Daylight Harvesting Made Easy

Conserve Energy, Save Money and Increase Productivity.

LEVITON®
Building a Connected World

Overview

Faced with the skyrocketing cost of energy and environmental concerns, builders, architects and lighting specialists are increasingly turning to daylighting as a primary source of illumination in mainstream construction. Daylighting will provide tremendous operating cost reductions if properly integrated with an electrical lighting control system.

At the same time, proper daylighting can increase the comfort and productivity of a building's occupants. It provides superior quality light for a wide range of tasks in the workplace. Windows, skylights and other clearstories used for daylight integration can also improve ventilation, lower air conditioning costs, and provide workers with visual stimulation. Exposure to both daily and seasonal cycles of natural daylight has also been shown to positively affect both the mood and stress levels of occupants.

For successful daylight integration, certain principles need to be followed in terms of optimum building placement: the location,design and selection of materials for fenestration (windows, skylights, etc.) and electrical lighting design. In general, the earlier in the design process of new buildings that daylighting issues are addressed, the more successful the daylight harvesting project will be.

To take full advantage of daylight integration, buildings should have automated controls that either turn off or dim artificial lighting in response to the available daylight in the space. This is traditionally called "daylight harvesting."

A Closer Look at the Advantages of Daylight Harvesting

Greater Health, Well-Being and Productivity

There is strong evidence that daylighting can improve the health, well-being and productivity of occupants. Daylight generally has a high color temperature, high color rendition and is rich in blue radiation. Both good color identification and improved visibility are attributed to these factors. People generally describe daylight as providing better visual clarity and color differentiation. One 2003 study of office workers in California[1] confirmed that workers exposed to daylight through a window with a view versus those with no window performed 10-25% better on mental functioning and memory recall tests. On the other hand, the study also found that glare from windows was associated with poorer office worker performance. Greater glare caused performance on three mental function tests to decrease by 15-21%. Clearly, daylighting needs to be carefully planned to reap its benefits while avoiding the pitfalls.

Although artificial lighting is an integral part of modern living, the positive effects of daylight remain unchanged. Daylight provides a connection to the outdoors and supplies occupants with information on time of day, the seasons and weather conditions. In so doing, it keeps occupants more alert by providing frequent changes in focal distance, which helps eye muscles to relax. Whether associated with a view or not, daylight also entrains and reinforces circadian rhythms, helps to maintain daily sleep cycles, avoids seasonal affective disorder and more. Lastly, research in Sweden measuring cortisol (a stress hormone) levels in school children also found that working in classrooms without daylight adversely affected concentration and cooperation and eventually impacted developmental issues and frequency of absences due to illness.

Increased Energy Savings

With lighting accounting for approximately 38% of all energy consumed in modern buildings, daylight harvesting can significantly lower energy costs by providing illumination while allowing electric lighting to be automatically dimmed or switched off. Daylight harvesting also produces a lower cooling load than electric lighting for the same amount of illumination, resulting in lower cooling costs. This assumes that the daylight integration will be thoughtfully designed to avoid glare and overheating. In the end, to achieve high quality lighting and produce energy savings, daylighting and electric lighting systems must be designed together so they complement each other. Lighting controls are a major area of integration for these two sources of illumination.

Daylight harvesting starts with lighting controls that are flexible enough to accommodate the changing requirements of occupants in a space. Factors such as bi-level and multi-level switching or dimming capability as well as separate circuiting of luminaires in daylighted zones enhance both the usability of a space and energy savings. Control flexibility improves lighting energy performance by establishing a base level of illumination and then encouraging the use of only those lights that are needed for the activity at hand. It also increases occupant satisfaction through user control.

On the other hand, while some occupants are quite conscientious about manually "tuning" lighting for their needs, including turning off or dimming lighting when not needed, automatic systems tend to result in greater energy savings over the long run. They should always be supplemented with manual override to accommodate individual differences. Automated systems usually include optical sensors (photocells) that read ambient light levels to both maintain a base level of illumination, by using as much free natural daylight as possible, and occupancy sensors to shut lights off when spaces are unoccupied. Depending on the level of sophistication of the system, it might also include time scheduling capability, load shedding, an HVAC interface, and other lighting control strategies to extend the energy-savings generated by a daylight harvesting system.

[1]Windows and Offices: A Study of Office worker Performance and the Indoor Environment – CEC PIER 2003 (Heschong Mahone)

Key Issues of Daylight Harvesting Design

From a lighting perspective, daylight can be treated as any other light source and used to compose lighting design solutions with illuminance, luminance, contrast, color and other lighting design elements. The best daylight harvesting designs are initiated early in the design process of new buildings when building orientation and location of fenestration – the glazed entry points of daylight – are decided. Designers should also fully assess the availability of daylight prior to design of the electrical lighting system.

