

Cornering Lights of 2020 CRF1100L Africa Twin Adventure Sports Using Additional Light Source

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ABSTRACT

After the revision of United Nations regulations in 2013, cornering lights are permitted for motorcycles. A number of cases of cornering light applications to motorcycles are seen up until now. We have developed the cornering lights for comfortable touring, especially suitable for riding suburban roads mainly at moderate speeds, and applied to the CRF1100L Africa Twin Adventure Sports. Using the said motorcycle, we conducted studies on the three key factors in the designing of cornering lights; the setting the operating range according to the bank angle, the setting the light distribution with an additional light source, and the control of visual distraction. The operating of cornering lights is determined from the frequency of bank angles measured from actual night riding. The distribution of light from the additional light source is determined so as to illuminate the cornering direction at the same intensity as the dipped beam. Regarding the visual distraction, the cornering lights are designed so as to increase intensity gradually after turning it on until reaching 100%. A hysteresis is also set in the switching to help prevent flickering. With these measures taken, the cornering lights suitable for touring have been realized.

1. Introduction

The bend lighting generally seen in automobiles illuminates the going direction depending on the steering angle. There are two ways for that function: the one that moves the dipped beam (LO beam) to the direction of steering and the other that turns on the additional light source in which the light distribution is exclusively designed⁽¹⁾.

On the other hand, with respect to the cornering lights for motorcycle, the United Nations regulations (UN regulations)^{(2), (3)} approve only such a type that turns on the additional light source that illuminates going direction depending on the bank angle, rather than the steering angle at the time of cornering (enacted in 2013). At this occasion, we applied the cornering lights using the additional light source first time in Honda motorcycles to the CRF1100L Africa Twin Adventure Sports (CRF1100L AS)⁽⁴⁾ having such a basic concept as “a true adventure model that invites you to adventure trips across the lands of challenge.” The aim of comfort technology in the CRF1100L AS are targeted at “go anywhere, high touring ability” presuming

long-distance touring. In that concept, we presume night riding on suburban roads as the typical situation where the cornering lights are especially effective to enhance visibility. The new system is developed with an aim at retention of illuminated road surface area inside of the going direction even when the bank angle increases in night riding on suburban roads. **Figure 1** shows CRF1100L AS with the right cornering light turned on.

In the CRF1100L AS, the cornering lights are located under the right and left headlamps. Each lamp is composed of three LED light sources. As the bank angle increases, the LED turns on one after another starting from the outer-most one (Fig. 2).

The following three are the key factors in the designing of cornering lights for motorcycles.

- (1) Setting the operating range according to the bank angle
- (2) Setting the light distribution with an additional light source
- (3) Control of visual distraction

The details of the three factors in the development of cornering lights for the CRF1100L AS are described from the next chapter.

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Fig. 1 CRF1100L AS with right cornering light turned on

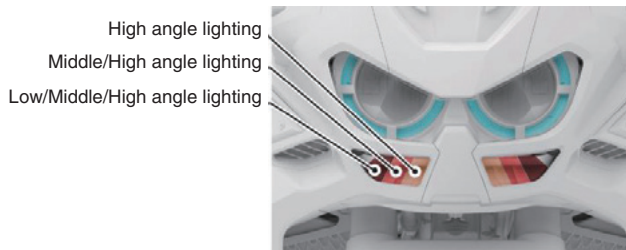


Fig. 2 Lighting pattern of cornering light of CRF1100L AS

2. Setting the Operating Range According to the Bank Angle

2.1. Bank Angle Frequency

As the cornering lights are illuminated depending on the bank angle in motorcycles, it is necessary to detect bank angle and setting the operating range according to the bank angle of the cornering light accordingly.

The UN regulations do not allow illumination by cornering lights when the bank angle is less than 5° because the added light may give glare to oncoming drivers. Taking into account the fluctuations of bank angle sensor reading from unevenness of road surface or other reasons and the changes of headlight distribution when accelerating or decelerating, we chose to turn on the cornering light when the bank angle is more than 10° .

