LED Office Lighting and Advanced Lighting Control System (ALCS)

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LEGAL NOTICE

ABBREVIATIONS AND ACRONYMS

ALCS	Advanced Lighting Control System
CLTC	California Lighting Technology Center
ET	Emerging Technologies Program
GSA	U.S. General Services Administration
IES	Illuminating Engineering Society
IPMVP	International Performance Measurement and Verification Protocol
LED	Light-emitting diode
NA	not applicable
PG&E	Pacific Gas and Electric Company
TBD	to be determined
THD	total harmonic distortion

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EXECUTIVE SUMMARY

An initial energy savings of 21% resulted from replacing fluorescent lighting with LED lighting in an office. A further energy savings of 41% resulted from adding an advanced lighting control system (ALCS), according to the results of a test in a Class A commercial office space in 2012.

ANALYSIS OF PHASED APPROACH

To assess the energy savings potential of LED lighting with ALCS, the control strategies were implemented and monitored in the following phases:

0. Existing fluorescent lighting
1. New LED luminaires at full power, with manual on/off control, using 2'x2' LED fixtures from Cree and Corelite
2. ALCS with task tuning only (80% powered) using a wireless control system from Adura
3. ALCS with task tuning, occupancy sensors, and daylight sensors, using sensors from Leviton
4. Fully functional ALCS with individual dimmers

Energy was saved at each phase. Task tuning the light level for different spaces (phase 2) provided a stable reduction in power for the entire floor; however, implementing occupancy sensors and daylight sensors (phase 3) provided the most savings. Some additional savings accrued based on individual controls (phase 4).

If a more aggressive task tuning approach were implemented with each space individually tuned to user requirements or standard illuminance values, then the savings for task tuning (phase 2) would increase. The savings from occupancy sensors and daylight sensors (phase 3) might not vary much from the levels measured in this study, but the additional savings from user control (phase 4) would probably be reduced, were more aggressive task tuning implemented.

PRODUCT DISCUSSION

LED sources were selected as they are highly configurable, providing the same or more lumens per watt than the incumbent technology. ALCS provides a control platform that permits fixtures to be individually tuned, switched, or dimmed.

APPLICABILITY

The high degree of configurability offered by this fixture-control pairing is attractive to customers who operate at technology's leading edge, especially those who have interest in maximizing both individualized distributed environmental control and sustainable energy saving practices.

POTENTIAL BARRIERS

The project payback period calculated in this study for the retrofit of LED office lighting and controls is generally greater than 50 years. The project economics at this stage are a significant barrier to market adoption for most commercial customers, particularly in a retrofit situation, where functioning lights and equipment would be replaced. By contrast, in a new construction situation the incremental costs are much lower, where LED lighting with ALCS is compared to other options. In new construction, the payback period is expected to be more favorable.

Moving forward, standards for the controls are vital to ensure energy savings. Standards should include those for establishing a baseline, commissioning the product, and reporting the results. Standards and future policy decisions to promote market adoption should give users increased confidence in performance reliability.

POTENTIAL BENEFITS BEYOND ENERGY SAVINGS

ALCS is recommended as a utility-approved energy savings measure for a variety of reasons: besides yielding proven energy savings, ALCS promotes increased flexibility in the user interface. ALCS can extend lamp and lamp driver life. LED sources offer lighting distribution, color rendering, and color temperature which are comparable to or better than fluorescent sources. ALCS allows LED sources to be controlled with precision.

INTRODUCTION

Keeping pace with the ever-increasing options for energy-efficient technology, PG&E seeks to broaden its incentive program for energy savings by testing LED lighting controlled by an advanced, wireless system. Lighting is addressed because it contributes greatly to a building's energy consumption. To encourage efficiency improvements by commercial customers, PG&E must consider viable energy solutions and verify results. Doing so permits PG&E to continue leading California toward a more sustainable future.

For this project, PG&E teamed with EMCOR Energy Services to conduct a test on the tenth floor of the General Services Administration (GSA) office building at 630 Sansome Street, San Francisco, CA. The goal was to evaluate the impact of LED lighting and an advanced lighting controls system in a generic commercial setting. To complete the project, PG&E contracted Enovity, a local engineering firm, and Adura, a specialist in wireless lighting controls, to install Cree and Corelite 2'x2' LED fixtures and accompanying equipment and to implement the Adura wireless control system. The project lasted approximately four months, testing different light fixtures and controls over five phases.

BACKGROUND

Lighting is the largest single category of end-use energy consumption in the commercial sector.[1] Lighting accounts for 38% of all electricity used within commercial buildings and contributes to about 20% to 30% of peak hour commercial loads.

Presently, linear fluorescent lights illuminate the majority of commercial facilities. According to a study of installed commercial lighting, linear fluorescents are 80% of the total installed lighting, compact fluorescents are 10%, and the rest are incandescent, halogen, high intensity discharge, or other sources.[2]

Lighting upgrades are adopted whenever cost effective efficiency improvements appear in the marketplace, as is well demonstrated through the rapid acceptance of T8 fluorescent and electronic ballast upgrades over the last twenty years. This phenomenon is especially true in the commercial sector and in Class A office space particularly. Property managers and owners tend to be early adopters of technology, having resources and making investments to promote competitive sales and leasing. Visual comfort, a modern image, sustainability, user choice, and other intangibles might result from an advanced lighting controls upgrade. Improved lighting with advanced lighting control systems could potentially reduce overhead operating cost (through energy and maintenance savings) as well as boost worker well-being and productivity. For these reasons, an office space provides an appropriate setting to test acceptance of the combination of LED fixtures and Advanced Lighting Control Systems (ALCS).

EMERGING TECHNOLOGY/PRODUCT

With the development of general illumination white LED lighting, the lighting industry is experiencing a revolution as important as the development of fluorescent lighting in the 1930s. After the investment in resource development of LED lights, the cost of LED lights is predicted to decline.

