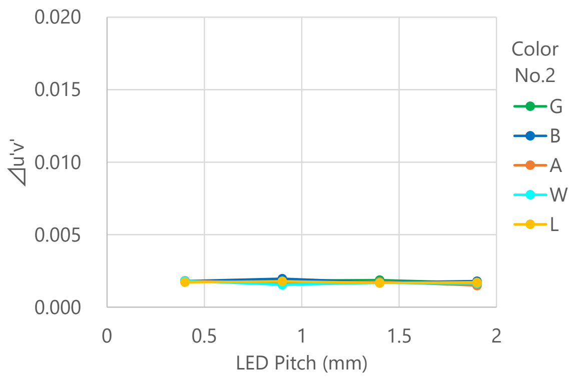


Figure 12. Color No. 1: Red

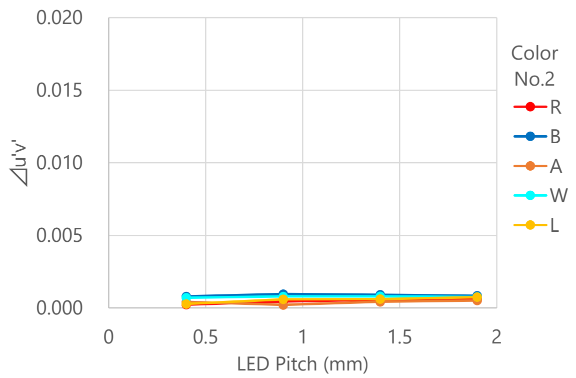


Figure 13. Color No. 1: Green

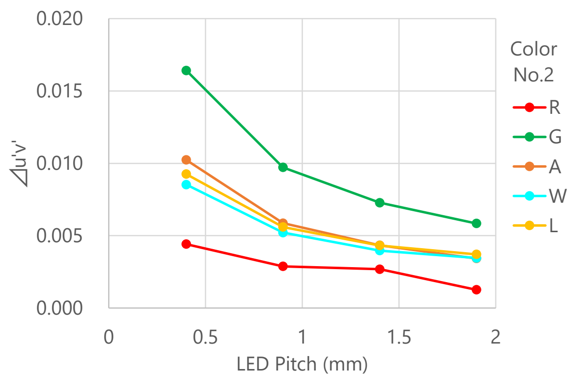


Figure 14. Color No. 1: Royal Blue

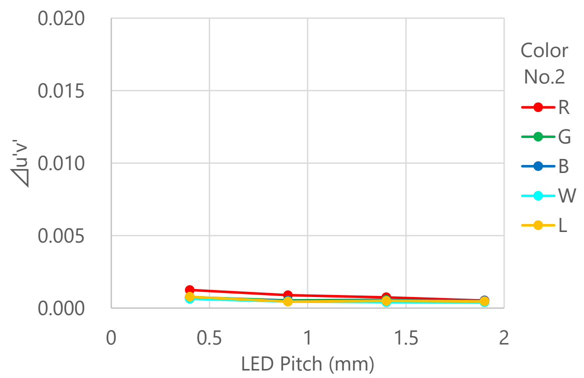


Figure 15. Color No. 1: Amber

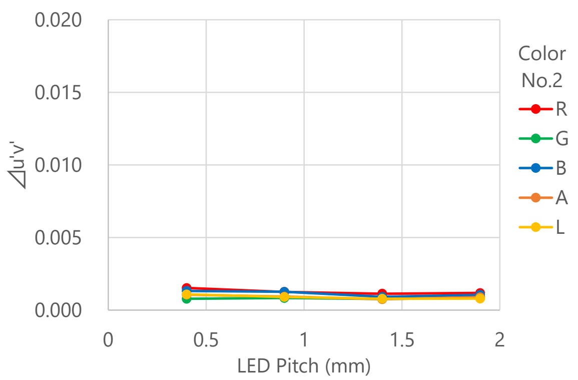


Figure 16. Color No. 1: Cool White

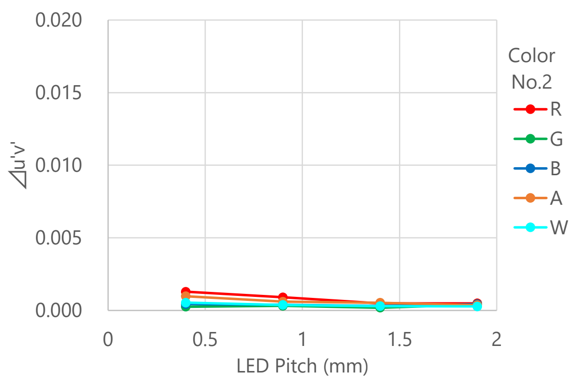


Figure 17. Color No. 1: Warm White

Evaluation Results and Conclusion:

