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Final Ballast/Control Device Specification Report

Deliverable 2.3.2f – *Elevator downlight*

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Ballast/Control Device Specification Report

1 Introduction

This report for Project *2.3 LED Low Profile Fixtures* provides the specification for the ballast/control device (also called the driver) that will be used for the low-profile LED luminaire in an elevator downlight application. The overall goal of the project is to design, build, and demonstrate in the field a working prototype of a low-profile LED luminaire that is 25 percent more efficient than a comparable incandescent luminaire. The information presented in this report has been gathered during the design phase of the low-profile LED luminaire and was used as a baseline to decide what commercial driver will be used in the final prototype. Please refer to the publication *Final LED Specification Report Deliverable 2.3.1d-e-f – Elevator downlight*, a document from this project, for more detailed information regarding the electrical and general requirements of the LEDs chosen for the final prototype.

The research team for this project includes Nadarajah Narendran, Jean Paul Freyssinier, Richard Pysar, and Ramesh Raghavan with the Lighting Research Center (LRC).

2 Specifications and general requirements

2.1 Specifications of the driver used in the low-profile luminaire

The driver chosen for the low-profile luminaire is model Xitanium LED120A0024V10D from Advance Transformer. The main electrical characteristics of such driver are listed in Table 1 (Lumileds, 2003a, 2003b). **Figure 1** shows the typical package and physical dimensions, and **Figure 2** shows the connection diagram of the driver (Lumileds, 2003a, 2003b).

Table 1. Electrical characteristics of Advance Transformer's electronic driver model Xitanium LED120A0024V10D (from Lumileds, 2003a, 2003b).

Input voltage	108 – 132 V ac, 60 Hz
Input power	2.9 – 31.9 W maximum
Input current	0.30 A maximum
Output voltage	10.4 – 24.6 V dc
Output power	2.3 – 25.5 W
Output current	100 – 1050 mA ±5%
Efficiency	80% typical
Total harmonic distortion	20% maximum
Power factor	0.9 minimum
Current crest factor	1.5 maximum
Line regulation	1% output voltage variation across input voltage range
Load regulation	5% output current variation across load range

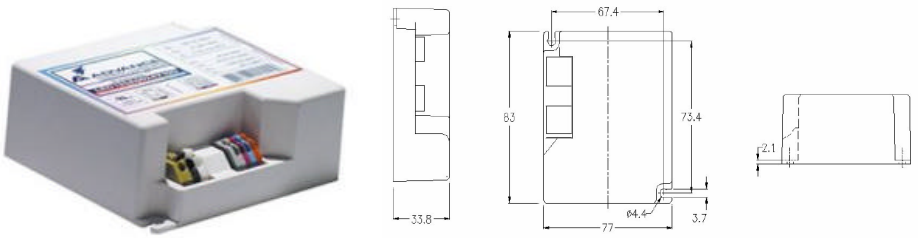

Figure 1. Picture of typical commercial package of driver model LED120A0024V10D and mechanical dimensions (from Lumileds, 2003a, 2003b).

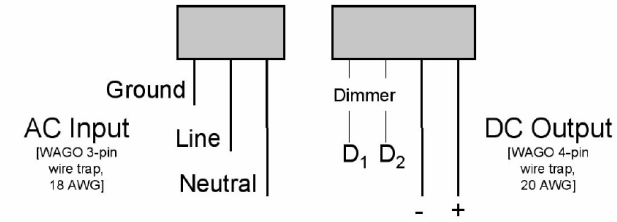

Figure 2. Wiring diagram of driver model LED120A0024V10D; top view of connectors (from Lumileds, 2003b).

From reading the full set of specifications provided by the manufacturer (Lumileds 2003a, 2003b), it will be obvious to the reader that the driver selected has dimming capabilities. Dimming is not a function that is absolutely necessary for the objectives of the project; however, dimming was selected because it adds extra potential for energy savings that may be demonstrated in a future field installation of the LED luminaires.

The following sections of this report contain more detailed specifications and the rationale behind this choice.

2.1.1 Electrical requirements of the LED luminaire

As discussed in the report entitled *Final LED Specification Report Deliverable 2.3.1d-e-f – Elevator downlight*, the LED that seems most suitable for the prototype, considering the goals of Project 2.3 and the specifics of the application (elevator downlighting), is the Luxeon III Emitter, a 3W phosphor-coated white LED (Lumileds 2004).