As projected by the lighting industry, the payback periods for some LED light fixtures will soon be on par with fluorescents as an option for new construction in offices. However, LED lights presently remain an expensive alternative to fluorescents as an option for retrofits.

LED lighting has the following benefits in comparison to traditional light sources:

- Long life, projected at 50,000 hours and greater for well-designed luminaires
- Directional light source that allows for well-controlled light distribution
- Low energy consumption
- No ultraviolet radiation
- No radiated heat from the light

[1] Rosenberg, Mitchell (August 2012), *Moving Targets and Moving Markets in Commercial Lighting*. Washington, DC: American Council for an Energy-Efficient Economy (ACEEE) Summer Study on Energy Efficiency in Buildings. http://www.aceee.org/files/proceedings/2012/data/papers/0193-000084.pdf

[2] Ashe, Mary, et al. (January 2012), *2010 U. S. Lighting Market Characterization*. Washington, DC: U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy. http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/2010-lmc-final-jan-2012.pdf

- Variety in color spectrum with no usage of filters
- Shock resistance
- Easy digital control

The benefit of easy digital control enables an advanced, wireless control system. Controls have advanced significantly over time – from wired rheostat dimmers to auto-transistors, switching relays, and now to wireless controls. Each advance has reduced energy consumption and permitted added control capabilities. This project considers a few market options which can be incorporated into a wireless control network: daylight sensors and occupancy sensors.

Daylight sensors have been on the market for over ten years but still are not prevalent. They respond to artificially and naturally overlit conditions, dimming either independently or by means of an energy management system. Unlike occupancy sensors, daylight harvesting can produce significant savings from peak reduction, which can improve the payback period.

Ultrasonic and infrared occupancy sensors have been available for over twenty years. Consequently, their commercial presence is greater and more is known about their capabilities. Like daylight sensors, occupancy sensors can function independently or with an energy management system. Savings depend on the occupancy rate and duration, sensor type, layout, time setting, and commissioning.[3]

The wireless ALCS that responds to the sensors has significant benefits compared to the wired alternative:

- The wireless design reduces material and installation costs.
- The wireless design facilitates access and servicing.
- The wireless network scales easily and can be expanded cost effectively.
- The wireless network simplifies and enables easier tuning of fixtures and other equipment.
- Finally, the wireless design permits customization per space requirements.

[3] Brambley, M.R., et al. (April 2005), *Advanced Sensors and Controls for Building Applications: Market Assessment and Potential R&D Pathways*. Washington, DC: U.S. Department of Energy. http://apps1.eere.energy.gov/buildings/publications/pdfs/corporate/pnnl-15149_market_assessment.pdf

ASSESSMENT OBJECTIVES

The main objective of this field assessment is to rate the energy savings potential of LED lighting in combination with ALCS in an office environment. Discerning reliable designs and solutions will enable PG&E to broaden its incentive program for commercial customers to potentially include LED fixtures with or without added controls.

The products evaluated in this project are relatively new and not widely adopted. The LED market is growing steadily, and wireless networks in lighting designs are in practice. However, the performance of LED lighting and ALCS in real world installations has not been broadly studied.

To assess the energy savings potential of ALCS, control strategies are implemented incrementally and maintained for a fixed period of time before additional strategies are enabled. Based on the data collected from each period, the energy use can be determined and compared to the energy use from the other periods to determine the savings attributable to each set of control strategies. The base case for this project consists of the incumbent fluorescent fixtures at full power with manual on/off controls. The fixtures are replaced with LED lighting, and energy use is again monitored to quantify savings from the LED lighting. Advanced lighting controls are then installed, and control strategies are implemented incrementally and monitored. There are five periods, or phases, as follows:

- Phase 0 (base case): monitoring period of full power, on/off-controlled fluorescents.
- Phase 1 (new LED luminaires): monitoring period of full power, manual wall-switched on/off-controlled LED.
- Phase 2 (ALCS task tuning only): monitoring period of 80% powered, on/off-controlled LED lights.
- Phase 3 (ALCS task tuning, daylight harvesting, and occupancy sensors): monitoring period of task-tuned lights with daylight and occupancy sensors. The daylight sensors would dim as more natural light entered the space and brighten as less did. Occupancy sensors would shut off the lights if the monitored space were vacated for several minutes.
- Phase 4 (fully functional ALCS): monitoring period similar to phase 3, but with the added capability to individually dim the fixtures via hand-held remote controls.

Data loggers are installed, associated with six spaces on the office floor. Variables are collected every five minutes. The analysis focuses on power and illuminance measurements, and also reviews total harmonic distortion (THD) and power factor. The goal is to determine the energy savings and lighting performance impacts for each phase as the lighting system is changed and control strategies are implemented. The base case is expected to be the least efficient design.

For the dates and other details of the actual phases, see Test Plan on page 11.

TECHNOLOGY/PRODUCT EVALUATION

LED light fixtures have been available for years, but the energy saving potential of pairing LED lights with an ALCS is not well understood. For this project, two different LED fixtures were tested, one from Corelite and another from Cree. GSA utilized a local company, Enovity, to facilitate procurement of the LED fixtures and complete installation of all hardware. Adura oriented the Enovity installers on the first day to ensure that the sensors and hardware would be properly installed and configured.

There are a variety of sensor and control technologies available in the market. Consequently, PG&E, EMCOR, and GSA met with Adura to learn about available control products in the market. For the project, Adura provided daylight and occupancy sensors, dimming controls and wireless controls.

Below are the specifications for the products included in this study.

