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ROTARY-COOLED SOLID-STATE LIGHTING (RCSSL)

Patent Pending
Technology Readiness Level: 3
Active research & development is initiated. Components are not integrated.

TECHNOLOGY DESCRIPTION

Rotary-Cooled Solid-State Lighting (RCSSL) is a novel solid-state lighting (SSL) architecture that addresses several longstanding technical challenges in SSL luminaires.

RCSSL improves upon the groundbreaking thermal management performance of the R&D 100 Editors' Choice award-winning Sandia Cooler by situating an LED array directly on a rotating heat-sink-impeller, thereby eliminating the air gap thermal interface of the Sandia Cooler and lowering the overall thermal resistance. The rotating heat-sink-impeller combines the functions of a heat sink and a fan, while exploiting fluid mechanical phenomena in the rotating frame that enhance heat transfer per unit volume by nearly 10x compared to conventional heat sinks.

An RCSSL luminaire's extremely low thermal resistance allows for a smaller size and weight with fewer LEDs compared to a traditional luminaire. The heat-sink-impeller has also proven to be silent and intrinsically resistant to dust fouling, ensuring consistent performance in long-term continuous operation.

The rotating LED array also allows for direct white light synthesis through rotational spatial averaging, where the output of a circular color LED array is mixed into white light with zero optical insertion loss and no perceptible flicker. This rotational color mixing provides a simple and efficient way to use color LEDs to generate white light, allowing for adjustable color output and higher overall efficiency than phosphor-converted white LEDs.