- When the illuminated LEDs (i.e. Color No. 1) were not royal blue, the color shift that occurred was very small.
- When the illuminated LEDs were royal blue (see Figure 14), color shift occurred. The amount of the color shift depended on the color of the adjacent LEDs (i.e. Color No. 2). The smaller the LED pitch was, the greater the color shift was since the adjacent LEDs received more light from the illuminated LEDs when these LEDs were mounted with a smaller pitch.
- When the illuminated LEDs were royal blue (see Figure 14) and the adjacent LEDs were green, the greatest color shift occurred among all the color combinations. It is considered that the green light is more likely to cause a color shift since the green wavelength is close to the peak response wavelength of the human eye and the green light has a higher luminous flux. Contrary to the green light, the red light does not cause a great color shift since its luminous flux is lower.

These results indicate that the color shift is likely to occur when blue LEDs and LEDs of other colors are mounted next to each other. Nichia recommends selecting a color combination that does not cause a great color shift when mounted next to each other, mounting the LEDs in a greater pitch, etc.

4.5. Color Uniformity on the Illuminated Surface

An LED-based high-power luminaire (e.g. floodlight) uses an optical component (e.g. lens, reflector) for each of the LEDs. The reason for this is that if the light directivities of all the LEDs are controlled together using only one optical component, the optical component would be very large since there would be many LEDs mounted in the luminaire to obtain a high power, resulting in a large emitting surface; the size of the luminaire can be reduced by controlling the light directivity of each LED independently. However, this method has disadvantages for color-tunable luminaires including that the individual colors may be seen at the outlines of each light since the colors are mixed on the illuminated surface to create a required color, and the colors emitted from the LEDs that are mounted in the edges of the PCB may not be mixed in the created color on the illuminated surface and be seen as they are.
With the Nichia E17A Series LEDs, the sizes of the optical component and the luminaire can be reduced even when the light directivities of all the LEDs are controlled with one optical component since the package of the LEDs is very compact resulting in the area of the emitting surface of the luminaire to be greatly reduced. In addition, for the luminaires using this series of LEDs with one optical component, the color can be more uniform on the illuminated surface since the colors are mixed on the emitting surface. Nichia performed evaluations on the color uniformity on the illuminated surface with the E17A Series LEDs mounted on a PCB with a small pitch to create colored lights, using one reflector to collimate the lights. This section provides the evaluation results.

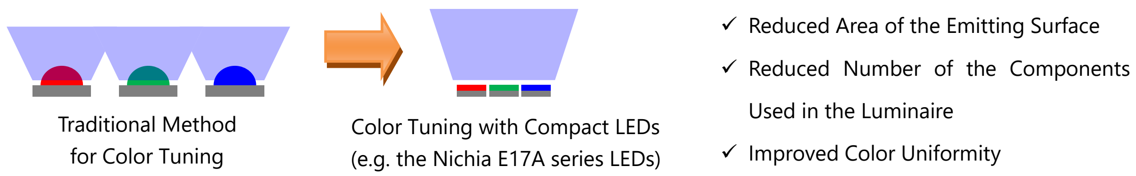


Figure 18. Reference Image of Color Tuning using the Nichia E17A Series LEDs

4.5.1. Evaluation Conditions

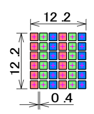
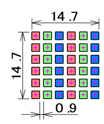
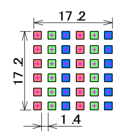
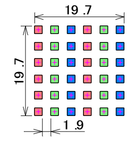
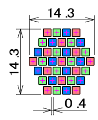
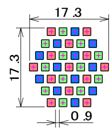
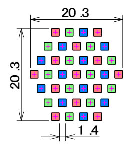
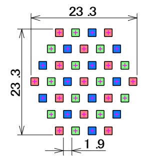
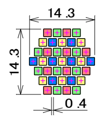
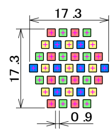
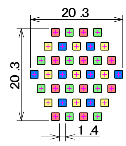
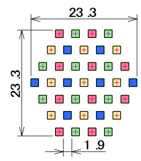
Evaluated LEDs:

R: NCSRE17A (Red), G: NCSGE17A (Green), B: NCSCE17A (Royal Blue), W: NCSWE17A (Cool White,5000K)

LED Pitch, Configuration, and Color Combination:

The LEDs were mounted with three different configurations and color combinations, and with four different pitches between 0.4mm and 1.9mm. See Table 3.

