Greener Commercial Lighting

With Ambient Light Sensors for Daylight Harvesting

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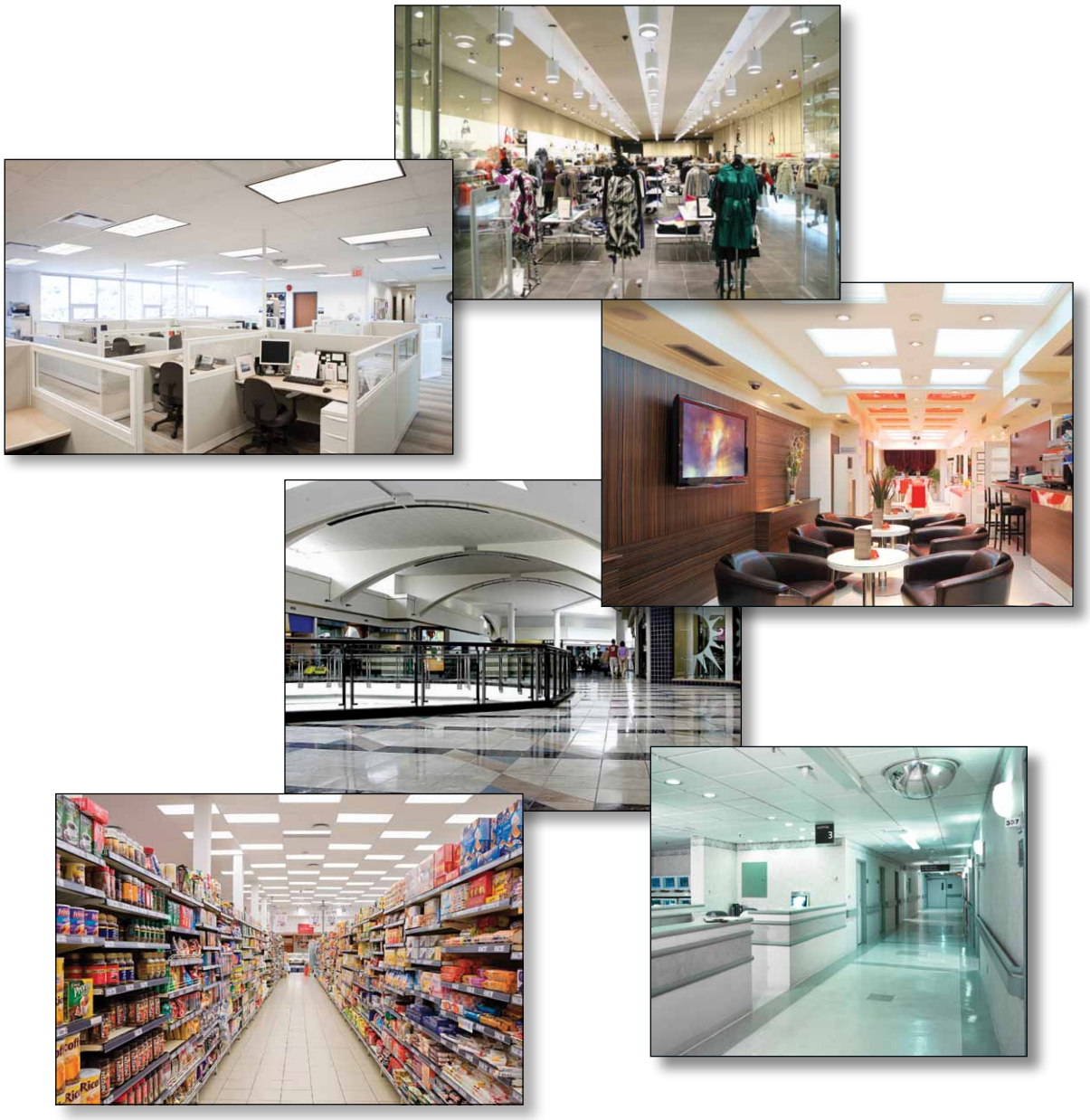

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Against the backdrop of new regulations mandating better lighting efficiency, and business' need to save on energy, low-cost ambient light sensors combining photopic, human-like sensitivity with wide dynamic range are enabling a new generation of lighting controls that may be built directly into replacement lamps and luminaires to shift more of the interior lighting burden onto the available daylight. Operating either as autonomous lighting controls or in a networked environment, ambient light sensor-based controls are crucial for saving energy with daylight harvesting. While much attention has been focused on residential lighting, where the shift from incandescent to compact fluorescent lamps is creating large improvements in lighting efficiency, this paper focuses on the commercial lighting market, where fluorescent luminaires are already in widespread use but where efficiency gains of 30% and even 50% or more are achievable through smarter lighting controls.

