LED SIGNAL LIGHTING UNITS

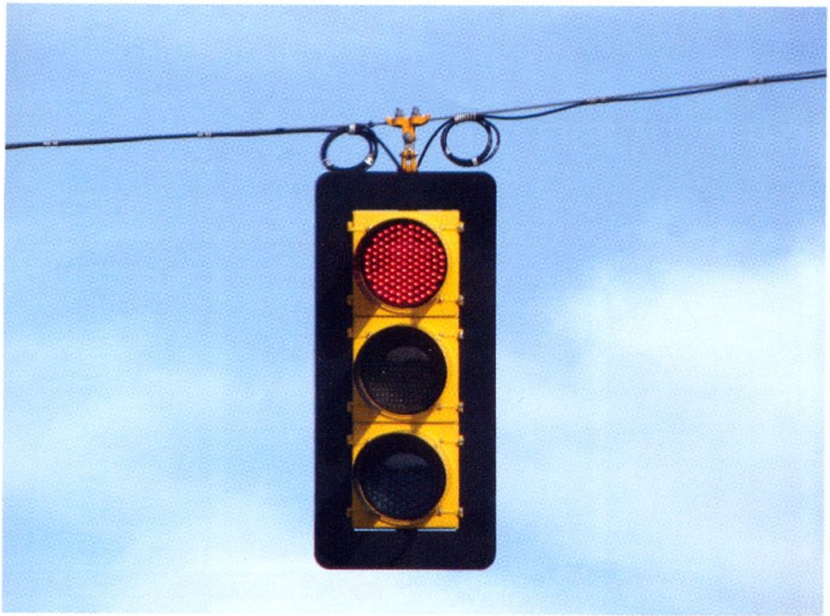
USED FOR RAILWAY AND ROAD SIGNALING

The design challenges faced in the development of robust LED signal lamps are being addressed in different ways by signal manufacturers.

By Efftronics Systems Pvt. Ltd.

LED's became commercially available since its invention in 1962. Since mid 1990's High Brightness LED's have emerged to meet the requirements of the Automotive and Display Industries. LED's have doubled in brightness every 18 to 24 months since their invention.

LED Technology is about three times more efficient in producing light from



LED road signal

electricity than incandescent tech nolgy. It offers sustained advantages in energy efficiency, directivity and light intensity and also lasts longer than incandescent bulbs. Hence LED's emerged as the solution as a new technology for Lamps used in Color light signaling for a majority of manu facturers.

The design challenges faced in the de velopment of robust LED signal Lamps are mainly- Optical design, Electrical design, Engineering, measurement procedures and Specification compli ances- which are being addressed in different ways by signal manufactur ers. We shall confine to the Optical Challenges in this article.

All the known designs of LED based signals involve the use of many LED's in an array or cluster to form a signal aspect. The first design challenge is how should the LED's be arranged? To address this challenge there are other inputs required such as size and shape of the Aspect. To determine the size of the Aspect we should know the visibility criteria. The visibility criterion is dependent upon the traveling speed at which the signal should be visible to the driver. The visibility is fundamen tally described in two parameters: the visibility distance and the viewing angle. The visibility distance should be greater than the breaking distance. The sizes are differing from applica tion to application hence the signals used for Road Signaling are of differ ent sizes as compared to the Signals used for Railway Signaling.

In Road Signaling there are two dif ferent sizes prevailing, mainly the 8 inch diameter and 12 inch diameter signals but the 12 inch diameter is the universally accepted size. In India the 12" diameter is the most widely used standard. In Railway signaling the sizes vary from Signal type to type and from country to country. In India the main line signal size is around 125mm diameter.