- The 44 W Corelite fixture product sheet did not specify the manufacturer's ratings for the 2'x2' Class Z3 Linear Prismatic Lens. However, based on a California Lighting Technology Center (CLTC) test report, the stated efficacy is 78.8 lumens/watt, which is comparable to the CLTC test's result of 80 lumens per watt.[4] The test also produced a color temperature of 3,982 K which is lower than the rated 4,000 K and a lumen output of 3,489 versus the rated 4000 lumens. The fixture has a 50,000 hour lifetime.
- The 35 W Cree CR22 2'x2' troffer is the other type of fixture tested in the project. The manufacturer's efficacy is 90 lumens per watt, which is close to 91.2 lumens per watt, the value reported in the CLTC test results. The test also showed a lower color temperature of 3,939 K instead of the spec sheet's 4,000 K and a lumen output of 3,127 versus the supposed 3,200 lumens. This fixture has a 50,000 hour lifetime and a five year warranty.
- Adura provided the wireless controllers and the sensor interface that enables the wireless network. The controller (LC-1RD) is compatible with dimming, has an input frequency of 60 Hz, and full scale accuracy for voltage and current of 2%. The sensor interface (SIAC-L2) has a radio frequency of 2.4 GHz.
- Leviton supplied the dimmer modules, daylight sensors, and occupancy sensors. The dimmer modules (WSD01-001) accept a range of 50 to 100 feet and within a 315 MHz frequency. The daylight sensor (OSP20-0D0) operates at the same frequency and its range is up to 100 feet. The occupancy sensor (WSC04) has an input frequency of 60 Hz. No physical range is specified. Both sensors have a five-year warranty.
- The dimming wall switches are the Leviton single rocker Decora switch (WSS0S-D).

[4] Graeber, Nicole (July 2012), *Cooper Corelite 2x2 Photometric Report* and *Cree CR-22 Photometric Report*. Davis, Calif.: California Lighting Technology Center. In collaboration with the California Energy Commission, the U.S. Department of Energy, and the National Electrical Manufacturers Association, the California Lighting Technology Center (CLTC) at the University of California, Davis tested lamps against the manufacturer specifications and provided the measured results. The CLTC tested both the Cree and Corelite fixtures. See Appendix E for the results.

PRODUCT CONFIGURATION

These products are tested in a real world office installation, an appropriate choice because lighting use in an office can be found only in a real world situation. The use of occupants working and testing the lights is essential to determining the energy savings. A lab test could discern the "best" solution under strict conditions, but would not account for the variability that occurs in an office.

As a practical matter, varying illuminance levels can be measured at desk (or work) level along with the impact of new ALCS. Office spaces tend to be wired electrically in a modular, uniform way so that energy use can be separated and aggregated with relative ease. Even though worker habits vary, the monitoring of an entire office space would illustrate in general whether greater individual lighting control and dimming would increase savings.

The GSA building at 630 Sansome, San Francisco, CA is the host site for the field assessment. The project scope includes the tenth floor. The physical requirements were simple: a Class A commercial office space utilized by end-users who would have regular exposure to the environment, both before and after the retrofit. The project required access to these workers for surveys, accommodations for equipment on site, the installation and configuration of equipment, building access even in off-hours, commitment to support the project for its duration, and a publication of findings.

Before the project, all fixtures had T8 fluorescent lamps and electronic ballasts. These were monitored for a period before the installation of the LED lights. For that monitoring period, the controls other than simple on/off manual controls were removed.

To better optimize the lighting in the space, a lighting designer advised shifting some the light fixtures in certain spaces and even removing superfluous ones. This occurred during the LED light installation and resulted in a decrease in the total number of light fixtures on the floor. The modifications contributed to energy savings. However, the modifications required extra effort, especially since the LED fixtures are 2'x2' and the original fluorescent fixtures were 2'x4'. Thus, the ceiling tiles for the moved fixtures needed to be cut, replacement tiles were taken from another space, and new tiles were ordered. Such special provisions might not be necessary for similar projects.

EMCOR coordinated with Enovity to complete the installation of all equipment. Adura set up a wireless system, task tuned the lights, and capped "full" power at 80% of the lamp driver capacity. Adura implemented and modified the control strategies and assigned addresses to the fixtures, necessitated by the wireless controls. When problems arose, many could be resolved remotely.

Manual user control was enabled for all phases. The main difference is that final phase featured user-controlled dimming while the other phases featured only manual on/off control. The first two phases lacked any dimming or automatic shutoff, which was provided in the third phase by means of daylight and occupancy sensors. The daylight sensors dim based on the natural light entering a zone; the occupancy sensors are standard motion sensors that turn off the lights when no motion is sensed for several minutes. The schematic layout is provided in the monitoring plan in Appendix C.

TECHNICAL APPROACH/TEST METHODOLOGY

FIELD TESTING OF TECHNOLOGY

The test site is the GSA building in San Francisco. Data were collected for five distinct spaces on the tenth floor. The spaces are two private offices, two open offices (cubicles), and a hallway. Data for the entire floor (referred to as the panel) was also collected.

One of the private offices (Private Office 1) is in the northeast corner of the floor. There are two windows, one on the north wall and the other on the east, and four light fixtures. The other private office (Private Office 2) is on the south side of the floor and has a window on the south wall. There are three light fixtures in this office.

The two cubicles selected for the project are part of an open office area. These two are adjacent to each other, but one is by a south-side window (Open Office 2) and the other is against an interior wall (Open Office 1) away from the windows. There are three light fixtures directly over each cubicle and one between the cubicle partitions.

The hall (Hallway) is the space most isolated from natural daylight. There are four fixtures, including an emergency light on all the time. Some daylight reaches the space from the adjacent offices.

Panel refers to the entire floor. Data are collected for this space and include fixtures not monitored by the individual spaces described above. In other words, the sum of the fixtures of the private offices, the open offices and the hallway is less than the total fixtures on the floor (panel).

Table 1 below summarizes the monitored spaces.

TABLE 1. MONITORED SPACES

SPACE	LOCATION	DESCRIPTION
Private Office 1	Northeast corner	2 windows and 3 Cree fixtures
Private Office 2	South side	2 windows and 4 Corelite fixtures
Open Office 1	Interior	No direct windows and 3 Corelite fixtures
Open Office 2	South side	1 direct window and 3 Corelite fixtures
Hallway	Interior	No direct windows and 3 plus emergency Corelite fixtures
Panel		Originally had 59 fluorescent lights; 26 Cree and 27 Corelite fixtures.