In order to achieve the target light level in the elevator cabin, six luminaires are needed, each with six LEDs. The nominal forward current of the Luxeon III emitter is 700 mA. Given that all LEDs have slightly different voltage characteristics, the easiest and most efficient method to ensure that all six LEDs are driven at the exact same forward current is to connect them in series (Schie, 2004). With this in mind, a custom metal-core printed circuit board (MCPCB) was designed to house the six LEDs per luminaire. **Figure 3** shows the schematics of the circuit configuration of the LED MCPCB prototype.

The nominal forward voltage of the Luxeon III emitters is approximately 3.5 volts at a forward current of 700 mA. Therefore, the driver should be able to provide at least an open circuit voltage of 21 volts at the given nominal 700 mA forward current. The power consumption of the LEDs is anticipated to range from approximately 15 watts to 18 watts,

not including the losses of the driver. This estimate is based on laboratory measurements of LED samples available at the time of this report. Also, drivers and transformers usually perform more efficiently when the load factor is less than 100 percent. Therefore, if we assume a load factor of 70 percent, the driver should be able to provide and sustain an output power of 25 watts under all conditions present in the elevator downlighting application.

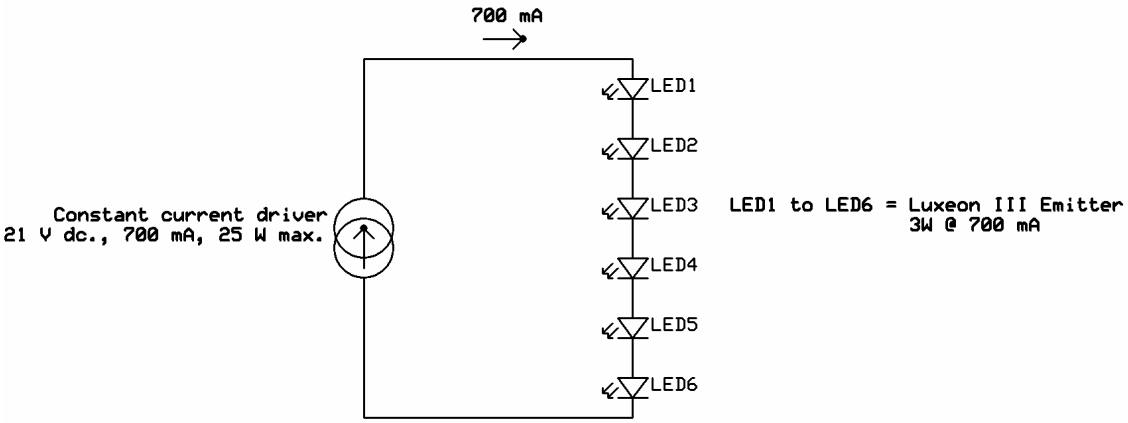

Figure 3. Schematic of the circuit configuration to drive the six Luxeon III emitters that will be used for the LED low-profile luminaire.

The obvious choice for the procurement of such a driver for the LED luminaire is an off-the-shelf product. Among the many commercially available solutions of LED drivers, the model selected from Advance Transformer offers the best match to the requirements of the LED luminaire.

2.1.2 Efficiency requirements

As explained in more detail in the publication *Final LED Specification Report Deliverable 2.3.1d-e-f – Elevator downlight*, the efficiency of the driver is one of the main factors affecting the overall efficacy of any luminaire system. The same publication outlines the required system efficacy of the LED luminaire to achieve the goals of this project (i.e., 25.8 lm/W).

To reach the required system efficacy, a driver with an efficiency of at least 90 percent is desirable. However, after looking into the commercially available options, the Xitanium series from Advance seemed to offer one of highest efficiencies with a nominal value of 80 percent. This does not imply that a higher efficiency is not practical or economically justifiable. Simply, at the time the driver was selected it offered the best solution from a commercial driver that met the voltage, current, and power requirements of the LED luminaire. Some products offer an apparently higher efficiency, but that is measured at lower wattages and when operated in direct current circuits; that is, the losses of an ac to dc interface are not considered.

2.1.3 Safety requirements

The main reason behind the selection of a fully packaged and commercially available driver, as opposed to a custom design prototype, was the need to test the LED luminaire in a field installation. The installation of the LED luminaire in a functional elevator required that all safety precautions were taken, including a secure and reliable connection to the power supply of the elevator.