Table 3. How the Evaluated LEDs were Mounted

Configuration	LED Pitch			
	0.4mm	0.9mm	1.4mm	1.9mm
Configuration 1: R: 12 LEDs G: 12 LEDs B: 12 LEDs				
Configuration 2: R: 13 LEDs G: 12 LEDs B: 12 LEDs				
Configuration 3: R: 10 LEDs G: 10 LEDs B: 8 LEDs W: 9 LEDs				

Configuration 1: Each of the red (R), green (G), and royal blue (B) LEDs were mounted in a line. This simple way of mounting the LEDs would make designing the wiring pattern for the PCB easier.

Configuration 2: The red, green, and royal blue LEDs were mounted in a manner where the same color LEDs were not next to each other.

Configuration 3: The red, green, royal blue, and cool white (W) LEDs were mounted in a manner where the same color LEDs were not next to each other. Using white LEDs with the red, green, and royal blue LEDs enhances the expression of pale colors (i.e. pastel colors).

Evaluated Reflector:

A reflector whose half-power beamwidth was approximately 10° was used to achieve a narrow directivity. Figure 19 shows the approximate outline dimensions of the evaluated reflector.

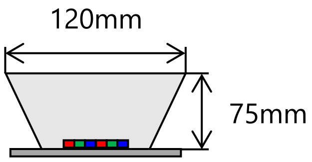


Figure 19. Evaluated Reflector

Created Colors:

Table 4 shows the created colors that were evaluated. The brightness and chromaticity of each created color were controlled to be the same for all the evaluated PCBs by adjusting the current that flowed through each LED.

Table 4. Created Colors

Configuration	Created Colors	Note
Configuration 1 & 2 (R, G, and B)	5000K	The red, green, and royal blue LEDs were illuminated to achieve a color temperature of 5000K.
	3000K	The red, green, and royal blue LEDs were illuminated to achieve a color temperature of 3000K.
	Red (R)	Only the red LEDs were illuminated.
	Green (G)	Only the green LEDs were illuminated.
	Royal Blue (B)	Only the royal blue LEDs were illuminated.
	Yellow (Y)	The red and green LEDs were illuminated.
	Magenta (M)	The red and royal blue LEDs were illuminated.
	Cyan (C)	The green and royal blue LEDs were illuminated.
Configuration 3 (R, G, B, and W)	Cool White (W)	Only the cool white (5000K) LEDs were illuminated.
	Red (R) + Cool White (W)	The red and cool white LEDs were illuminated.
	Green (G) + Cool White (W)	The green and cool white LEDs were illuminated.
	Royal Blue (B) + Cool White (W)	The royal blue and cool white LEDs were illuminated.
	Yellow (Y) + Cool White (W)	The red, green, and cool white LEDs were illuminated.
	Magenta (M) + Cool White (W)	The red, royal blue, and cool white LEDs were illuminated.
	Cyan (C) + Cool White (W)	The green, royal blue, and cool white LEDs were illuminated.

Evaluation Method:

For each evaluated PCB, the light was emitted on a white wall that is three meters away from the PCB (i.e. the illuminated surface). The color uniformity of each of the created colors (see Table 4) was evaluated on the illuminated surface.

4.5.2. Evaluation Results

Tables 5-7 show pictures of the illuminated surfaces for Configurations 1-3.