For a sense of the different lighting, see the photographs in figure 1 of the open office by the window. Other photographs of the spaces are in Appendix B.

FIGURE 1. FROM TOP TO BOTTOM, THE OPEN OFFICE IS SHOWN AT A DIMMED SETTING (APPROXIMATELY 50% OF FULL POWER), AT FULL POWER, AND WITH LIGHTS OFF.

TEST PLAN

This project met the International Performance Measurement and Verification Protocol's (IPMVP) guidelines for Option A, "Partially Measured Retrofit Isolated." This is appropriate because the project focuses only on lighting and the directly related loads (which can be measured at the light and power sources and illuminated surfaces). Indirect changes, such as an increased or decreased space temperature, are not considered in this project.

The protocol requires short-term or continuous post-retrofit measurements, and the project complies. Measurements are taken frequently, every five minutes, and each phase with a specific set of functional control strategies is held for three weeks before the next implementation. Three weeks is a sufficient period to recognize reliable patterns and account for infrequent changes in the office. This period length is standard for each phase.

EMCOR visited the test site at least weekly to collect the data and check the equipment. EMCOR was aware of all the fixtures, equipment, and supposed functionality. Routinely, EMCOR reported to PG&E and contacted the subcontractors to address any issues.

The monitoring plan with the map of the sensors and control submitted to PG&E for the project is in Appendix C.

The project accounts for both the incumbent fluorescent base case (phase 0) and the new LED lights (phases 1–4). In phases 0–3, the only manual controls for the lights were to turn them on and off. Before the LED fixtures were installed, the existing fluorescents were monitored for three weeks. The operating hours from this fluorescent case were used as a model for the LED case. This is appropriate because the two periods consisted of the fixtures operating at full power and with simple manual controls.

Power (wattage), illuminance (footcandles), total harmonic distortion (integer), power factor (percentage), and other data points were collected throughout the testing period, May 24, 2012, through September 21, 2012. Power, illuminance, and power factor were collected for individual spaces. Power, total harmonic distortion, and power factor were recorded for the panel. Spot measurements of color temperature and illuminance were taken weekly during the data downloads.

EMCOR oversaw the installation and implementations of the data loggers and fixtures. Later, they worked with Adura to install the sensors. In general, each space monitored is associated with its own power data logger; however, the two open offices share one logger with the rest of the open office area. Thus, as will be seen in the data analysis below, the power analyzed for the two open offices is the same. However, each space had its own illuminance reader and those data are different.

Each phase was three weeks, and data were recorded at five-minute intervals. Downloading of measurements typically occurred each Friday. There was a gap between phases 1 and 2 due to upgrading the fluorescent fixtures to LED lights. This interim period produced data about a varying mixture of fluorescent and LED fixtures on the floor, and all irrelevant data were excluded from this study. In contrast, phase 1 consisted of only fluorescent lights and phase 2 only of LED lights. The phases are described below.

- Phase 0 (5/24/12 to 6/15/12): This is referred to as the base case. The T8 fluorescents were monitored for three weeks before installing the LED lights. Few incidents happened during this period.
- Phase 1: The LED lights were installed after Phase 0. However, due to time constraints, the power was not logged for three weeks but for approximately an hour before task-tuning. To determine potential energy consumption over a longer period, the recorded data were projected onto the trends from Phase 0.

- Phase 2: (7/20/12 to 8/10/12) Once all LED fixtures were installed, the fixtures were task tuned to approximately 80% of full power. Data were recorded at the same interval. Some data loggers were "disturbed" before the complete installation of the LED lights, but they were corrected before the start of phase 2. A private office occupant (northeast corner) vacated the office on 7/28/12.
- Phase 3: (8/10/12 to 8/31/12) Fixtures were outfitted with daylight sensors and occupancy sensors. Data were recorded at the same interval. One of the Cree LED fixtures malfunctioned, affected only the panel data because it was not one of the fixtures being monitored in the five selected spaces.
- Phase 4: (8/31/12 to 9/21/12) Fixtures retained the features of phase 3 and became enabled for individual dimming controls. Data were recorded at the same interval. The failed light fixture from phase 3 persisted into phase 4, and some of the dimming controls malfunctioned. When controlled by the switch on the wall, the lights over the open office area would not stay dimmed. A similar problem occurred in the copy room, but since the copy room is not monitored specifically, that issue affects only the panel data. The open office dimming issue affects both the space and panel data.

Adura's sequences of operation for each phase are in Appendix A.

INSTRUMENTATION PLAN

The following instrumentation tools were used to measure and collect data:

- The Summit Technology Current Probe (HA100) measures from 0.1 to 100 amps with an accuracy of ±2% of ±0.2 A_{RMS}.
- The Summit Technology PowerSight Power Logger (PS2500) measures the power and power factor with an accuracy of 1% plus the accuracy of the current probe. The THD measurements have an accuracy of 1%. The logger resolution is 1 second to 99 minutes.
- The T&D illuminance logger (TR-74 UI) has an accuracy of 5% for the 10 to 100,000 lux range. The tool refreshes every two seconds for the 5 minute interval and has a resolution of 0.01 lux.
- The Konica Minolta CL-200A Chroma Meter measured the color temperature during the weekly data collections. Its range is from 0.1 to 99,990 lux, and its accuracy is ±2% ±1 digit of the displayed value.

The monitoring plan is in Appendix C. The cut sheets for all products are in Appendix D. The CLTC test results are in Appendix E.