To determine operating range according to the bank angle of the cornering lights, we measured frequency of bank angles from actual night running tests using the CRF1100L AS.

The measurements were taken on the EU suburban course⁽⁵⁾ in the Honda test course where road illuminations

were scarce at night. Figure 3 shows the bank angle frequencies measured with the Inertial Measurement Unit (IMU) when tested by a number of test riders with a height of 170 cm up to 180 cm.

The horizontal axis represents the angle, the vertical axis bar graph represents the relative frequency, and the line graph represents cumulative relative frequency.

When the CRF1100L AS was tested on the suburban road at night, the bank angle frequencies were virtually the same when the bank angle was between 10° and 24° , and 99.9% within 34° .

2.2. Bank Angle to Turn On Each LED Lamp

The test data in the preceding section indicates that the bank angle of CRF1100L AS ranges widely from 10° up to 34° when tested on the suburban road. Accordingly in the CRF1100L AS, three additional light sources are incorporated on one side, and the threshold bank angle is set at 10° , 18° , and 26° , which means three even splits with an increment of 8° . The equally-split angles to turn on the cornering light is aimed at an equalization of operating timing in the process the bank angle increases. Figure 4 shows threshold bank angle and the lighting pattern of the cornering lights.

The system is designed in such a manner that a

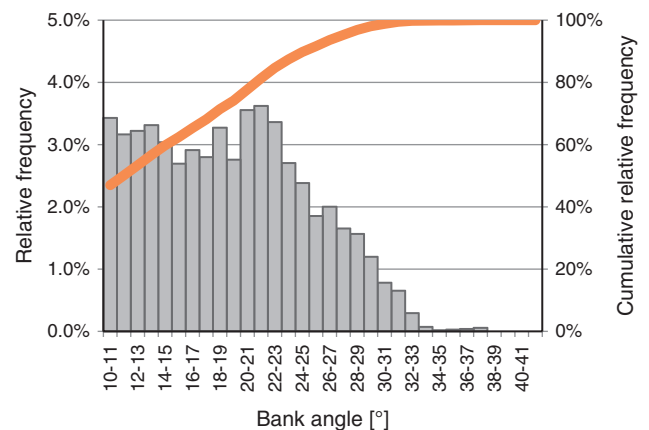


Fig. 3 Bank angle frequencies when tested on EU suburban course at night using CRF1100L AS

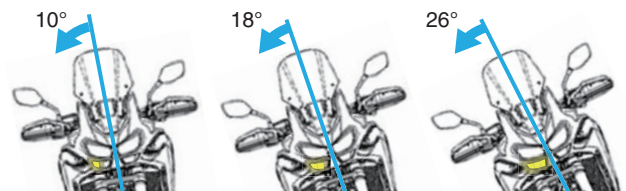


Fig. 4 Threshold bank angle and lighting pattern of cornering lights in CRF1100L AS when leaning right

cornering light turns on at a bank angle, and the other one turns on additionally as the bank angle increases. The lamp remains on until the bank angle becomes lower than the prescribed operating bank angle. Therefore, when the cornering light for above 18° turns on, two lamps are illuminating. When the one for above 26° turns on, all three lamps are illuminating.

3. Setting the Light Distribution with an Additional Light Source

3.1. Parameters to Determine Light Distribution

To help prevent disturbing of driver’s vision of oncoming vehicle, the upper part of headlight beam is usually cut off. As the motorcycle leans when cornering, the illuminated area inside of the going direction decreases. It is therefore necessary to adjust the light distribution of the cornering lights into such a direction that compensates the area lacking illumination. Figure 5 shows image pictures of the area lacking illumination inside of the going direction as the bank angle increases in a right corner.

In automobiles, as the steering angle of front wheels changes depending on the turning of steering wheel and determines turning radius accordingly, the direction of illumination of the bend lighting depends only on a single parameter. On the other hand in motorcycles, as the motorcycle turns while leaning at a bank angle at which the centrifugal force and the reaction force from the road are balanced, the turning radius depends on the balance of the bank angle and the vehicle speed.