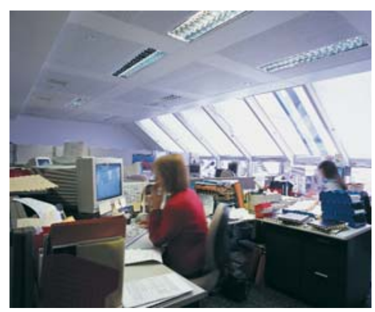
Optimizing a Building's Orientation

A building's orientation must be optimized so that its position allows maximum daylight while minimizing unwanted solar gains. This is easiest to achieve with north-facing windows as sunlight only strikes a north-facing window in early morning and late evening during the midsummer period. South-facing windows are the next best option because of the high angle of the sun, which can be easily shaded using horizontal overhangs. Windows that face in an easterly or westerly direction, where the sun is low in the sky, are more problematic as overhangs or other fixed shading devices are of limited utility in controlling glare. Any window orientation that is more than 15° off of true north or south requires careful assessment to avoid unwanted sun penetration. Extreme northern latitudes are the exception and care must be taken in the design of south-facing windows because of the low altitude of the sun during the winter.

Optimizing the Effects of Fenestration

In addition to windows, fenestration can also include glazed doors, skylights and other forms of top lighting. The placement, design and the selection of fenestration materials are also extremely important and can tip the balance between a high- and low-performance building. Fenestration impacts building energy efficiency by affecting cooling loads, heating loads, and lighting loads. Visual comfort is also strongly impacted by window location, shading, and glazing materials. Well-designed windows can be a visual appeal while poorly designed windows can create a major source of glare. Thermal comfort can also be compromised by poor fenestration design. Poorly insulated windows render a space too cool in the winter and too hot in the summer. Windows with low U-values can improve thermal comfort by keeping glass surface temperatures closer to the interior air temperature. In addition, east-west windows and unshaded south windows can cause excessive cooling loads. Windows and skylights provide opportunities for natural ventilation, but they must also be designed to ensure a safe, secure, and easily maintained facility.

Defining the Daylight Harvesting Opportunities of a Building



Daylight harvesting opportunities can be best described as standard, advanced or integrated depending on the following scenarios:

- **Standard:** The architecture, building orientation, fenestration and daylighting opportunities are "fixed" when the daylight harvesting design process starts. The focus is on lighting controls. The designer's key concerns are whether daylight can provide useful illumination during occupied hours and if any electric lighting can be circuited for manual or automatic dimming or switching in response.
- **Advanced:** The lighting designer has the opportunity to influence some of the building's glazing properties, shade controls and other features to improve the benefits of daylight harvesting. The focus is on quantifying the contribution of daylight harvesting and glare management. In this scenario, the designer would recommend external shading devices or internal window controls such as blinds to allow occupants to make adjustments to ensure comfort. For skylights or roof monitors, they would also recommend diffusing glazing, baffles or louvers to diffuse sunlight. Working with the design team, they would also evaluate the impact of changes in glazing performance, assess the effect of potential

glare sources such as white or bright reflective surfaces on occupants and help define any repositioning of occupant's activities needed to avoid potential sources of glare. Automated, daylight-responsive controls should be incorporated in areas with daylight contributions.

- **Integrated:** An in-depth analysis is performed on the daylight harvesting potential of a building at the earliest possible stage before construction. The focus is on architectural solutions and their full integration with electric lighting and lighting controls to provide high quality daylight illumination. The designer would evaluate if the quality, distribution or amount of daylighting could be improved during pre-design and schematic design phases. Modeling software would be used to evaluate the full integration of daylight harvesting and electric lighting controls with buildings characteristics. A thorough evaluation encompasses testing window placements for maximum distribution of daylight, including ceiling plane adjustments, the effect of adjusting light transmission levels of windows, and the consequences of the position and level of reflectivity of surfaces, either internally or externally, to direct daylight more deeply into the building's interior. Total building automated lighting controls are used to maximize daylight harvesting benefits and energy savings.

Predicting Potential Savings from Daylight Harvesting

From an energy perspective, the most obvious use of daylight is to permit dimming or switching off of the electric lighting system. However, predicting energy savings based on available daylight is not easy. As these savings often justify the added cost of daylighting integration elements, such as dimming ballasts and photoelectric controls, predicting potential savings with some certainty is a very important and powerful tool. The savings can best be described as providing minimal, good or optimal control depending on the following scenarios:

