Benefits of low current series circuit systems

A simple upgrade to LED with ELLEGO AGL

ELLEGO Insigh

The AGL current standards

The standard 2.8 - 6.6 A is a highly used current range in aeronautical ground lighting (AGL) systems. It has been well established during the tens of years it has been in use worldwide. It is specifically designed for the operation of a tungsten filament, a.k.a. halogen bulb as the light source. It is however not an ideal current range for an LED.

The newly published series circuit power supply standard, the IEC 61820-3-2 from 2023, defines a device category also for non-6.6 A power supplies. These power supplies may operate with other than 6.6 A current levels and have typically been designed to specifically operate LED-based AGL fixtures.

IEC 61820-3-2

LED vs Halogen current ranges – Why they are different

One major difference relates to the current threshold for light output. A tungsten filament used in halogen bulbs requires a comparatively large current before the onset of light output. For the standard halogen bulbs used in AGL, this threshold is approximately 40 % of the nominal current for full brightness.The luminous output from an LED on the other hand starts practically as soon as there is any current flowing through the component. Additionally, the nominal current ranges of most of the modern LED components fall short of the typical 6.6 Arms nominal AGL current.

Another significant difference between the halogen and LED current response curves is the linearity. Or in the case of halogen, the lack of it.The luminous output of a halogen bulbs increases highly nonlinearly with increasing current,

The current levels defined to be used with halogen are therefore fundamentally incompatible with an LED component.This incompatibility is emphasized by the strict requirements for controlling the luminos- ity levels.

Operating the series circuit primary with current levels that are designed for the halogen technology requires active current control mechanism within an LED based fixture.The current needs to be further regulated before it reaches the LED component.

Figure (page 6) shows a comparison between the ELLED™ and 6.6 A halogen current ranges.

Driverless LED – passive light source providing robustness and efficiency

The Driverless LED technology is a novel method for powering LED based AGL fixtures in a series circuit configuration without control electronics within the AGL fixture. This extreme simplification of the field technology provides significant improvements to both durability and energy efficiency. The total energy savings follow from reduced energy losses in AGL fixtures and lower resistive losses throughout the entire series circuit.

The ELLED™ power control technology operates the AGL series circuit primary with currents that are directly suitable for the LED. It follows the robust and simple idea behind the halogen based series circuit current, where a single power supply directly controls the luminous output of all the fixtures within the series circuit. It follows the fundamental control idea behind a series circuit technology.

ELLEGO PECS – a next generation AGL series circuit power supply

The ELLEGO PECS is a next generation series circuit power supply for AGL. It is a modern IGBT-controlled device designed according to the requirements of the newly published AGL series circuit power supply standard: the IEC 61820-3-2:2023. It belongs to the device class General PECS for AGL systems.

The ELLEGO PECS operates almost identically to a traditional 6.6 A CCR. The only significant difference is the amplitude of the series circuit current. The nominal series circuit primary current range is from 0.05 to 3.0 A RMS. This current range is suitable for directly controlling the current of the actual LED component, and therefore no control electronics is needed inside the AGL fixture. In the ELLEGO AGL system all series circuit field components are passive, following the simple operation of a halogen based setup.

Even though the current range is lower, the ELLED™ power supply method has been designed to operate with standard 6.6 A cabling and series circuit isolation transformers.

ELLED™ Bulb – A simple, robust and efficient LED solution for AGL

The fact that the ELLED™ LED bulb contains no active control electronics makes it a very long-lasting and low-energy light source. The ELLEGO AGL system combines the simplicity and repairability of the halogen based systems with the robustness and extremely low energy consumption of the LED.

The simplicity of the driverless LED technology offers the possibility to replicate the size and shape of a typical AGL halogen bulb with an LED based light source. The ELLED bulbs follow the form factors of PK30d and MR16 and MR11 type reflector halogen bulbs. These form factors allow upgrading existing halogen setups to LED by simply replacing the halogen bulbs to ELLED LED bulbs in the existing halogen fixtures*. For powering the ELLED, the series circuit power supply (CCR) is replaced with the new ELLEGO PECS. This kind of a retrofit process offers the possibility to upgrade an AGL circuit to LED without replacing the entire fixtures or other field components. The ELLED bulbs are also used as the light source in the new ELLED fixtures,

*Photometric compatibility will be verified for each fixture make and model.