Because commercial lighting is mostly fluorescent, and thus inherently more energy efficient than incandescent residential lighting, it was subjected to less scrutiny for many years, but those days have now ended. Although an efficient source of lighting, even fluorescent technologies that are the source of most commercial lighting, waste energy because of the inability to commonly account for available daylight within a building. These technologies are a prime target for improvement. Lighting accounts for some 40% of a typical commercial building's electric bill, and commercial lighting accounts for approximately 70% of all lighting energy currently used.[1]

Meanwhile, many governments are beginning to require greater efficiency in commercial lighting. The European Union is in the midst of an aggressive plan to phase out inefficient light bulbs, and has regulations for commercial lighting mandating automated timer controls. In the U.S. state of California, where offices are commonly awash in bright daylight while artificial lights remain at 100% full-on brightness, new building codes called Title 24 mandate "Daylighting," which is the reduction in artificial lighting when daylight is available – also called "Daylight Harvesting." This law requires automatic lighting controls for large commercial areas of 2,500 square feet or greater by 2015, and also limits maximum lighting power density to 0.8 watts per square foot.

Fortunately, efficiency gains of 30 to 50% may be attained using smarter lighting controls based on light sensor technology, without sacrificing light quality or brightness, especially in offices where daylight enters windows or skylights. The opportunity for manufacturers of commercial lighting products to offer their customers this sudden improvement in energy efficiency is extraordinary.

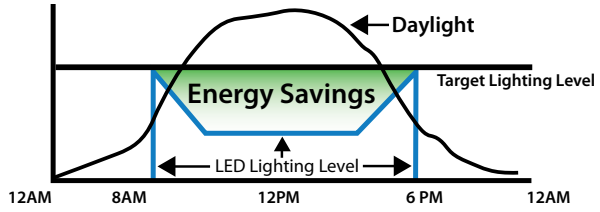

Fig 1. Daylight Harvesting saves energy while maintaining target interior lighting level (above) to avoid keeping lights on at full power when daylight is readily available (below).

Previous generations of automated lighting controls for commercial spaces would assume a centralized control system, but today's trend is towards decentralized lighting controls. With ever-lower costs and lower power consumption for both control systems and networking, and with Light Emiting Diode (LED) lighting on the rise, manufacturers are now creating new autonomous and semi-autonomous light control systems that are built into individual luminaires and even LED-based replacement lamps themselves.

Light Sensor Technology

The crucial link in any control system that will adjust indoor lighting based on ambient light level is the light sensor. In earlier generations of lighting controls this might have been a simple photoresistor or photodiode. Now system-on-chip light sensor solutions provide a complete light sensing subsystem, including conversion of analog readings to a digital I^2C output signal. This includes correction for any errors caused by light flicker, on an integrated circuit as small as 2mm square, and costs about the same, or even less, than a simple photosensitive component alone.

When selecting an appropriate light sensor solution for commercial lighting applications, key features to keep in mind include:

Photopic Response: When measuring ambient light levels for lighting control, it is important to measure only the visible portion of the electromagnetic spectrum, and to weigh the various colors to roughly match the sensitivity of the human eye. (Our eyes are most sensitive to green light, for example.) This is called "photopic response" – matching the characteristics of human vision. Unless they have been specially designed for ambient light sensing applications, most ordinary light sensors respond to infrared and ultraviolet wavelengths in addition to visible light. This creates erroneous readings, especially when daylight is involved. Light sensors offering photopic response have a distinct advantage.

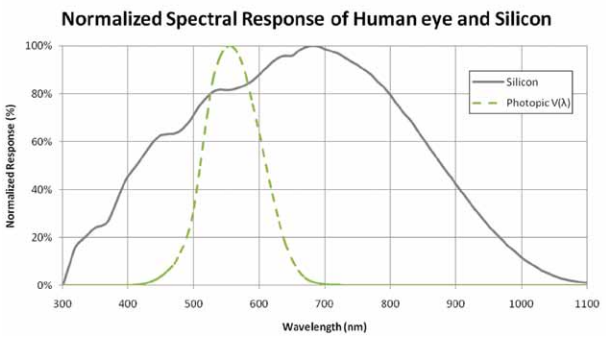

Fig. 2. Photopic response, mimicking the spectral response of human vision, senses a narrower range of wavelengths than a silicon photodiode.