Potential Savings from Daylight Harvesting

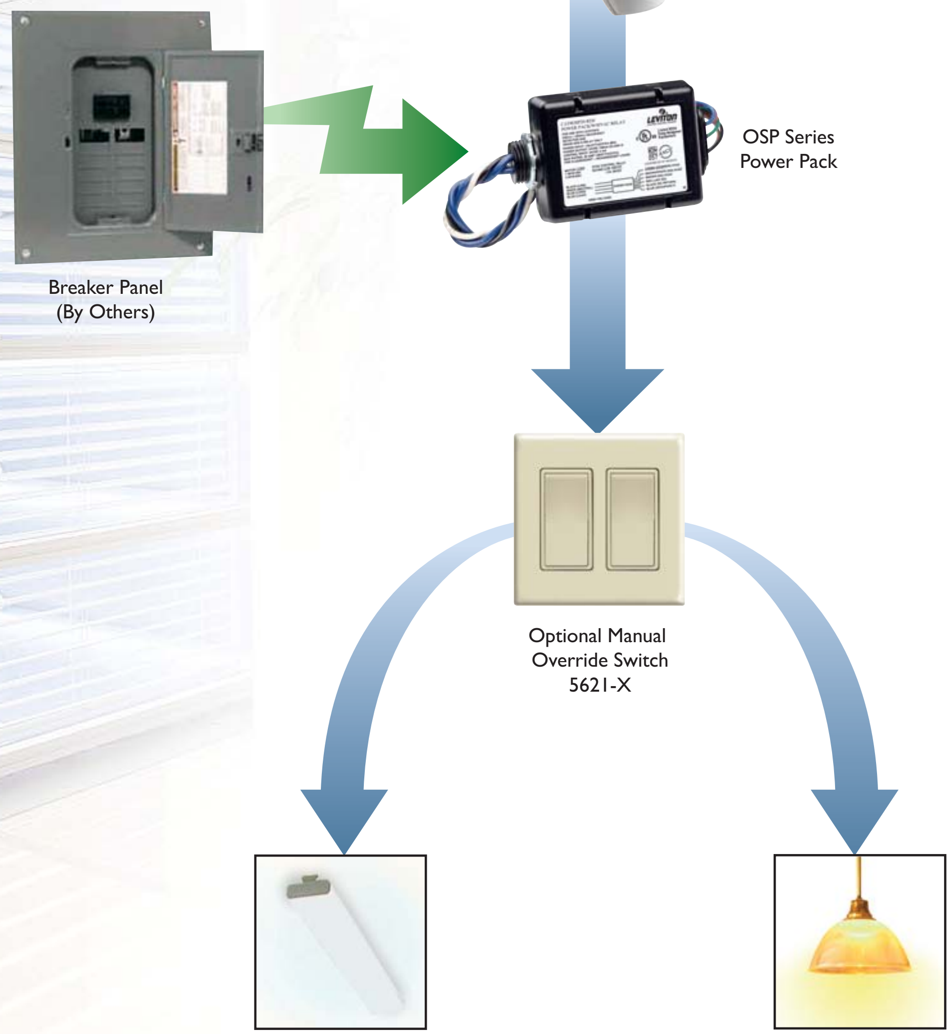
Strategy	Savings	Issues	Products
Minimal Control: Either separate bi-level manual switching for overhead lights within 15' of all perimeter windows, or occupancy sensors with Ambient Light Hold-OFF feature. Task lights should have local switching.	Consumption will be reduced 10 to 20% in areas with daylight contribution.	Occupant preference and training in the use of daylighting controls will result in the most significant energy savings. This strategy is most beneficial in owner- occupied buildings.	Leviton standard line-voltage switch for bi-level approach. Leviton ceiling, wall or wall box occupancy sensors.
Good Control: Same as above, but add manual dimming in place of switching schemes.	The average savings has shown to be 25% with the addition of manual dimming.	Fluorescent dimming ballasts can add $0.25 to $0.75 per square foot to system cost. Energy savings can offset incremental costs quickly.	Same as above, plus Leviton wall box fluorescent dimmer controls.
Optimal Control: Automatic daylight harvesting controls in all areas with daylight. Should be connected to whole building automation controls with occupancy sensors for optimal savings.	Studies performed by LBL* have shown energy savings as much as 45% when an integrated daylighting control system is used with scheduling and occupancy sensors. *Lawerence Berkley Laboratory	Savings will be dependent on the typical occupant use of the space. Occupant satisfaction is very high with this approach.	Leviton miniZ Daylight Harvesting System networked with a Z-MAX building lighting automation relay controller.