It is therefore necessary in motorcycles to set the direction of cornering light illumination accordingly not only to the bank angle but also to the vehicle speed when turning. In the CRF1100L AS, as the running on suburban roads at moderate speeds was presumed, studies were conducted at a speed of 50 km/h when turning.

3.2. Light Distribution Direction Design

Two types of cornering lights are already applied to mass-production motorcycles; the high-speed type which illuminates far ahead presuming use on motorways having a large corner radius, and the low-speed type presuming use in city having a small corner radius such as in an

intersection (Fig. 6).

As the high-speed type is intended to enhance visibility on motorways having gentle curves, the system is set in such a manner that the more the bank angle, the farther the illuminated area extends. On the other hand, as the low-speed type is aimed at enhancement of visibility in city such as in an intersection, the setting is such that the more the bank angle, the illuminated area extends more toward inside of the direction of banking. Thus, the light distribution is adjusted to the specific purpose.

In view of the concept of CRF1100L AS, we set the light distribution so as to illuminate medium-distance area with an aim at enhancement of visibility at moderate speeds presuming curves in suburban roads. As the illumination is often non-existent in suburban roads, we consider that riders will often feel cornering lights useful. When the speed is 50 km/h, the turning radius is approximately 110 m at which the bank angle is 10° and the first cornering light turns on, where the angle included between the future position after traveling for 2.5 sec⁽⁶⁾ and the light source of the cornering lights is approximately 9°. When 50 km/h, the turning radius is approximately 40 m at which the bank angle is 26° and the third cornering light turns on, where the angle included between the future position after traveling for 2.5 sec and the light source of the cornering lights is

Type	High-speed riding	Low-speed riding
Illumination image		
Add direction image (3 additional light sources)		

Fig. 6 Examples of cornering lights for motorcycles

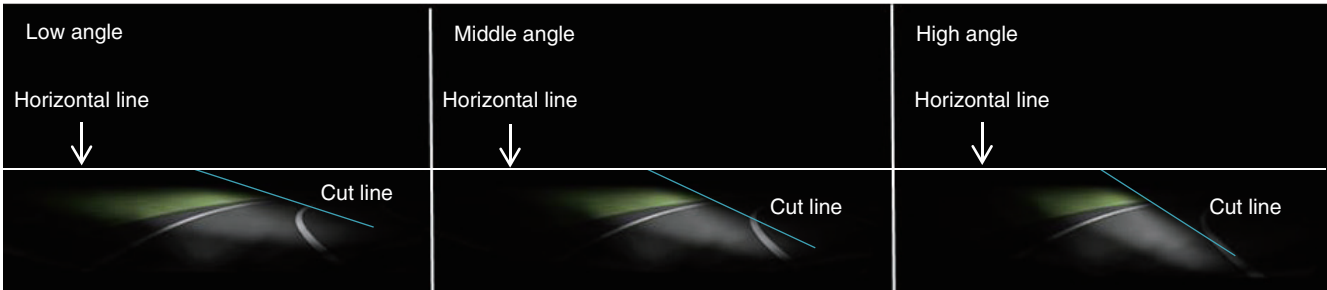


Fig. 5 Area lacking illumination inside of going direction as bank angle increases when only LO beam used

approximately 25°. Based on these findings, we set the light distribution in the middle of the above angles at 17° (Fig. 7).

3.3. Setting the Light Distribution Range

To determine light intensity that forms a basis of light distribution design, we have had a number of riders with a height between 165 cm and 180 cm ride the motorcycle on the earlier-mentioned EU suburban course using the LO beam to clarify luminance on the road surface at which the rider feels comfortable. As the majority of riders perceived adequate illumination when the luminance was above 8 lx (8 lx zone), we set a luminance standard of cornering lights at above 8 lx zone. Figure 8 shows the 8 lx zone when using the LO beam of CRF1100L AS. The picture indicates that the light distribution of the LO beam of CRF1100L AS is such that covers the road surface area having a depth of 5 m-30 m and a width of 6 m.