Table 5. Illuminated Surfaces for Configuration 1

	5000K	3000K	R	G	B	Y	M	C
0.4mm								
0.9mm								
1.4mm								
1.9mm								

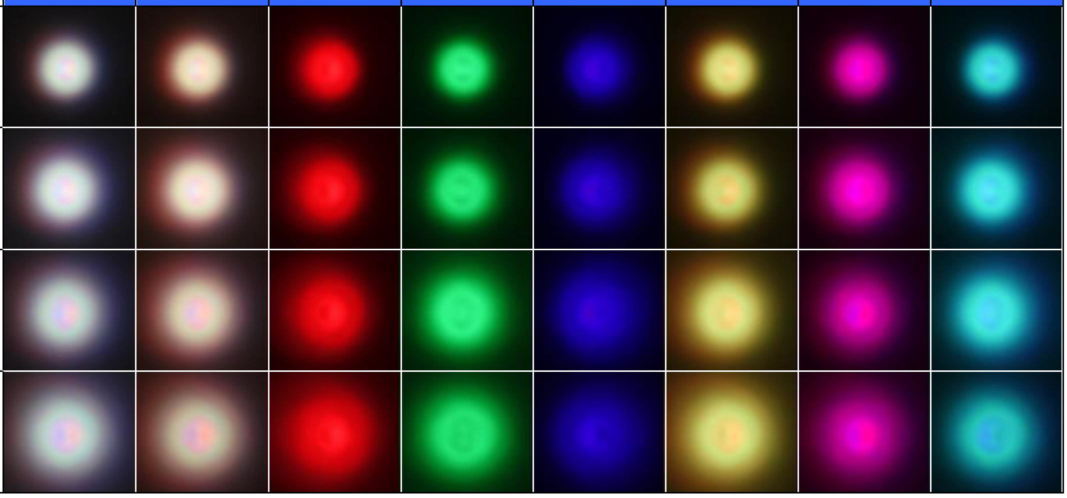


Table 6. Illuminated Surfaces for Configuration 2

	5000K	3000K	R	G	B	Y	M	C
0.4mm								
0.9mm								
1.4mm								
1.9mm								

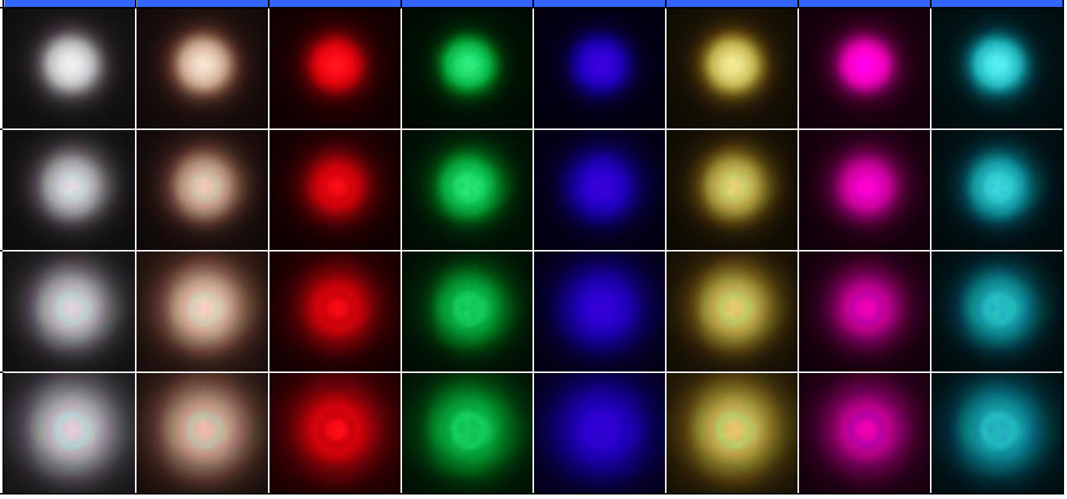
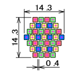
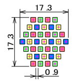
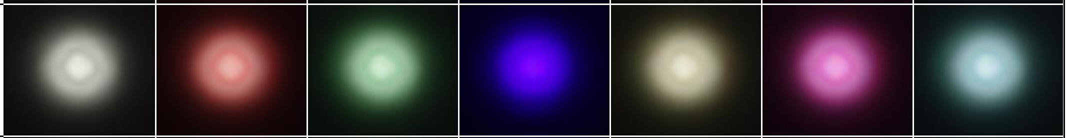
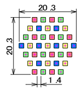
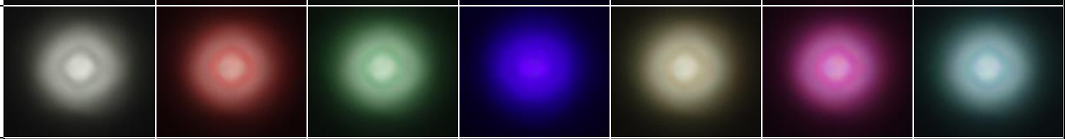
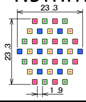
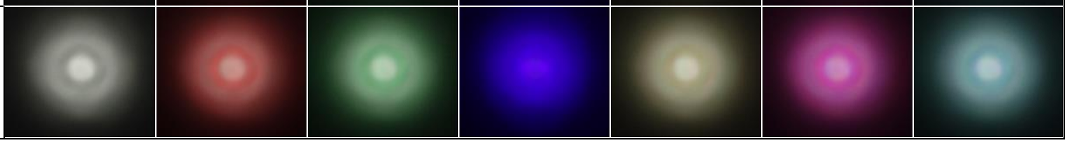