Typical Diagrams For Minimal, Good and Optimal Control

Minimal Control with Photocell Hold-Off Feature

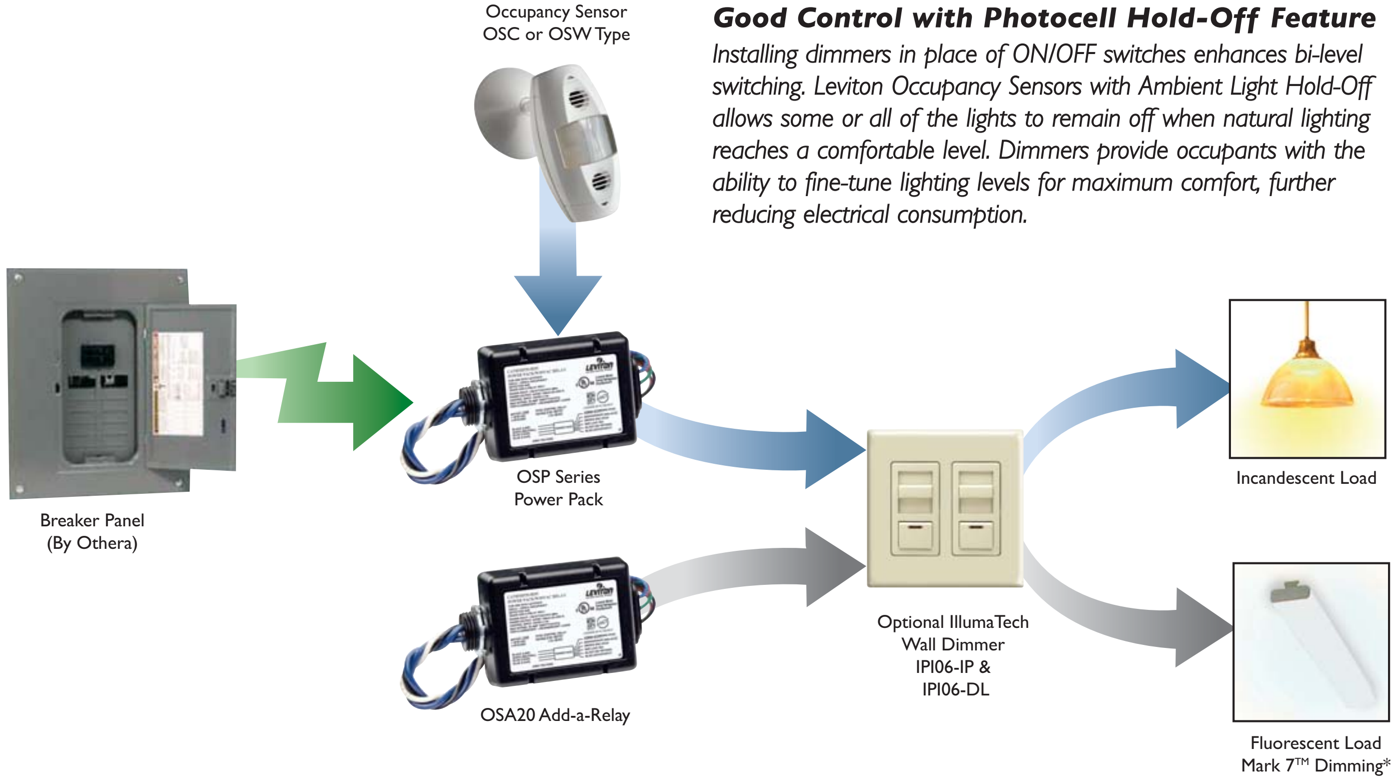
Basic bi-level switching is achieved with a mix of manual switches and Leviton Occupancy Sensors with Ambient Light Hold-Off. This allows some or all of the lights to remain off when natural lighting reaches a comfortable level, reducing electrical consumption.

Occupancy Sensor
OSC or OSW Type



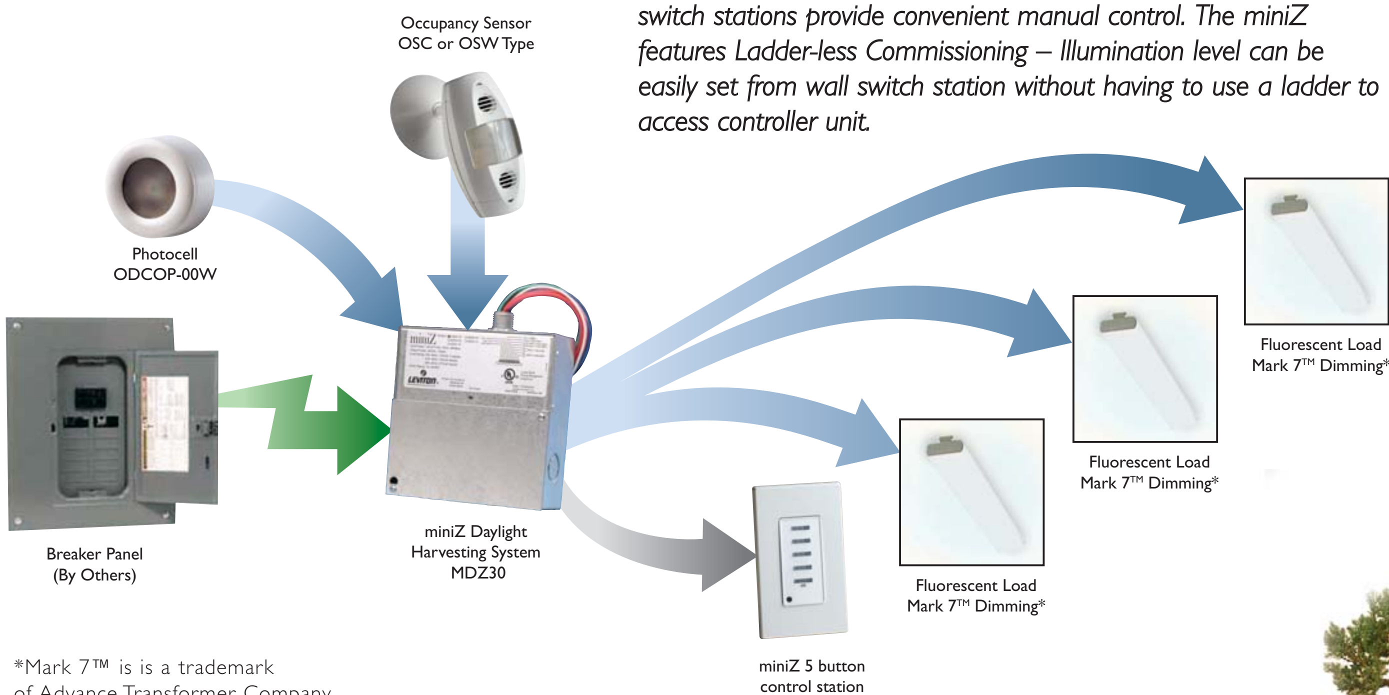
Good Control with Photocell Hold-Off Feature

Installing dimmers in place of ON/OFF switches enhances bi-level switching. Leviton Occupancy Sensors with Ambient Light Hold-Off allows some or all of the lights to remain off when natural lighting reaches a comfortable level. Dimmers provide occupants with the ability to fine-tune lighting levels for maximum comfort, further reducing electrical consumption.