We have designed the light distribution in such a manner that covers a depth of 15 m-25 m and a width of 6 m in the direction of banking so that the 8 lx zone the cornering light illuminates does not look strange when overlapped with the

8 lx zone the LO beam illuminates. The orange frame in Fig. 8 shows the illuminated zone.

3.4. Dynamic Light Distribution Design

As Fig. 6 shows, there are several types of light distribution of cornering lights depending on the purpose; the one that extends light distribution ahead as the bank angle increases and the other that extends illumination to inside of the banking direction. In either type, presuming that the speed increases as the bank angle increases, the illuminated zone is shifted depending on the increase of speed and the presumed radius of the curve.

In the meantime, during daytime cornering, the rider keeps looking at the corner exit. Riders rarely change their line of sight during cornering. We have therefore designed the light distribution in such a manner that does not require the rider to change the line of sight even at night. In other words, we have designed the light distribution so as to maintain illumination area in the inside of going direction even when the bank angle increase. Figure 9 compares the light distribution on the 8 lx zone with and without the cornering lights at each bank angle when leaned when right cornering. The solid lines show the 8 lx zone when the cornering light and the LO beam are turned on. The broken lines show the 8 lx zone when only the LO beam is turned on.

As Fig. 9 shows, when the bank angle increases only with the LO beam turned on, the illuminated zone decreases, failing to maintain the 8 lx zone in the going

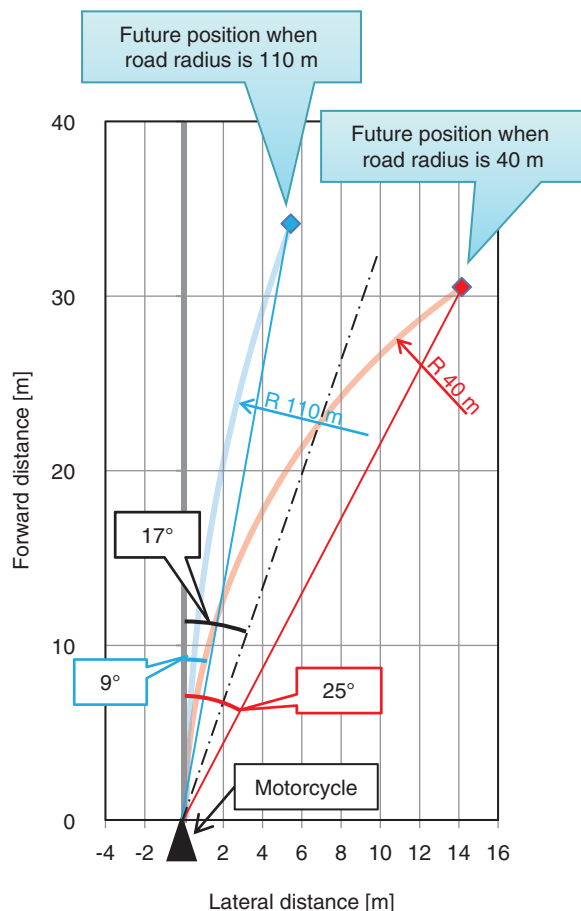


Fig. 7 Future positions after traveling for 2.5 sec on road having turning radius of 110 m and 40 m, and line in middle

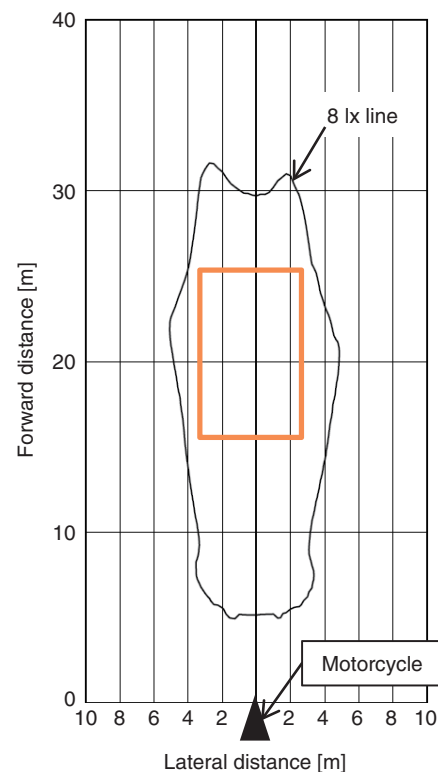


Fig. 8 LO beam light distribution

direction. On the other hand, when the cornering lights are equipped, the 8 lx zone in the going direction is maintained.