The viewing angle for Road signal is around 12.50 and for the signal used in Railway signaling it is around 80. The significance of the viewing angle is that it should be clearly visible only to the driver in that lane/track and not visible to drivers in other lanes. The narrow beam approach is typical for railway engineers; the light signals used on the railway line itself for the benefit of the train have a very narrow beam. Since all trains place their drivers at the same height, and since the drivers are all constrained to a track only about a meter wide, the aiming of the signal is a straight forward exercise. However, when this same technology is used on roads, the target drivers may be coming from a wide variety of directions, be seated at different heights, and be dealing with many more distractions than the driver of a train. Once the visibility distance and the viewing angle are determined, these form the inputs for selection of LED's for achieving the required parameters.

The viewing angle of the signal aspect is same as the viewing angle of the LED's used. But practically the standard viewing angles of the LED's commercially available are 60,150,300 etc.

Hence achieving the required viewing angle is not a straight forward solution. Fundamentally this can be achieved in several ways. One of such methods is by using secondary optic lenses which is a complex and design critical solution. Another method is to use a combination of available LED's arranged in a typical interlaced pattern to achieve the required viewing angle. The simplest way can be using light guides on wider viewing angle LED's to cut the light into required viewing angle.

The narrower the viewing angle of the LED, the higher will be the available intensity range of the LED. The wider the viewing angle of the LED, the lower will be the available intensity. Alternatively a Signal Lamp with a narrow viewing angle will have a longer visibility distance for the same number of LED's used as the energy concentration is more. Similarly a Signal with

Fig. 1

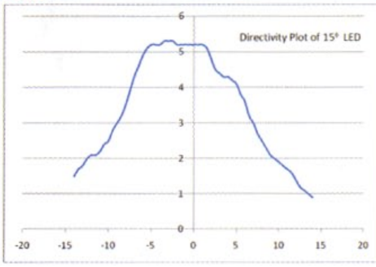


Fig. 2

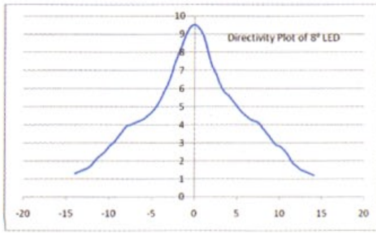
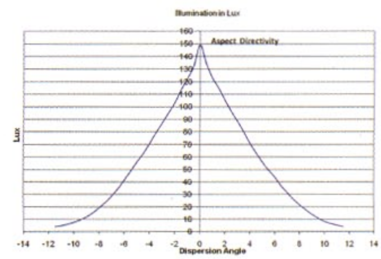


Fig. 3

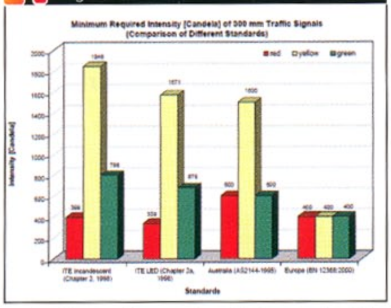


wider viewing angle will have a shorter visibility distance for the same number of LED's used.

Different standards specify different levels of required intensity levels. In India Road Signals do not have stringent standards but insist for intensities greater than 200 Candela. The

RED Aspect	Yellow Aspect	Green Aspect
150 Lux	175 Lux	150 Lux

Fig. 4



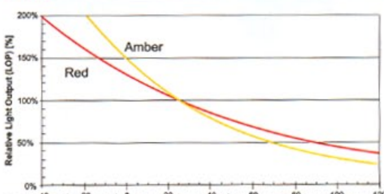
main line railway signals have the following standards:

The Institution of Transport Engineers (ITE) defines the intensity ratios between Red, Yellow and Green in the Ratio 1:2.5:1.3 respectively with viewing angle of 12.50 above horizontal for Road Signaling.

Based upon the intensity requirement of the Lamp the minimum intensity level of the LED is determined. Generally the LED's manufacturers specify the nominal intensity level at a specified forward current but the specific intensity binning structure should be taken into account while selecting the required intensity of the LED. Other factors influencing the selection of the LED's is the operating current and the Color specifications.