RESULTS

At the end of the monitoring period, all the data collected were compiled to create a dataset of date, time, power, illuminance, THD, and power factor for each space and the panel. The data were organized by space and phase. The data were plotted as time series, and the analysis hinges on the chronology-based plots. Other configurations, such as a scatter plot of power and illuminance for a space, were not telling. Another note is that although power is not always drawn, sometimes there is an illuminance reading due to natural light or light entering from an adjoining space.

The discussion below begins with an analysis of power and energy use, followed by illuminance, THD, and power factor. Representative plots are explicitly discussed, and anomalous incidents are mentioned when necessary. Appendix F contains additional plots.

With regard to the numbers collected, the total energy consumption could be approximated for each space during each phase and for the entire project based on the power data recorded and the sampling rate. The consumption difference between these phases would indicate the energy saved or expended.

Upon review of the data with PG&E, it was determined that one of the private offices was vacated part way through the project. Data from this office are therefore not representative of typical operation and was not used in the energy savings analysis.. This produced a 3% reduction in savings between phases 1 and 4 for the panel.

DATA ANALYSIS

POWER

Below in figure 2 is an aggregate plot of power consumed by the entire office floor (panel) for each phase. The energy reduction from the early phases before tapering is conspicuous. Relative to the fluorescent lights, the LED retrofit improved energy savings. The impact of the daylight and occupancy sensors is more noticeable relative to the LED lights than the fluorescents. Note that the power consumption for phases 0, 1, and 4 is low on Monday because of holidays (Memorial Day and Labor Day).

While the energy consumed decreased in total each phase, the maximum power (1570 W) drawn in the first week of phase 4 is slightly greater than the maximum (1568 W) in phase 3. The maxima from the phases 0, 1, and 2 are 2634 W, 2037 W, and 1684 W. Figure 3 shows one day in the same week for better resolution. More detailed analyses of each phase appear in the sections below.

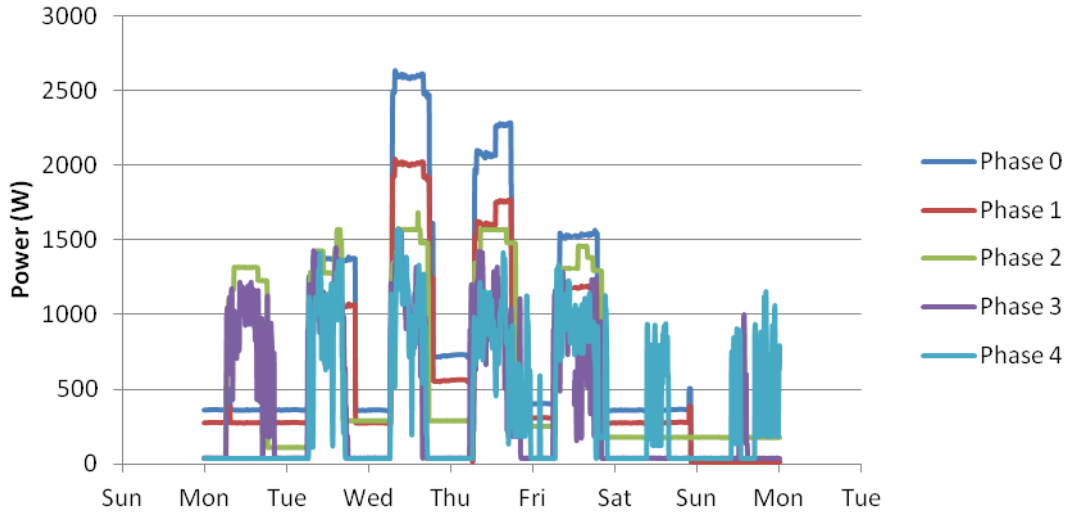

FIGURE 2. PANEL POWER AGGREGATE FOR THE FIRST WEEK OF EACH PHASE

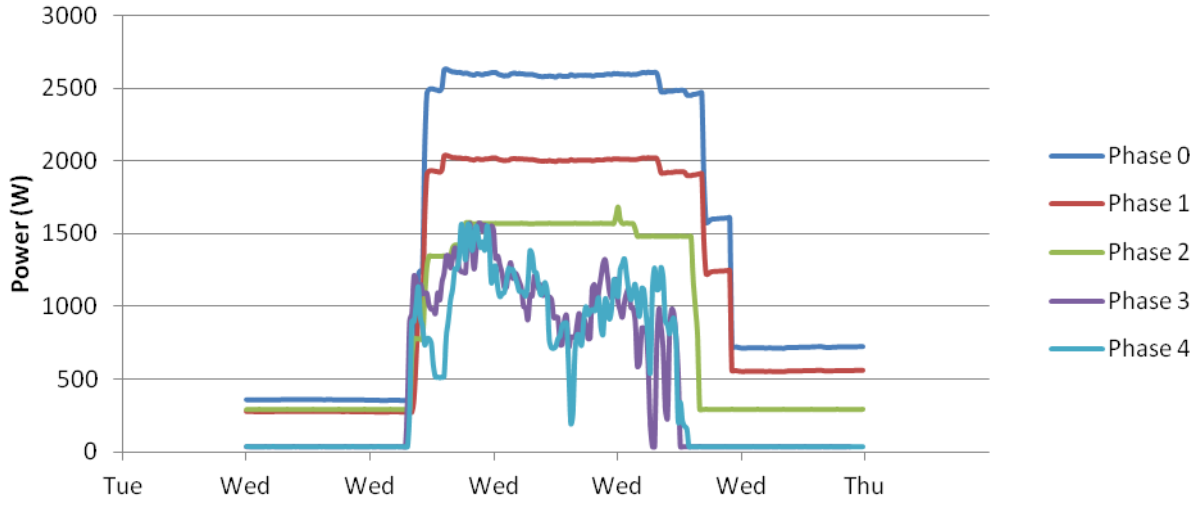

FIGURE 3. PANEL POWER AGGREGATION FOR THE FIRST DAY OF EACH PHASE

PHASE 0: FLUORESCENT INCUMBENTS

Nothing unusual occurred during phase 0, a monitoring period of the original lights controlled on/off. Overall, the data looks as expected. The illuminance and power line up and fluctuate in tandem. Very few anomalies are noted and none are of concern. The most puzzling is the irregular power draw that does not always follow the five- weekday pattern. This phase coincides with Memorial Day, which might account for some irregular patterns.