With the cornering lights installed in the CRF1100L AS, a number of test riders having a height from 165 cm up to

180 cm tested on the previously-mentioned EU suburban course, and confirmed that the light distribution was effective for cornering. Figure 10 compares CG pictures of illuminated road surface in the right corner when only the LO

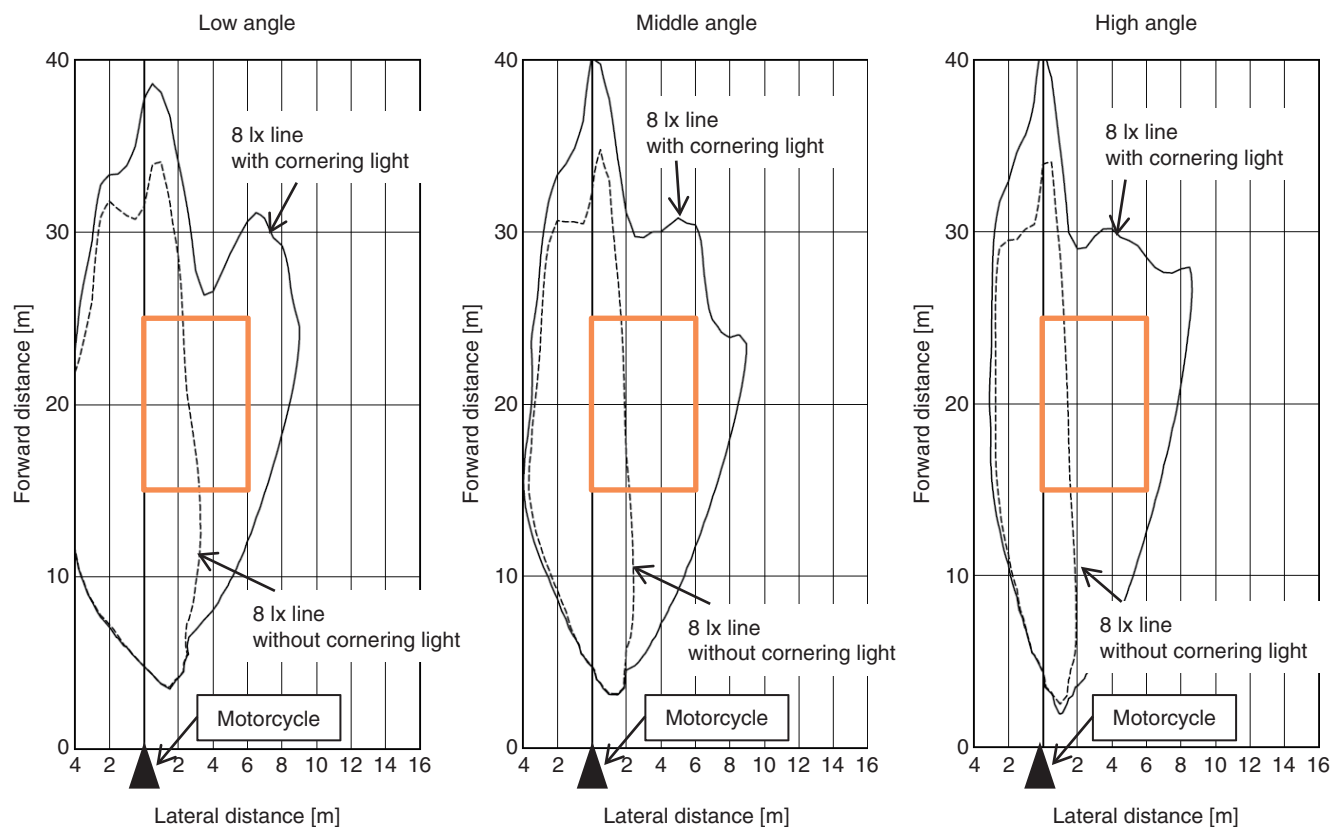


Fig. 9 Comparison of light distribution with and without cornering lights at each bank angle when right cornering

