

**METHOD AND APPRATUS FOR ENHANCING LED DISPLAY'S  
PERFORMANCE VIA THERMAL MANAGEMENT THEREOF**

**FIELD OF THE INVENTION**

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The present invention relates to low power semiconductor devices and the display systems that are made therefrom. In particular, the present invention pertains to improved electronic display system is made from Light-Emitting Diodes (LED) for transportation systems.

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**BACKGROUND OF THE INVENTION**

Motorists and pedestrians have been relying on optical display systems such as signage or traffic lights for managing and directing flow of automobiles or humans for decades. Hitherto, incandescent or halogen lamps have been the optical sources for such display systems as they are inexpensive and reasonably easy to maintain and operate. Since the middle 1990s, display systems employing LED devices have started to replace traditional display systems using incandescent or halogen lamps because the former consume only a fraction of the energy of the latter. For instance, one red LED traffic signal head that contains 196 individual LEDs operates on a 120 Volt circuit consumes less than 10 Watt, as compared with a 150 Watt incandescent lamp it is intended to replace. Published estimates of the energy savings that can be achieved due to the replacement of a red signal head with an LED unit range from 82% to 93%. See, *Optimizing the Design and Use of Light-Emitting Diodes for Visually Critical Applications in Transportation and*

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*Architecture*; Lighting Research Center, Rensselaer Polytechnic Institute;  
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LEDs have much longer rated lives than the incandescent lamps used in traffic  
5 signals systems: LEDs have average rated lives of over 100,000 hours as  
compared to 8,000 hours rated live of an incandescent traffic lamps. In terms of  
maintenance and operating costs, LEDs have a distinct advantage over the  
existing incandescent lamps.

10 Although LEDs appear to have certain advantages over incandescent lamps,  
incandescent lamp has a significant edge in terms of cost: it cost \$2.50 - \$3.00  
to replace an incandescent lamp, while a red LED head is about \$100. Green  
LED head cost between 2.5 and 5 times more than the red ones. Across the  
United States a number of electric utilities and public agencies have offered  
15 financial incentives to municipalities to install LED traffic signals with mixed  
success. The high initial cost appears to be a significant barrier to LED's wider  
adoption.

A further key to the possible wider acceptance of LED traffic signal system is  
20 the ability of the LED industry to address the visibility issue. LEDs are  
sensitive to temperature changes in two significant ways: actual live and  
luminous output. Existing LEDs are rated for operating temperatures of 25  
degree C; at lower temperature they produce more light and at higher  
temperature, less. For example, at -40 degree C AlInGaP LEDs have an  
25 output that is 192% of the output at 25-degree C; at 55 degree C, the  
luminous output is 75% of that at 25 degree C.

One option LED manufacturers develop is to optimize for operation at higher temperature than those currently designed. Another potential alternative is to vent the signal head or include a heat sink to decrease the interior temperature.

5 OBJECT OF THE INVENTION

It is an object of the present invention to enhance the performance of LED display system without imposing any physical or electrical overhead to LED traffic signal system.

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It is another object of the present invention to reduce the fluctuation of temperature within the LED traffic signal heads in order for the LED to achieve optimal visibility criteria.

15 It is yet another object of the present invention to isolate the optical module from the power module of LED traffic signal heads in order to prolong the rated life of LED optical module.

20 It is a further object of the present invention to segregate the optical module from the power module of LED traffic signal heads such that the power module can be replaced with more energy efficient transformers without retiring the optical module.

25 It is an additional object of the present invention to seal the optical module of a LED traffic signal head for all weather conditions and attaining superior performance.

## SUMMARY OF THE INVENTION

By segregating the optical and power modules of a LED traffic signal head and sealing each against all weather conditions, an improved LED display system  
5 is realised that can achieve the expected energy saving and visibility performance consistently without increasing the payback period of the system. The isolation of the optical module minimizes the fluctuation in temperature of the LED devices and hence ensures a greater luminous output from the optical module. As such, the chances of motorists and pedestrians missing the  
10 appropriate traffic signals in inclement weather conditions are reduced. The compartmentalization of the power module not only offers better thermal management of the LED display system but allows upgrade of the transformer without the need to retire the optical module. It follows that the present invention permits the LED display system to meet ever stringent energy  
15 efficient standards and yet retaining its initial investment.

## BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a perspective elevational view of an embodiment of a LED display  
20 employed in a traffic light module.

Fig. 2 is a side elevational plan view of the embodiment in Fig. 1 highlighting the segregation of the optical and power modules.

25 Fig. 3 is a exploded, perspective elevational view of the components of a traffic light module incorporating the present invention.

## DETAILED DESCRIPTION OF THE INVENTION

Central to the present invention is the concept of improving the thermal management of LED display by separating the optical module from the power module. Unlike prior art disclosed in U.S. Patent No. 5,636,057 where the optical and power module are integrated as one unitary head, the present invention is less susceptible to fluctuation of internal temperature of the optical module.

Furthermore, the present invention seals the optical and power modules against all weather conditions. In contrast with prior art such as that taught in U.S. Patent No. 6,036,336 where the LED display head is exposed to ambient temperature, the present invention is more likely to achieve the expected rated live and luminous output.

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## PREFERRED EMBODIMENT OF THE INVENTION

Fig. 1 is a perspective elevational view of an embodiment of a LED display employed in a traffic light head. A LED display head 5 comprises at least one protective cover 2; at least one optical board 6 and at least one optical module cover 8. The protective cover 2 can be made of any synthetic material that is transparent. In the preferred embodiment of the present invention, the protective cover 2 is made of clear, dirt and scratch resistant polycarbonate material. The optical board 6 can be made of any surface mount material or similar substrate. In the preferred embodiment of the present invention, the optical board 6 is a printed circuit board made from FR4 material and having a plurality of LED devices 38 inserted through said board. Finally, the optical

module 5 is sealed with the cover 8; in the preferred embodiment of the present invention, the optical module cover is made from polycarbonate material. The power module is shown only partially with a power module cover 12 coupled to the optical module. Details of the power module will be  
5 elaborated further below in connection with the description of Figs 2 and 3 respectively.

Fig. 2 is a side elevational plan view of the embodiment in Fig. 1 highlighting the segregation of the optical module 9 and the power module 15 with a  
10 plurality of spacers 40. Prior art LED signal heads integrate the optical module with the power module as manufacturers of LED traffic signal systems did not appreciate the effects of temperature have on low-power and low-current semiconductor devices such as LEDs. As mentioned briefly in the background section above, the luminous output of LEDs changes with temperature: the  
15 lower the temperature, the higher the luminous output and vice versa. It was therefore not surprising that few of the LED signals heads in production approached the performance benchmarks of the prototype LED signal heads.

Referring again to Fig. 2, the LED optical head 5 of the present invention  
20 comprises separate optical module 9 and power module 15. Furthermore, the optical module 9 isolates the LED board 6 from the environment by encasing it with the protective cover 2 and the optical module cover 8. A plurality of legs 42 also raise the LED board 6 away from the optical module cover 8. Disposed on the surface opposing the LED board are a plurality of spacers 40  
25 for coupling detachably the optical module 9 with the power module 15.

Again in Fig. 2, the power module 15 comprises at least one transformer (not shown in Fig. 2 but in Fig. 3) that is encased with a power module cover 12 and a power module housing 24. A power cord 44 provides sources of electric power to the power module 15. Although the power module emits  
5 comparatively large amounts of heat, the effects it has on the optical module 9 are minimized because of the isolation of the two modules and the sealing of the two modules.

Fig. 3 is an exploded, perspective elevational view of the components of a  
10 LED signal head 5 incorporating the present invention. As mentioned above, the LED signal head 5 comprises two distinct modules: the optical module 9 and power module 15, respectively. The optical module 9 further comprises the protective cover 2, an O-ring 4, the LED board 6 and the optical module cover 8. The optical module 9 is sealed such that it is weather proof against  
15 moisture, air and dust by encapsulating the LED board 6 with the protective cover 2 and the optical module cover 8 with the O-ring 4. Power to the LED board 6 is provided by an optical power cord 10 that terminates at the optical module cover 8. The sealing of the optical module minimizes fluctuation of operating temperature of the LED. The immediate benefit is the greater  
20 luminous output of the LEDs – a key factor in determining the visibility of LED traffic signal in inclement weather. As compared with traffic signals employing either incandescent or halogen lamps, LED traffic signal do not suffer from sun-phantom effect. Sun-phantom effect arises when reflection of the sun on the reflectors of the traffic signals using incandescent lamps creates an illusion that  
25 the traffic light is activated when it is not. A secondary and long term advantage is the ability of the optical module to achieve the rated life – another key financial consideration in determining the acceptance and also payback period