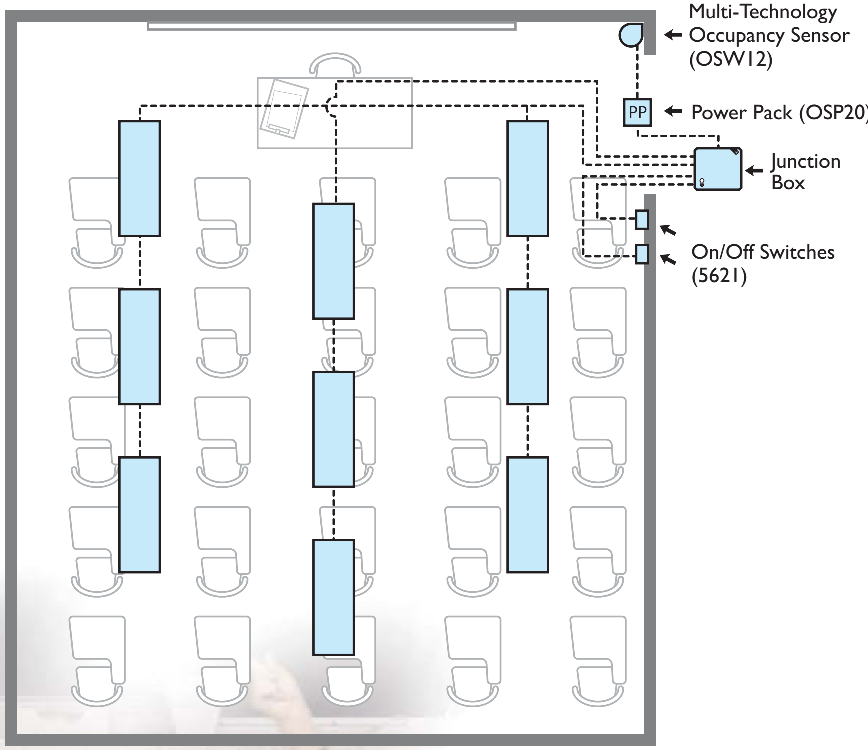
Optimal Control with Automatic Daylight Harvesting

Leviton's miniZ Daylight Harvesting Controller provides optimal balance of natural and artificial lighting for maximum comfort and energy-savings. The photocell measures the ambient light and the miniZ adjusts dimmable fluorescent fixtures accordingly to achieve user-preset illumination levels. The occupancy sensor ensures that lights remain off when the space is unoccupied. Low-voltage wall switch stations provide convenient manual control. The miniZ features Ladder-less Commissioning – Illumination level can be easily set from wall switch station without having to use a ladder to access controller unit.