Figure 4 illustrates the power and illuminance data from the hall. The baseload due to the emergency lights that operate constantly is observed.

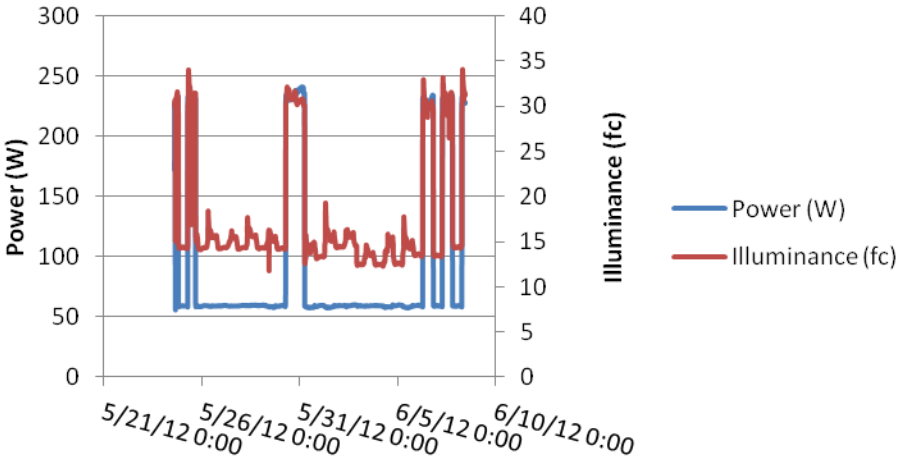

FIGURE 4. HALL: PHASE 0

PHASE 1: FULL-POWER LED LIGHTS

Because there are no measured data of the LED power for a full period, the data for phase 1 were generated by projecting short-term monitoring measurements of LED lights onto the fluorescent operating hours. The panel energy consumption during phase 0 was 404 kWh and phase 1 was 262 kWh.

The key difference is that the LED lights generally consume less energy. The exception is private office 2 and the hallway emergency light. The original fluorescent lights had lower wattage, and the superseding LED lights required more power. Specifically, the private office fixture power input increased from 33.8 W to 46 W and the emergency light power input from 58.5 W to 65 W. A more detailed breakdown of power per fixture for the study is in Appendix F.

PHASE 2: TASK TUNING

The data is largely without incident for phase 2, task tuning, when the lights are still on/off controlled but have a maximum operating power of 80% of capacity. Of note, private office 1 was vacated on 7/28/12.

Figure 5 is a combined plot of power for the whole cubicle area and the individual illuminance data for open offices 1 and 2 for one day. The power source cannot be individually identified because the log is an aggregate of the open office space. Consequently, that draw could be from one of the two monitored spaces or a nearby cubicle. Such constraints limit the analysis.

The plot also shows that open office 2 by the window is more brightly lit than open office 1.

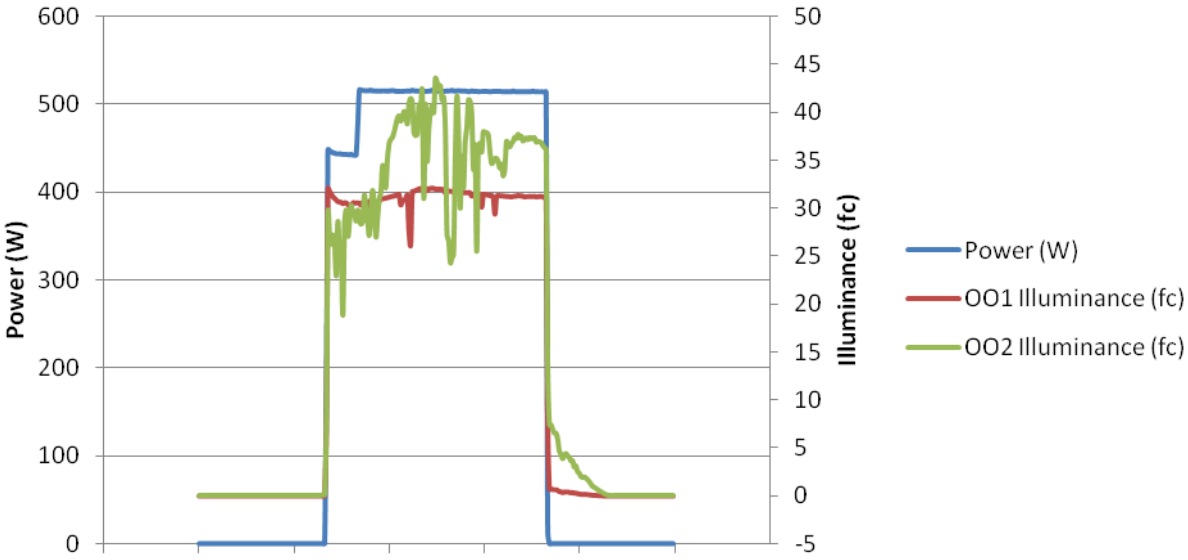

FIGURE 5. OPEN OFFICES 1 AND 2: PHASE 2

PHASE 3: DAYLIGHT HARVESTING AND OCCUPANCY SENSORS

Due to the varying influence of daylight in each space and the location of the illuminance readers in the spaces, the illuminance patterns vary from space to space. For example, open office 1 is away from the window, while open office 2 is adjacent to it. The hallway is the most isolated from daylight. Due to the defining walls, daylight is significant in the private offices. Private office 1 has two windows and private office 2 has one. During this phase, a Cree fixture malfunctioned in the copy room area (only reflected in the panel data) and was not replaced until the second week of phase 4.