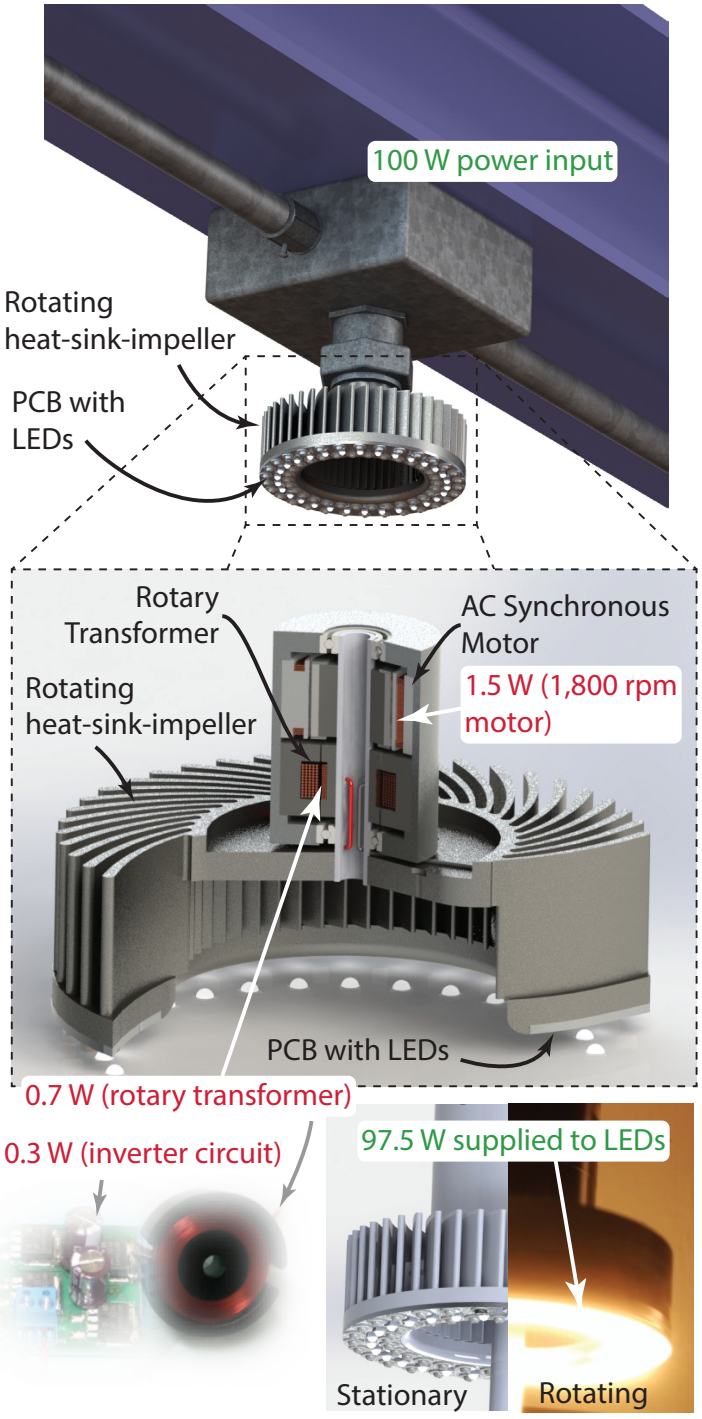

Figure 1: A 100 W RCSSL luminaire used for high-bay lighting. The rotating heat-sink-impeller provides low thermal resistance in a small overall luminaire size.

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Finally, RCSSL uses a novel driver circuit to power the LEDs at 99.0% efficiency, which includes a split-core rotary transformer to provide contact-free power to the rotating LEDs. The heat-sink-impeller's rotation is driven by a low-power (1.5 W), reliable, contact-free synchronous AC motor whose power consumption is more than made up for by the increased luminous efficacy associated with low LED junction temperature. Currently, the critical subsystems of RCSSL have been individually verified in the laboratory and we are seeking partners to develop an integrated prototype.

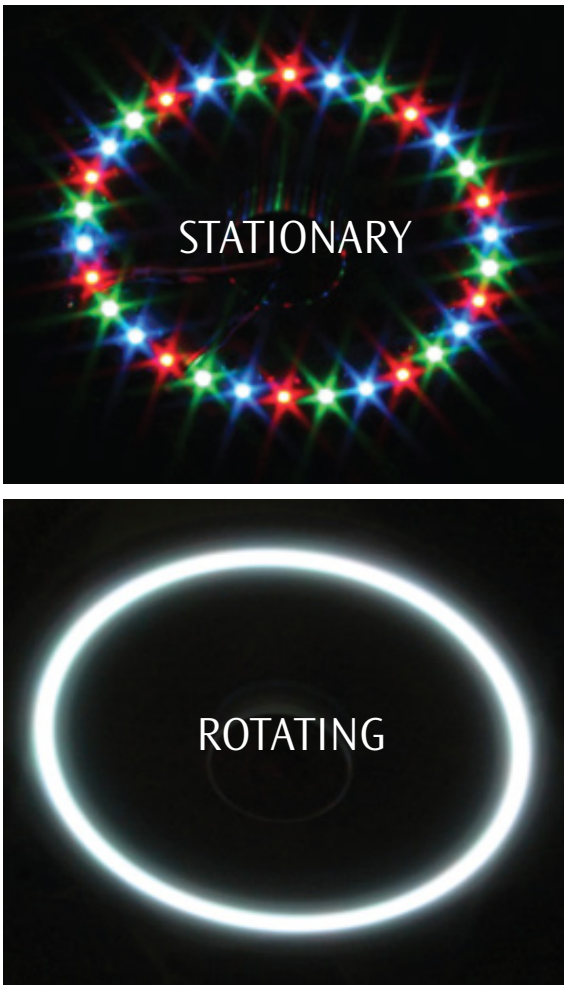

Figure 2: A circular array of color LEDs produces a ring of white light with no optical insertion loss or phosphor loss. By varying the output of each color, the color balance of the white light can be adjusted.

TECHNOLOGICAL BENEFITS

- Low luminaire thermal resistance (~0.09 C/W) leads to increased luminous efficacy and lifetime of LEDs without large overall luminaire size
- High LED driver efficiency (99.0%)
- Rotational color mixing provides optical-insertion-loss-free white light using color LEDs and enables increased luminous efficacy and adjustable color balance with no perceptible flicker
- Designed to be easily manufactured in volume using established methods and tools

POTENTIAL APPLICATIONS

- High-bay lighting, industrial and commercial area lighting

CONTACT US

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