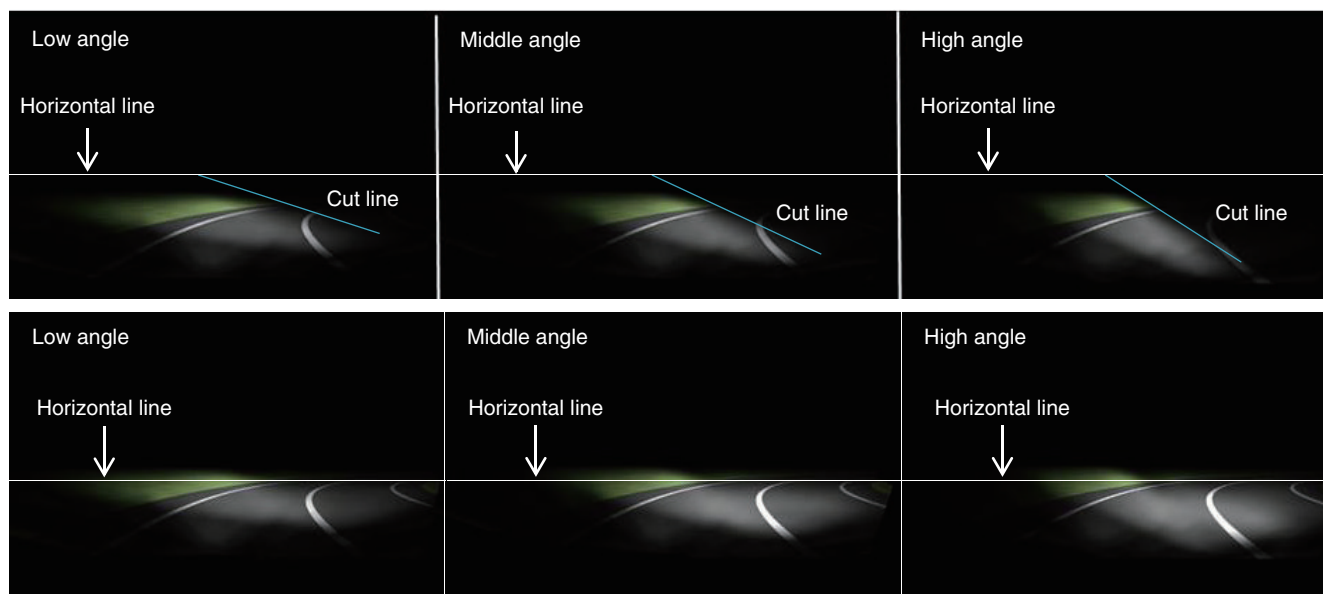


Fig. 10 Comparison of CG pictures of illuminated road surface in right corner when only LO beam is provided and when cornering light is provided

beam is provided and when the cornering light is provided.

It is obvious that the inside of going direction is adequately illuminated when the cornering lights are provided.

4. Control of Visual Distraction

The cornering lights turn on and off depending on the bank angle. Due to the nature that the lamp flickers when switched on and off, it is necessary to help prevent visual distraction, in other words, unnecessary attention, from the rider himself/herself or the drivers in the vicinity. We have therefore taken the following measures to deal with sudden changes of intensity when the additional light source is turned on and the flickering when turned on and off.