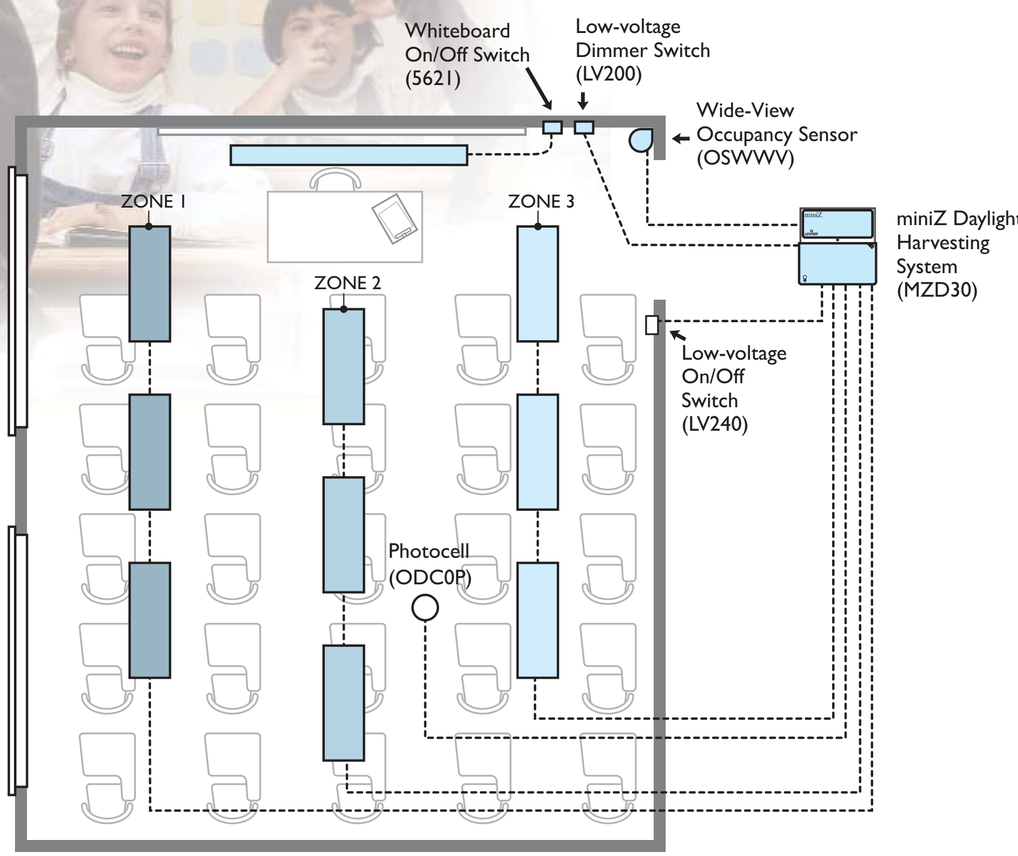


*Mark 7™ is is a trademark
of Advance Transformer Company.