The driver safety characteristics required for this field evaluation are similar to those needed for any other application; that is, a driver should be preferably UL Class 2 rated (see National Electrical Code; ANSI/NFPA 70; UL 1585 for more details), have short circuit protection, isolated output, and be rated for operation in ambient temperatures of approximately 40ºC. The selected driver features inherent short-circuit self-limited protection; overload protection; isolated output to 3.2 kV at 60 Hz; and is capable of operating in environments of up to 60ºC (with a maximum case temperature of 95ºC).

2.1.4 Mechanical requirements

The three most important mechanical requirements of the driver for the LED luminaire are overall physical dimensions (mainly reduced footprint and overall height), weight, and enclosure material.

The LED luminaire was designed with the goal of having a reduced profile, with a target overall height of 1½ inches to 1¾ inches. Preferably, the selected driver should be no more than 1½ inches tall after considering mounting hardware. Advance Transformer's model Xitanium LED120A0024V10D has an overall height of 33 millimeters (1.3 inches), which is just below the target. **Figure 2** shows the footprint and overall dimensions of the selected driver.

Ideally, the LED luminaire should weigh the same as or less than typical incandescent luminaires used for elevator downlighting. The driver's weight is 140 grams (5 ounces). Such weight is minimal compared to the metal parts of the luminaire (i.e., reflector, heat sink, mounting hardware).

Finally, the driver should not have any exposed live parts and should have a suitable housing for installation according to the National Electrical Code. The enclosure of the driver selected is made of Noryl HS2000, a UL 94-V0 flame retardant rated material, which is suitable for this application.

2.1.5 Controllability requirements

There are no special controllability requirements for the field evaluation of the LED luminaire. However, anecdotal evidence indicates that there is a significant potential for energy savings in elevator applications since lighting operates 24 hours a day and is not responsive to occupancy patterns of the elevator. Therefore, it would be desirable that in real applications, the driver would be capable of interfacing with continuous or step dimming systems, occupancy sensors, load-shedding systems, and the programmable controls of the elevator cabin (Norris, 2004).

The selected driver has dimming capabilities within the range of 5 percent to 100 percent. Dimming is controlled by means of a 10 V dc signal available from many commercially available dimmers and controls systems. In reality, it is possible to interface the selected driver with almost any existing control system.

2.1.6 Reliability requirements

The reliability requirements for the LEDs selected for the low-profile luminaire were established as a desirable useful life of 40,000 hours. It is then desirable as well that the driver last at least as long as the LEDs in the luminaire (Norris, 2004). The selected driver has a lifetime of 50,000 hours and is offered with a 5-year warranty. Such lifetime is defined as 5 percent failures after 50,000 hours of operation. The selected driver seems a suitable option for this application.

3 Conclusions

Based on an evaluation of the attributes discussed above, the LRC has concluded that an electronic dimming driver such as the one selected is suitable for commercial applications where white LEDs are desired for general illumination.

The Xitanium LED120A0024V10D from Advance Transformer was considered a suitable choice as the driver for the LEDs used for the low-profile luminaire. It is expected that in the near future more efficient drivers will become available, increasing the overall system efficacy of the LED luminaires. A minimum efficiency of 90 percent would contribute to a more attractive LED system for energy savings applications.

One driver is required per luminaire, given the type (high-power phosphor-converted white), number (six per luminaire), and power (3 watts per LED) of the LEDs in each luminaire.

4 References

Lumileds. 2003a. *Form No. LE-6010-AF-ROI Xitanium LED electronic drivers, 25W 24VDC/1.05A dimming* (PDA 602801 Rev. 03/02). San Jose, California: Lumileds Lighting.

Lumileds. 2003b. *Form No. LE-6040-ROI Xitanium LED Drivers for Luxeon LEDs* (PDA 602801 Rev. 08/03). San Jose, California: Lumileds Lighting.

Lumileds. 2004. *Luxeon III Emitter Technical Datasheet DS45* (Rev. 05/28/04). San Jose, California: Lumileds Lighting.

Norris, R. 2004. Otis Elevators. Personal communication: January 16, August 22, September 15, and December 9, 2004.

Schie, D. 2004. Real-world systems demand application specific-designs. *Laser Focus World* 40(5):102-108.