Dynamic Range: From very bright outdoor sunlight to late night office conditions where just a few work areas remain lit, an ambient light sensor must deliver accurate, within-range readings. Bright daylight must not saturate the sensor. It is possible to add a variable aperture system to expand dynamic range, but this is less desirable than employing a wide native dynamic range.

Type of Light: For some applications, sensing the type of ambient light can be useful. A digital signage screen or PC monitor or television may automatically adjust its color temperature so that "white" on the screen matches ambient white, for example. As part of a commercial lighting control system, the ability to distinguish between daylight, incandescent, CFL and LED lighting can aid controllers in reducing energy consumption, by automatically switching to the more efficient light source(s).

Commercial Lighting Applications for ALS

Ambient Light Sensing (ALS) technology has been around for decades – practically every hardware store sells a patio light that turns on automatically when it gets dark outside.

Today, however, ALS technology benefits from microchip technology – "smart sensors" that can be inexpensively added to many different lighting devices, with the intelligence to do much more than make simple on-or-off decisions. Modern ALS sensors can precisely measure the amount of daylight or other light present, sending signals to adjust lighting control systems accordingly.

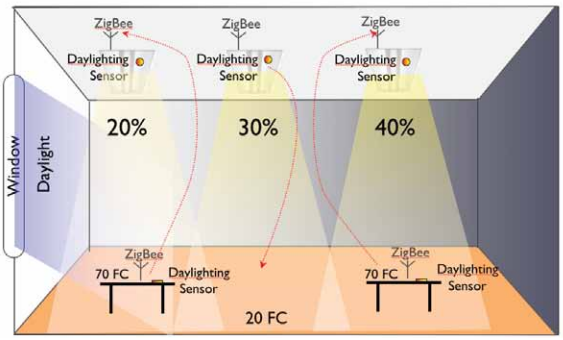

Fig. 3. Sensor driven lighting adjustments maintain constant illumination (70 foot candles on desks) while reducing output based on available daylight.

With a keen eye on efficiency, commercial lighting manufacturers are currently focused primarily on fluorescent and LED lighting technology. Fluorescent light is well known and offers very inexpensive, long-lasting (typically 20-30,000 hours) lamps. But for some users, fluorescent light has brought with it a less than positive overall reputation stemming from its subtle flickering at the AC line frequency as well as its limited spectrum (not all colors are present in fluorescent light). Although modern fluorescent lamps are highly efficient, adding the components to support dimming can be costly, and the nature of the ballast systems does not lend them to the faster on/off cycle times that would be considered ideal for motion sensor or proximity control scenarios.

LED lighting, when properly designed, offers even longer life (30-50,000 hours), a more pleasing spectrum, no flicker, and can be readily dimmed. The initial cost of LED-based lighting systems is generally more expensive than fluorescent, however, manufacturing costs are coming down and by 2021 LED lighting is expected to capture 52% of the commercial building market.[2] As with other higher efficiency light sources, LED lighting degrades over time. This "lumen depreciation" is accounted for in typical building lighting strategies, most often by initially over-lighting the space so that as the light source dims over time, the overall light level remains above the minimum target level. With it's readily controllable output, LED lighting technology lends itself to being initially "under-driven" to allow drive currents to maintain a constant light output as time progresses.

Strategies for automated energy saving for commercial lighting may include such features as occupancy/proximity detection to determine when people have left a room, timer controls, and daylight adaptation with ALS. The information obtained through ambient light sensing may be used to control lights in several ways:

Dimming: Works best with LED lights. The same type of sensor used for daylight harvesting can also be used to determine the amount of total light being generated by a specific luminaire. Using standard feedback loops and control mechanisms, the ALS can be used to maintain constant lumen-output throughout the life of the luminaire, eliminating the energy waste of overlit space.

Selective Light Switching: Works best with fluorescent lights. In large rooms, patterns such as turning on every second or third light can create increments of light output, dimming in fixed steps.

Autonomous Light Controls: Although previous smart lighting controls were always centralized, today's technology enables lights that think for themselves. With ALS built into each lighting instrument, you get on-the-spot decision-making regarding how much ambient light is present. With low-cost and low-power wireless networking (such as ZigBee), or wired networks, group intelligence (semi-autonomous controls aware of what each other are doing, and able to self-organize the most efficient lighting plan for each moment) and centralized control systems can be readily implemented.