Daylight Harvesting Applications

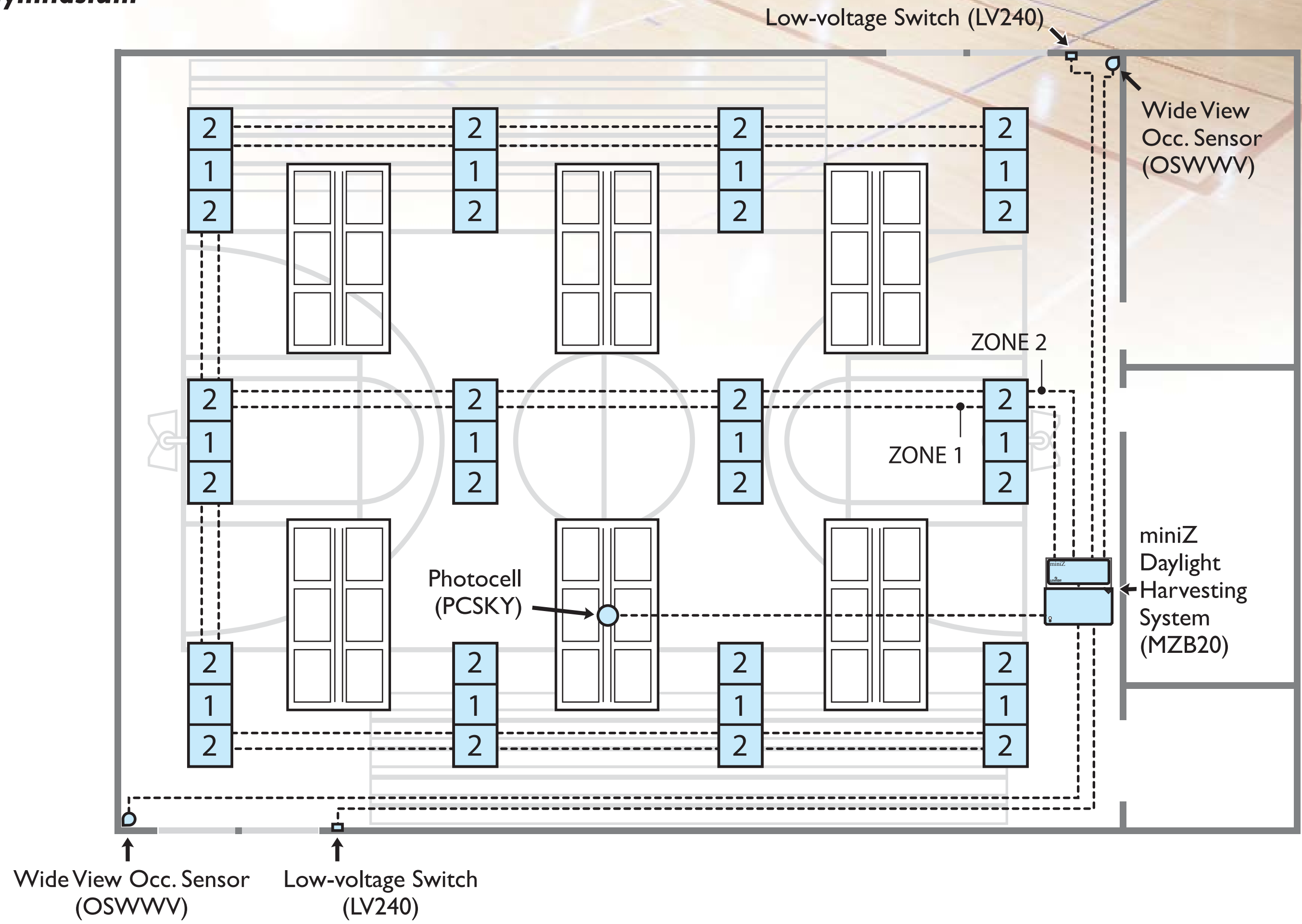


Basic Windowless Classroom



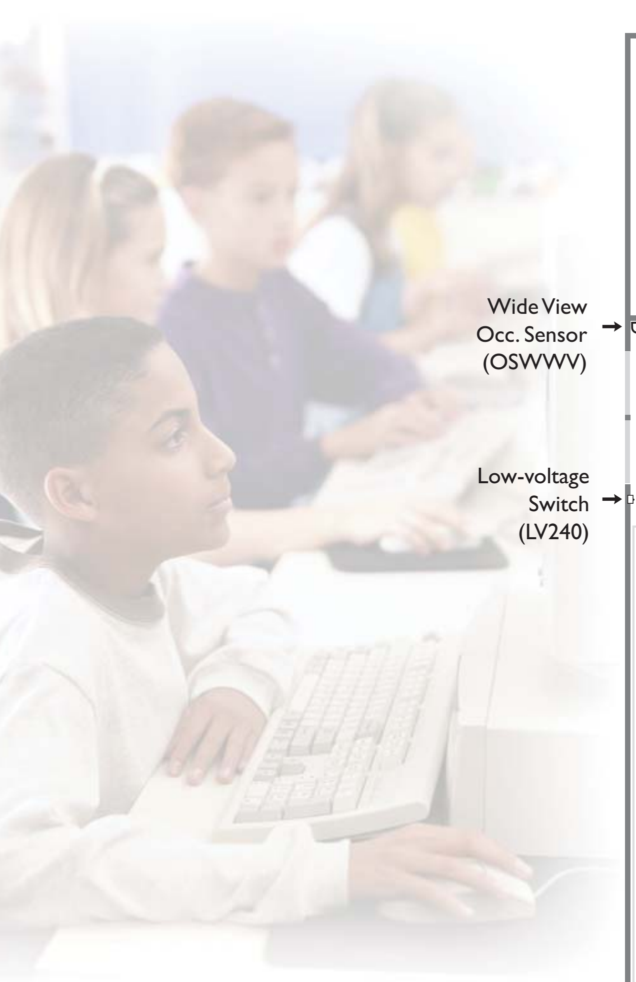
Advanced Classroom with Windows

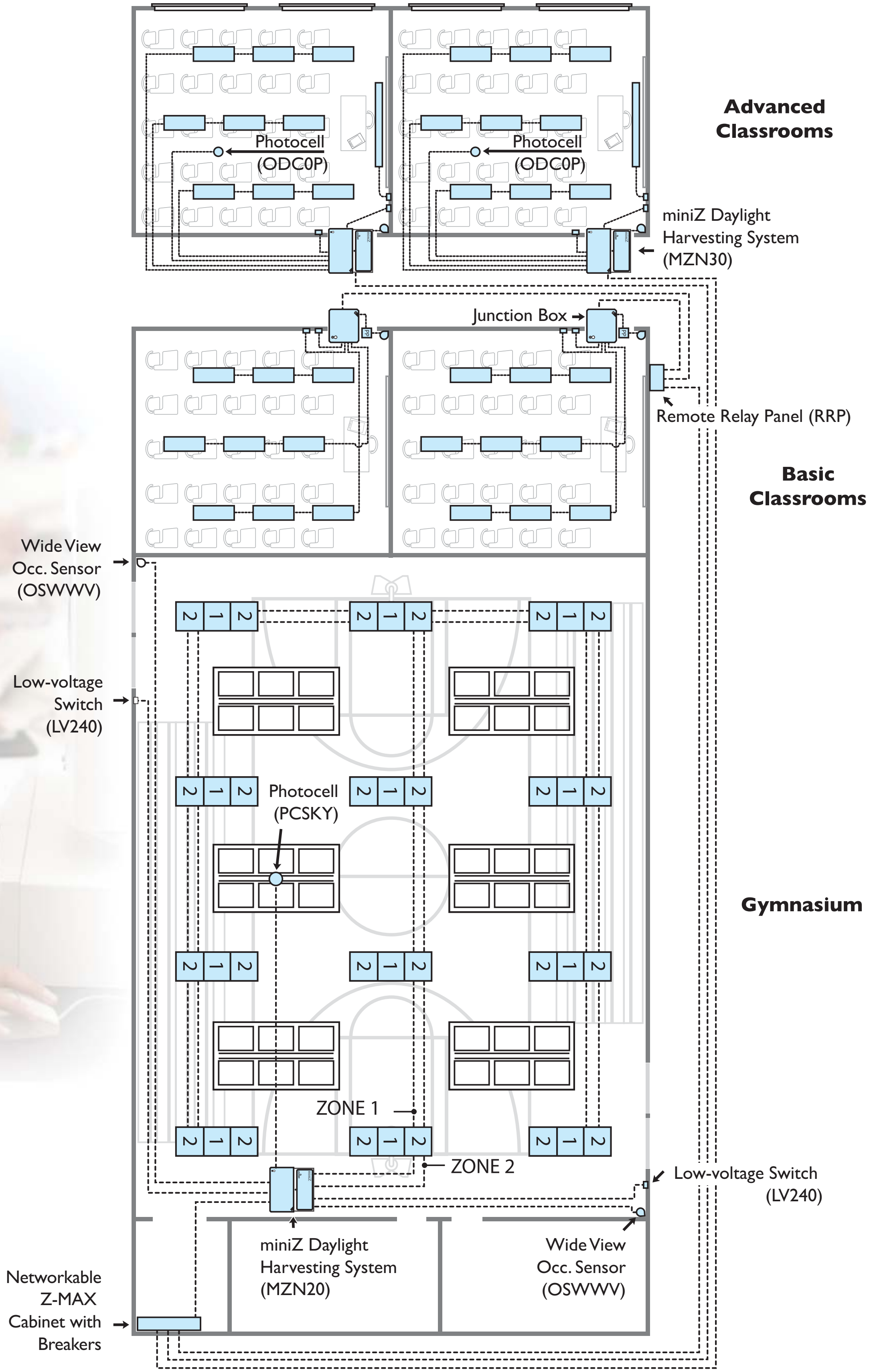
Gymnasium



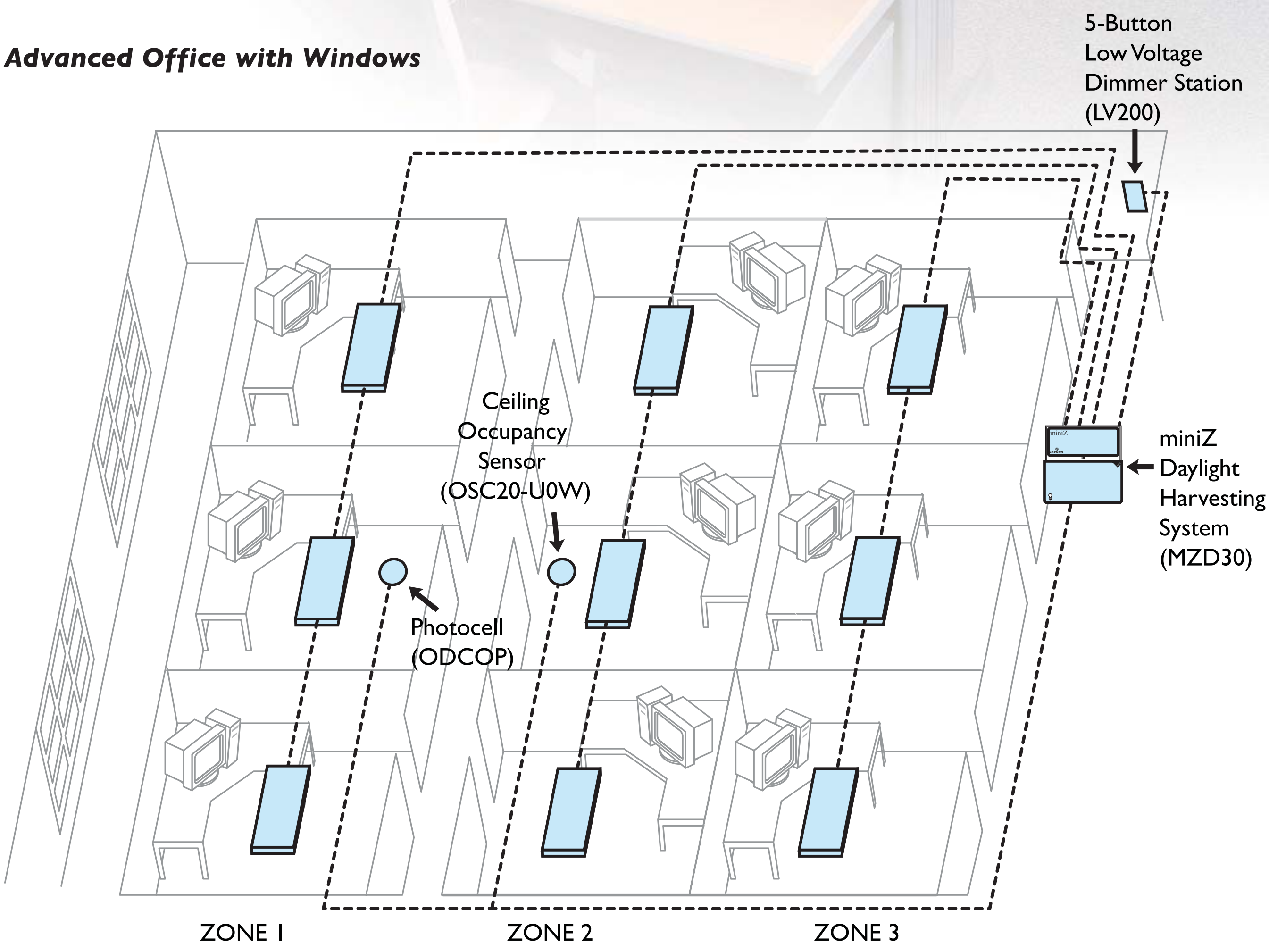
Low-voltage Switch (LV240)
Wide View Occ. Sensor (OSWWV)
ZONE 2
ZONE 1
miniZ Daylight Harvesting System (MZB20)
Photocell (PCSKY)
Wide View Occ. Sensor (OSWWV)
Low-voltage Switch (LV240)

Networked School





Advanced Office with Windows



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