Graphically, the data for phase 3 indicate that the illuminance levels are in accord with the daylight influence. The hall's illuminance continues to sync with the power drawn.

Figure 6 shows the interplay between sensors and electrical lights in private office 2. In the middle of the day, illuminance will increase while the power is off due to the natural light illuminating the office. This held true in the open offices as well.

Overall, the case-by-case analysis suggests that the lighting design with the different sensors works successfully. Each system modulates appropriately based on the captured light conditions in the space. Nothing in the system appears to be fixed or rigid.

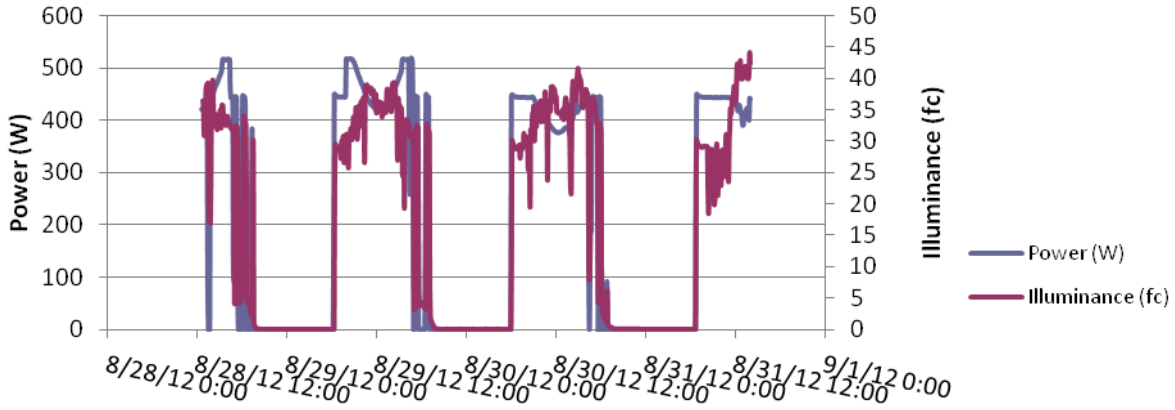

FIGURE 6. OPEN OFFICE 2: DAYLIGHT AND OCCUPANCY SENSOR PHASE 3 (WEEK 3)

PHASE 4: INDIVIDUAL DIMMING CONTROLS

Very little changed from phase 3 to phase 4. Adura enabled individual dimming controls. On the last day of data collection, malfunctioning of the remote controls at some of the open offices (cubicles) was reported. The impact of this on the data is probably small because the occupants did not seem to use the controls often. If they had, then EMCOR would have heard sooner about the issue. An earlier issue in this phase was that the lights in the copy room and open offices would not maintain dimness, that is, the lights would return to full brightness once the wall switches were released. This was corrected by the end of the first week.

The conditions for phase 4 are similar to phase 3. The added dimming controls ideally should show some power reduction based on user control. This might or might not lower the illuminance level, depending on the action of the daylight sensors. The plots for this phase do not differ greatly from those of the phase 3 ones. 7, a panel power plot for phases 3 and 4, reveals that power consumption is slightly reduced. However, whether this reduction is attributable to user dimming or to a change in office patterns cannot be stated.

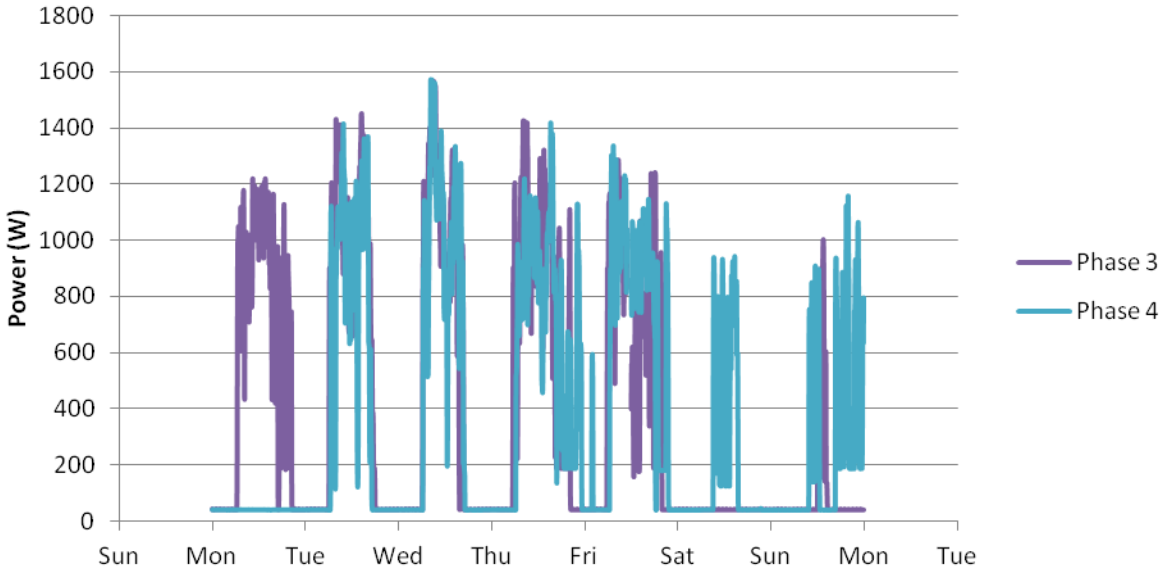

FIGURE 7. PANEL POWER FOR THE FIRST WEEK OF PHASES 3 AND 4

SUMMARY

Overall, upgrading to LED lights and implementing an ALCS were energy saving changes.

For a communal area like the hall where people pass in and out, task tuning is the most effective strategy. Ensuring that the space is adequately lit, not overly lit, is key for savings – more so than relying on occupancy sensors. Sensors reduced savings in the hall, likely because people were not in the space long enough to trigger longer periods of use. Further, if the space is largely isolated from daylight, daylight harvesting is of no value.