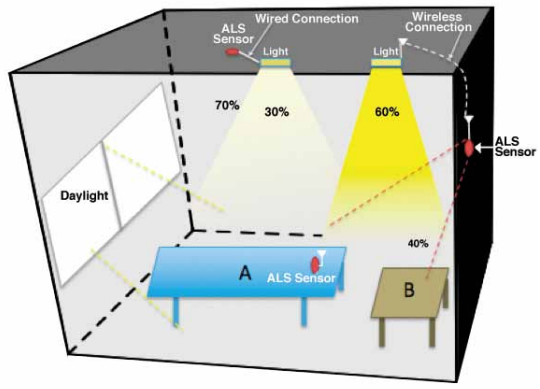

Figure 4. An ALS lighting control system using both wired and wireless communications.

The TSL4531 Ambient Light Sensor

Developed with commercial lighting applications in mind, the TSL4531 offers several key features needed for today's greener commercial lighting. It has:

- Photopic Response that mimics the human eye in color sensitivity, while excluding IR and ultraviolet energy.
- Wide Dynamic Range with High Lux capability, from approximately 220,000 lux down to 3 lux. (By contrast, a typical cell phone sensor only goes up to about 10,000 lux.)

- Digital I²C Interface readily connects to low-cost microcontroller and/or wired or wireless networking.
- Low Cost, at well under a dollar per unit in quantities it can be built into LED replacement lamps as well as lighting instruments.
- Low Power, negligible when compared with the power savings that are enabled while drawing only 110µA typically and 2.2µA in a power down state
- Small Size, at 2mm square, it's small enough to fit into almost any LED luminaire.

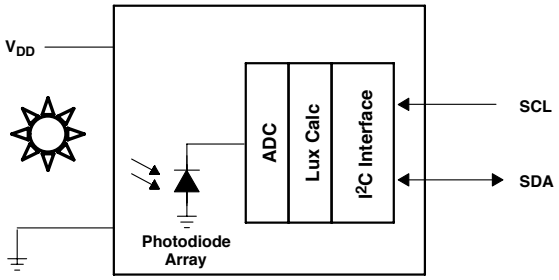

Fig 5. Functional block diagram of TSL4531.

The TSL4531 is well suited to manufacturers developing "Daylighting" lighting products that comply with California's new Title 24 building codes, as well as anyone else creating green, energy efficient next-generation lighting. A companion developer's kit, the TSL4531EVM, makes evaluation and development with the TSL4531 easier.

Fig 6. The TSL4531EVM evaluation board is a self contained ALS system. The sensor measures lux directly from ambient light.

Conclusion

Designers of commercial luminaires and lighting systems face pressure from both new government regulations and customer self-interest to make ever greener products offering higher energy efficiency. Daylight harvesting – ambient light sensing automatically reduces the use of artificial light when natural light is abundant and is an easy way to achieve significant reductions in energy consumption. Today's low cost ALS solutions can be built into every luminaire and even into LED replacement lamps which can use ALS to save energy even when no daylight is present. A specialized ALS solution offering photopic response, wide dynamic range and high lux capability, such as the TSL4531, is ideally suited to most intelligent lighting applications.

AMS-TAOS, a subsidiary of austriamicrosystems, makes intelligent optoelectronic solutions for a variety of markets covering smartphones, displays, medical and industrial applications, and offers intelligent ALS devices optimized for lighting applications. For more information, visit www.taosinc.com.

Footnotes:

1 - Source: Strategies Unlimited 2011
2 - Source: Pike Research, "Energy Efficient Lighting for Commercial Markets," 2011

About austriamicrosystems

austriamicrosystems is a leading designer and manufacturer of high performance analog ICs, combining almost 30 years of analog design know-how with state-of-the-art manufacturing and test facilities and production partnerships. austriamicrosystems leverages its expertise in low power and high accuracy to provide industry-leading standard and customized analog products. Operating worldwide with more than 1,200 employees, it focuses on the areas of power management, sensors & sensor interfaces and mobile infotainment in its markets Consumer & Communications, Industry & Medical and Automotive. Through the combination with TAOS, a world leader in advanced light sensors, austriamicrosystems has expanded its innovative sensor offering for growth markets such as mobile devices. TAOS' broad portfolio of display and lighting management products, including ambient light, proximity and color sensors and mobile lighting solutions, deliver improved system integration, user experience and energy conservation for a broad range of applications including mobile devices and LED lighting. For more information, please visit www.austriamicrosystems.com and www.taosinc.com.

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