Field installations

Driverless ELLED™ solutions have been in field use since November 2019. The very first installations were two low intensity approach lines at the Turku Airport in Finland. These installations were a prime example of a minimalistic AGL upgrade from halogen to LED. In this simple on/off controlled circuit a simple bulb replacement was sufficient. The PK30d -type ELLED bulbs have now been in use since 2019 without failures. In most cases it is necessary to replace the existing power supplies (CCRs) with a low current PECS, but certain applications and power supplies allow an upgrade by a simple bulb replacement.

Another long running installation is a taxiway edge circuit with 58 elevated fixtures and 78 bulbs in guidance signs resulting in a circuit with altogether 130 PK30d bulbs. The circuit is operated with an ELLEGO PECS at a nominal current of 1.0 Arms, for which the energy use dropped to 0.75 kW from the measured 8.7 kW with halogen before the upgrade. The respective dimmed brightness levels would use current levels of 0.3 and 0.1 Arms. The measured energy reductions with these currents were between 91 and 96 %. The power measurements taken from the input of the power supply, which considers the entire energy consumption.

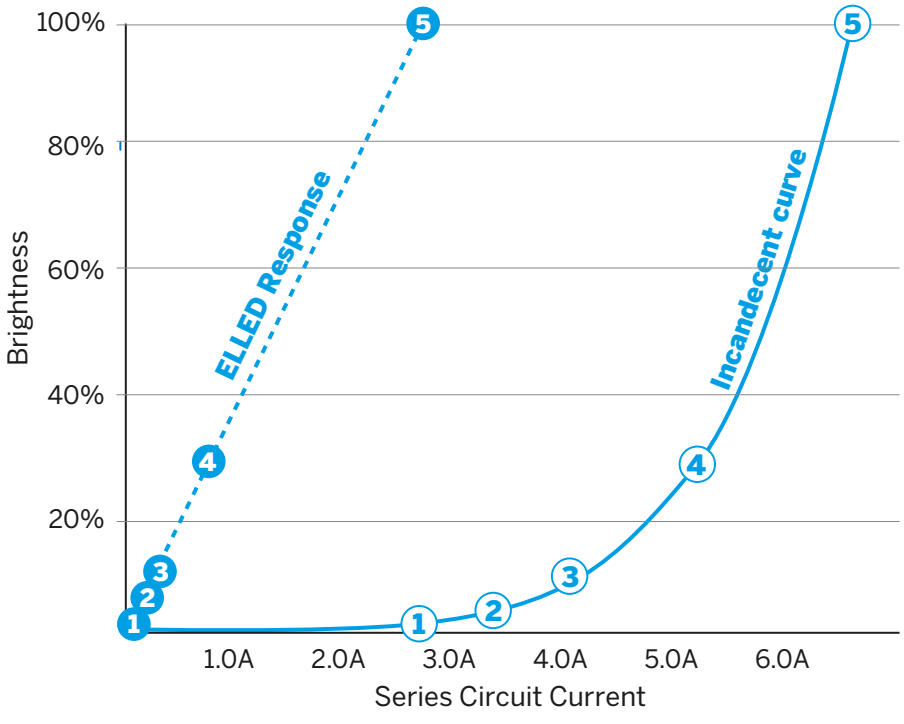
An example of a high intensity application is a CAT I approach line at Helsinki Airport. The existing Approach fixtures were refurbished using an ELLED bulb/reflector combination designed for elevated directional AGL fixtures. All three interleaved circuits were equipped with ELLEGO PECS power supplies.

Energy savings – what are they based on

The energy savings with low current AGL systems can exceed the fundamental halogen vs. LED efficiency difference. The savings follow from two separate but related sources. When comparing a halogen against an LED, the first one is the obvious efficiency differ- ence related to the physics of the light production. Just as importantly though, a low current system will benefit from Ohm's law throughout the tens or hun- dreds of kilometres of AGL cabling within an airfield. The well-known relation of resistive losses increas- ing with the square of the current is an especially good reason to use as low as possible current levels. An LED is an ideal light source for low current light production due to its natural response curve starting from practically zero. The often used low intensity brightness steps will minimize the AGL cable losses, including losses within the isolation transformers. As an example, the cable losses in a typical halogen based CAT I approach circuit can be in the kW range.