Generally LED Manufacturers specify the intensity at 20ma forward current and keeping the Junction temperature at 250C. But the specified intensity is

Fig. 5

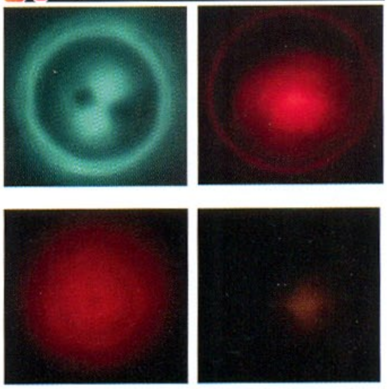


again function of Junction temperature i.e. intensity degrades as the junction temperature increases. This should be compensated in the design.

Practically the temperature within the Aspect enclosure will be greater than the ambient temperature. Hence the operating Junction Temperature of the LED's should be appropriately selected so that junction thermal breakdown does not occur.

Generally the light emitted from a Signal aspect when projected on a target board in a dark room should illuminate the target board uniformly. This is an indication that the light emitted from the aspect is uniformly illumi-

Fig. 6, 7, 8 & 9



nated. This happens only when the light emitted from individual LEDs is uniform but practically it is not, so as indicated in the figures below.

Different types of LEDs have different illumination patterns and also do not have uniform distribution. This should be overcome through proper alignment of LED's in such a way that they produce uniform illumination achieving the required viewing angle.

Another parameter to be considered in the selection of the LED is the color

Fig. 10

specification of the LED's. The Color Requirements of the Signal Aspects is generally as per CIE 1931 specification as described below:

This is important basically for two

reasons; first the drivers with normal color identification capabilities identify the colors similarly and secondly when they drive along the route all the similar signals appear uniformly for easy recognition by the drivers. This parameter should be selected from the dominant wave length parameter of the LED and the color binning of the LED's. The wavelength of the LED's also drifts with temperature which might cause two similar signals operating at different temperatures appear differently, hence care must be taken to select LED's with stable dominant wavelengths over entire operating temperature range of the Signal.

The Encapsulation of the LED's is also an important factor to be considered because when the LED's are exposed to the UV radiation in the sunlight the intensity of the LEDs degrades due to the encapsulating material becoming yellowish from clear color due to the effect of UV radiation. Hence the encapsulation material of the LED's should be UV Stabilized to prevent it from turning yellowish.

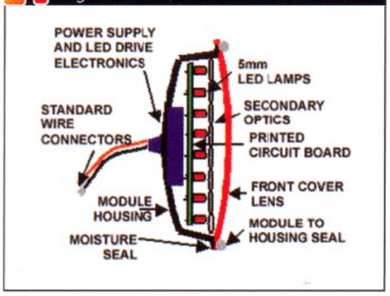
The Sun Phantom effect is another critical parameter to be considered. The Sun Phantom effect refers to the phenomena of sunlight shining into the aspect and reflecting back to give the appearance that the signal is switched on. This may produce confusion for the driver unless the luminous intensity of the real light signal is considered to be greater than the intensity of any false signal. An LED signal neither needs a reflector nor a colored Lens and further selection of a clear lens (encapsulation) for the LED's rather than colored Lens (encapsulation) eliminates the Sun Phantom effect.

This forms the broad criteria for the selection of LEDs required for a particular Aspect be it for a Road Signaling application or the Rail Signaling application.

a. The Practice of using black backgrounds improves the contrast and decreases the required signal intensity. Yellow backgrounds are beneficial when the Sun is in front of the signal. Backgrounds and hoods reduce the temperature raise within the signal aspect.

b. The LED's are clustered depending upon the drive Voltage .It is general practice to randomly distribute the LED's within the clusters so as to avoid the dark spots in case of failure of any of the LED's. Further a shunt path is also provided across each LED to prevent the blanking of the entire string in case of an open circuit of an LED.

Fig. 11



The diagram depicts the model of an arbitrary hermitically sealed signal aspect.