Table 7. Illuminated Surfaces for Configuration 3

	W	R+W	G+W	B+W	Y+W	M+W	C+W
0.4mm 							
0.9mm 							
1.4mm 							
1.9mm 							

Evaluation Results:

- For Configuration 1 (see Table 5), the colors did not mix well to create a uniform color when different color LEDs were illuminated. The luminance was also not uniform when only one color group of LEDs was illuminated.
- For Configuration 2 (see Table 6), the color uniformity was much better than Configuration 1. However, the larger the LED pitch was, the worse the color uniformity was.
- For Configuration 3 (see Table 7), the luminance was less uniform compared to Configurations 1 and 2. The reason is that more LEDs were left unilluminated for Configuration 3 than for Configurations 1 and 2.

The uniformity of the color and luminance can be improved by arranging the LEDs in a manner that ensures the colors are mixed evenly on the emitting surface (i.e. Configuration 2).
If the LEDs are not mounted in an equal blend of colors (i.e. Configuration 1), the color uniformity will be lower since the colors emitted from the LEDs are not mixed well either on the emitting surface or the illuminated surface.
The uniformity of the color and luminance can be improved even more by using a diffuser in addition to the optimum arrangement of the LEDs described above; with a diffuser, the colors are mixed near the emitting surface to achieve better color and luminance uniformity (see Figure 20). Note that the luminous flux and luminous intensity may be reduced when using a diffuser.

Without a Diffuser | With a Diffuser | Without a Diffuser | With a Diffuser

Figure 20. Reference Images of the Emission with/without a Diffuser and Picture of the Emitting Surfaces

5. Assembly Precautions

One of the features of the Nichia E17A Series LEDs is its compact package size; this feature can be utilized most when the LEDs are mounted with a small pitch to reduce the emitting area as much as possible. However, Nichia recommends an LED pitch of ≥0.4mm with consideration of various factors including the dimensional tolerances and deviations of the LEDs and other components, tilting/floating of the LED after reflow soldering, etc. in addition to the placement accuracy of a typical pick-and-place machine (i.e. chip mounter). If the LEDs are being used in a high-density application, perform a sufficient verification to ensure that there are no issues with the chosen conditions/environments before use.
For more information about assembly precautions, refer to the applicable specification and the application note: Assembly Precautions for the Nichia NCSxE17A or NVSxE21A Series LEDs.

6. General Cautions/Suggestions for Using the LEDs

When designing luminaires using the Nichia E17A Series LEDs, the following must be considered:

- The absolute maximum rated forward current must not be exceeded for any of the LEDs in the luminaire under any circumstances. Note that the absolute maximum rated forward current may be different depending on the color of the emitted light.
- The absolute maximum rated junction temperature must not be exceeded for any of the LEDs in the luminaire under any circumstances. Note that when the LEDs are mounted with a small pitch, the junction temperature of the LEDs mounted in the middle of the PCB tends to be higher than the other LEDs since heat will be concentrated in a small area.
- Each LED has its own current and temperature characteristics; the measured values of luminous flux/chromaticity may be different from the designed values when the LEDs are operated in luminaires.
- Depending on the design of the luminaire, the color of the light may not be uniform on the illuminated surface (i.e. the emitted colors from the LEDs are not mixed and there are different color patches on the illuminated surface). Perform sufficient verification to ensure that there are no issues with the chosen luminaire before use.

7. Summary

Nichia makes no guarantee that customers will see the same results for their chosen application described in this application note; sufficient verification must be done prior to use to ensure there are no issues for the chosen application.

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Oct. 19, 2021

Disclaimer

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