4.1. Gradual Increase of Intensity of Additional Light Source

When the additional light source is turned on to supplement and enhance the illumination on the road surface at the threshold bank angle, a sudden change of luminance occurs in the specific zone. It is therefore necessary to take measures so as not to draw rider's attention to the unnatural changes. In the CRF1100L AS, in addition to the retention of illuminated zone the rider looks at as mentioned in the preceding chapter, the system that gradually increases intensity is incorporated so that the rider does not feel a sudden change of luminance. Since the LED light source⁽⁷⁾ responds quicker than the filament bulb when turned on or off, it is necessary to intentionally control switching.

Regarding the duration the LED light gradually increases intensity, we have tested various cases from 0.1 sec up to 0.5 sec from turning on until reaching 100% intensity with an increment of 0.1 sec at a corner entry speed of 50 km/h on the earlier-mentioned EU suburban course. Upon the assessment by 10 in-house experts, 0.1 sec is too fast, 0.3 sec too slow. Accordingly, we concluded 0.2 sec best.

4.2. Flickering when Additional Light Source Turns On and Off

The cornering lights of CRF1100L AS are designed to turn on depending on the bank angle, starting from 10° up to 34°. The three thresholds are three-split with an increment of 8° as mentioned earlier. If no special considerations are taken, flickering of the cornering lights occurs when riding across the threshold bank angle back and forth. Especially near 10°, which is the smallest bank angle to turn on, even a light leaning such as for a lane change causes the additional light source to turn on and off. To deal with this issue, the bank angle to turn off the lamp is set at a smaller angle than the angle to turn it on. In other words, hysteresis setting helps prevent the flickering.

Regarding the threshold bank angle and the hysteresis, tests were conducted from 1° with an increment of 0.5°. When riding across the threshold bank angle back and forth,

flickering occurred in the additional-illuminated zone. When tested on the EU suburban course at 50 km/h, the flickering was still noticeable when the hysteresis was set at 1.5°. It virtually disappeared above 2°. Accordingly, the hysteresis is set at each of the three thresholds; the bank angle to turn on at 12°, 20°, and 28°, the one to turn off at 10°, 18°, and 26°. Figure 11 shows the hysteresis set at each threshold bank angle when cornering.

4.3. Validation by Actual Motorcycle

From the above findings, it has been confirmed that the gradual increase of intensity from turning on up to 100% in a period of 0.2 sec along with the 2° hysteresis set at the threshold bank angles keeps rider's attention from being drawn by the unnatural changes when the cornering light is turned on as well as helps eliminate flickering at the time of switching. Thus the settings help prevent the visual distraction to the rider himself/herself or other drivers from the flickering.

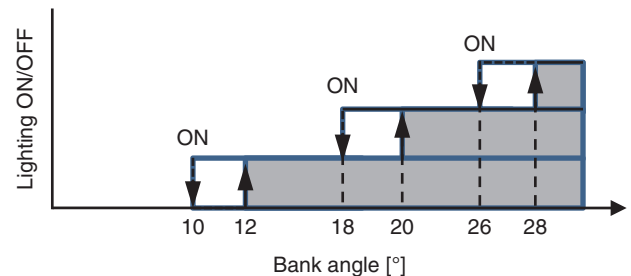


Fig. 11 Hysteresis set at each threshold bank angle

5. Conclusion

In accordance with the model concept of the CRF1100L AS, we have developed the cornering lights for motorcycles presuming use on suburban roads at night during a long touring. The following three measures were taken.

(1) Setting the operating range according to the bank angle

The necessary switching pattern of the cornering lights were set after measuring frequencies of bank angles occurring in the actual night riding tests using the motorcycle presumed to be equipped with the lights.

(2) Setting the light distribution with an additional light source

The light distribution when leaning is set so as to minimize strangeness when overlapped with the 8 lx zone of the LO beam.

(3) Control of visual distraction

To control visual distraction from sudden changes of luminance and/or flickering, the control system is designed so as to gradually increase intensity up to 100% after turning on the cornering lights along with the hysteresis set at the thresholds.

We hope the enhanced touring capabilities of CRF1100L AS will be well-accepted by customers, and the cornering lights will help customers enjoy unique riding that can be experienced only at night.

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