of adopting LED display for traffic signal systems. Finally, the stability in temperature within the optical module 9 also minimizes condensation therein irrespective of any fluctuation in ambient temperature.

5 Referring again to Fig. 3, the power module 15 of the LED signal head 5 further comprises the power module cover 12, a membrane 14, insulators 16, a transformer 20, an optional washer 18, a driver board 22 and a power module housing 24. In the preferred embodiment of the present invention, the power module 15 is sealed securely with the membrane 14. Power to the power  
10 module 15 is provided by the power cord 26 via the driver board 22. Unlike prior art LED signal heads, the power module of the present invention is segregated from the optical module 9 in order to reduce the thermal load the LED board 6 is subjected. One of the major advantages of having a separate power module is the ability of cities and/or municipalities to upgrade the power  
15 module without retiring the optical module to meet ever stringent energy efficiency regulations such as the harmonic current emissions standards in major industrialised countries.

It should be understood by one skilled in the art that the LED signal head of the  
20 present invention is adapted for replacing existing traffic signals using incandescent or halogen lamps. Furthermore, the replacement can be accomplished in a piece meal fashion: for instance, in view of the higher costs of green LED signal heads, some cities or municipalities may elect to replace the red traffic signals initially before deciding on those for amber and green traffic  
25 signals.

The present invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The presently disclosed embodiments are, therefore, to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the  
5 appended claims and all changes which come within the meaning and range of equivalency of the claims are, therefore, to be embraced therein.

**CLAIMS**

We claim:

1 1. In a LED display system including at least an optical module and a  
2 power module for displaying signals by providing power source to said  
3 system, an apparatus for enhancing the performance of said LED display  
4 system, said apparatus comprising:

5  
6 a seal for encapsulating said optical module against fluctuation in  
7 operating temperature within said module, said module further  
8 comprising at least one LED board, at least one protective cover and at  
9 least one optical module cover; and

10  
11 a spacer arrangement interposed between said optical module and said  
12 power module for further minimising the effects of thermal load  
13 generated from said power module on said optical module,

14  
15 whereby said apparatus maximizes the luminous output from said  
16 optical module while achieving the rated life of said optical module.

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1 2. An apparatus for enhancing the performance of LED display system  
2 wherein said power module is sealed to isolate the heat emission therefrom.

3  
1 3. An apparatus for enhancing the performance of LED display system  
2 wherein said spacer arrangement comprises an extension of said optical  
3 module cover.

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1 4. An apparatus for enhancing the performance of LED display system  
2 wherein said spacer arrangement comprises an extension of said power  
3 module.

4  
1 5. In a LED display system including at least an optical module and a  
2 power module for displaying signals by providing power source to said  
3 system, a method for enhancing the performance of said LED display system,  
4 said method comprising the steps of:



5 sealing said optical module against fluctuation in operating temperature  
6 within said module, said module further comprising at least one LED  
7 board, at least one protective cover and at least one optical module  
8 cover; and

9  
10 providing a spacer arrangement between said optical module and said  
11 power module for further minimising the effects of thermal load  
12 generated from said power module on said optical module,

13  
14 whereby said method maximizes the luminous output from said optical  
15 module while achieving the rated life of said optical module.

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1 5. A method for enhancing the performance of LED display system  
2 wherein said power module is sealed to isolate the thermal load generated  
3 therefrom.

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1 6. A method for enhancing the performance of LED display system  
2 wherein said spacer arrangement comprises an extension of said optical  
3 module cover.

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1 7. A method for enhancing the performance of LED display system  
2 wherein said spacer arrangement comprises an extension of said power  
3 module.

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