The 6.6 A LED systems utilize the same series circuit current levels that are fundamentally based on the operation of the halogen bulb. Using the 6.6 A current range allows using the power supplies designed for halogen lights, but this choice prevents reaching the full potential in energy savings. The cable and transformer losses will remain on the same level with halogen based installations and AGL fixture will require additional control electronics for current regulation.

The control electronics needed for controlling the LED current in a 6.6 A LED fixture is an additional source for power losses. Even a carefully designed and efficient LED current control system within an AGL fixture will consume several watts of power. This multiplied by the number of fixtures within a typical series circuit will lead to considerable energy losses. A low current series circuit system can be designed to operate the LED component directly, without any active electronics within the AGL fixtures, or in any of the field installed components. The ELLEGO designed ELLED™ Driverless LED is an example of such a system.



ELLED approximate brightness

Step 5	2.70A	100%
Step 4	0.80A	30%
Step 3	0.27A	10%
Step 2	0.08A	3%
Step 1	0.05A	1%

Incandescent approximate brightness

Step 5	6.6A	100%
Step 4	5.2A	30%
Step 3	4.1A	10%
Step 2	3.4A	3%
Step 1	2.8A	1%

Case example 1

Location: Turku Airport (TKU/EFTU), Finland

Installed products: ELLEGO PECS 400V, ELLED™ PK30d MI LED-lamps with the strain reliefs, The bulb holders in the signs changed to the aluminium versions for improved heat dissipation.

Circuit: Taxiway edge circuit
58 elevated taxiway edge fixtures
9 guidance signs

In total 130 halogen bulbs were replaced with ELLED LED bulbs. Existing cables, transformers, and fixture bodies and optics were utilized.

Case example 2

Location: Helsinki Airport (HEL/EFHK)

Installed products: ELLEGO PECS 400V, ELLED APCH-lamps with directional retrofit mirrors

Circuit: Three CAT I high intensity approach circuits 120 fixtures refurbished

Existing cables, transformers, and fixture bodies were utilized

Case example 3

Location: Enontekiö Arctic Airport (ENF/EFET)

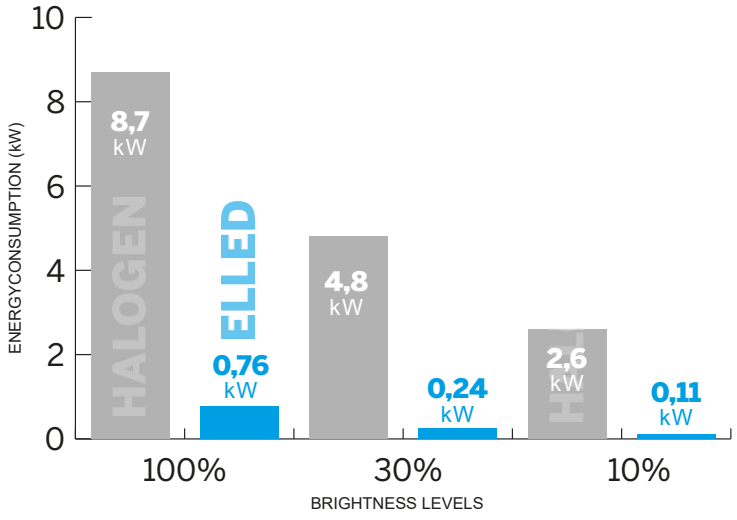
Installed products: ELLED PK30d MI LED-lamps

Circuit: Combined taxiway edge, apron and low intensity approach circuit 70 bulbs replaced in elevated fixtures and guidance signs

Existing cables, transformers, and fixture bodies and power supply were utilized

Brightness level	6.6A system current [Arms]	6.6 A CCR input power [kW]	ELLED current [Arms]	ELLEGO PECS input power [kW]	Energy saving
100 %	6.6	8.7	1.0	0.76	91 %
30 %	5.2	4.8	0.3	0.24	95 %
10 %	4.1	2.6	0.1	0.11	96 %

Energy and current measurements with FLUKE 435 Power Quality Analyzer and FLUKE 369 FC AC Leakage Current Clamps

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