Fig. 12

Ambient Operating Temperature [°C (°F)]	LED Temperature [°C (°F)]	Mean Time Between Failure (MTBF) [hours]	Device Failure Rate λ [%/1000 heures]
85 (185)	103 (217)	848,000	0.188
75 (167)	93 (199)	1,220,000	0.082
65 (149)	83 (181)	1,791,000	0.056
55 (131)	73 (163)	2,688,000	0.037
45 (113)	63 (145)	4,133,000	0.024
35 (95)	53 (127)	6,525,000	0.015
25 (77)	43 (109)	10,701,000	0.009
15 (59)	33 (91)	17,978,000	0.006
5 (41)	23 (73)	30,922,000	0.003

(Agilent Application Brief)

The Life of the signal depends mainly on the temperature at which the LEDs are operated at.

Fig. 13

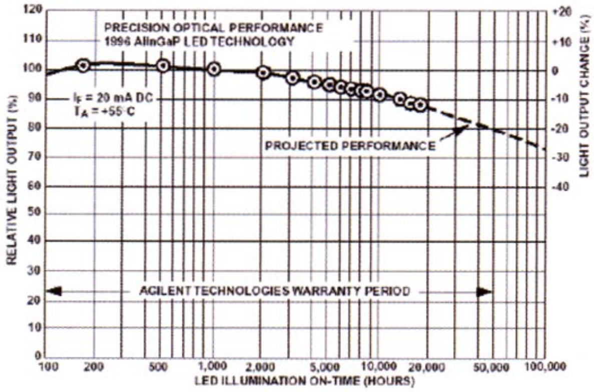
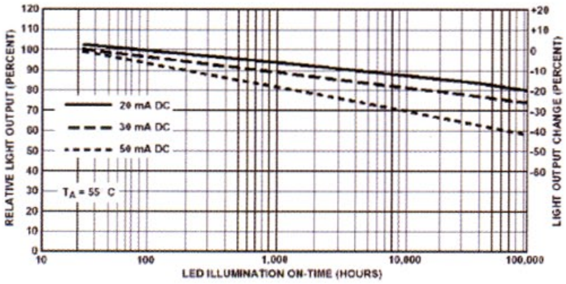
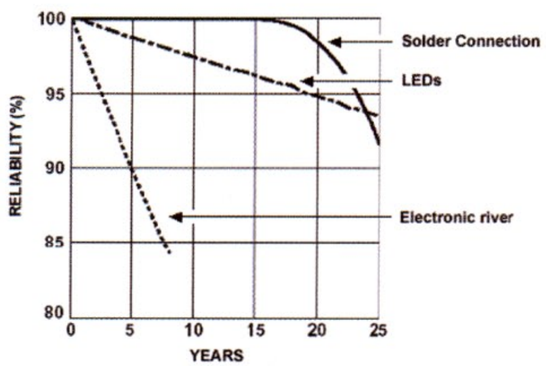


Fig. 14



The rate of decline also depends upon the drive current.

Fig. 15



Since LED's last so long, degradation with time is a concern that must be addressed. Light output from LED's declines with use, but the rate of degradation is extremely slow. The logarithmic graph shows the projected rate of decline.

The degradation is taken into account in the design generally by considering a 40% increase in the rated specified illumination level for the current LED technology.

In considering the issues regarding using LEDs as a light source for the signal lighting application, it is important to remember that it is the overall system reliability that is the important factor. Many LEDs must be soldered together to make an LED array, and drive circuitry is required to power the LEDs. The weakest link in this system is the electronic driver circuitry. If extremely long life and high reliability are essential, then it is prudent to have redundancy in the drive circuitry so that if a component fails, there is a backup circuit to drive the LEDs.

As a result of the increasing energy prices and the need to reduce greenhouse gases, a well designed LED Signal Lighting unit offers the chance to improve performance with decrease in energy consumption. ■

References:

1. ITE Specifications
2. RDSO Specification for LED Signal Lighting Units
3. Agilent Application Notes
4. Lumileds Application Notes