For work areas (private and open), both the occupancy and daylight sensors are effective, because those spaces are naturally lit (to varying degrees) and occupied for extended periods. Of note, individual controls did not save as much as task tuning.

For an entire floor area, the combination of occupancy and daylight sensors is the most effective control. Sensors incrementally reduced energy consumption by 45%. Individual dimming controls incrementally increase savings slightly, but the cost trade-off needs to be determined.

Together, all the measures included in phase 4 cut energy consumption by nearly half from an phase 1 consumption.

Table 2 outlines the savings between each phase for each space for a two-week period. The first week of each phase was excluded from these calculations due to the occurrence of holidays. If included, inaccurate savings would be amplified when extrapolated for a year.

TABLE 2. ENERGY SAVINGS

AREA	PHASE 0 CONSUMPTION (KWH)	PHASE 1 CONSUMPTION (KWH)	SAVINGS BETWEEN PHASE 0 AND PHASE 1	PHASE 2 CONSUMPTION (KWH)	SAVINGS BETWEEN PHASE 1 AND PHASE 2	PHASE 3 CONSUMPTION (KWH)	SAVINGS BETWEEN PHASE 2 AND PHASE 3	PHASE 4 CONSUMPTION (KWH)	SAVINGS BETWEEN PHASE 3 AND PHASE 4	SAVINGS BETWEEN PHASE 1 AND PHASE 4
Hall	30	25	16%	9	63%	17	-81%	18	-9%	27%
Private Office 2	13	17	-30%	13	25%	7	46%	7	-4%	58%
Open Offices 1 and 2	112	81	28%	63	22%	53	17%	55	-4%	32%
Private Office 1	21	12	42%	NA	NA	NA	NA	NA	NA	NA
Panel	286	221	23%	187	15%	127	32%	124	2%	44%
Panel Without Private Office 1	265	209	21%	187	11%	127	32%	124	2%	41%
	PHASE 0: FLUORESCENT	PHASE 1: LED		PHASE 2: + TASK TUNING		PHASE 3: + SENSORS		PHASE 4: + INDIVIDUAL CONTROLS		

Notes.
Private Office 1 was vacated on 7/28/2012; thus, data for Phase 3 and Phase 4 is not relevant and is not reported.
Panel includes areas which were not individually monitored.

THD

THD measures the distortion of the electrical wave form. Excessive THD may cause adverse effects to the electrical system. THD was measured only for the panel. Based on 8, there is little to note other than two occurrences on August 22 that are strongly anomalous. These cannot be easily explained. However, since they account for less than 1% of the 24,285 readings, the August 22 readings are insignificant.

There is no cause for concern about increased distortion due to retrofitting the fixtures to LED lights. Disregarding the anomalies mentioned above, the maximum THD is the same for both the fluorescent and LED lights. For verification, see the zoomed plots in figure 9 and figure 10.

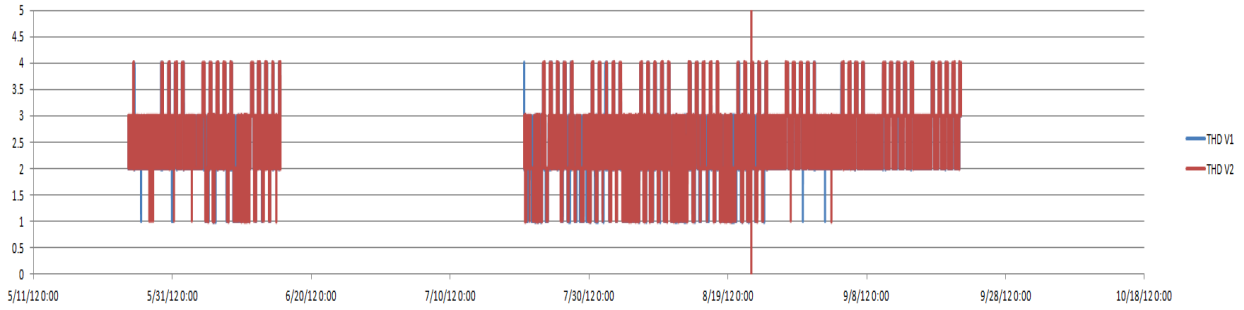

FIGURE 8. PANEL TOTAL HARMONIC DISTORTION (THD): PHASES 0, 2, 3, AND 4

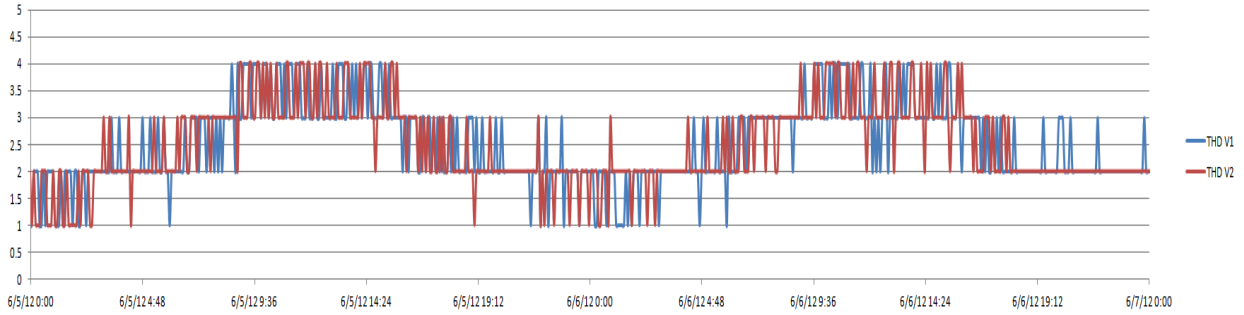

FIGURE 9. PANEL THD: TWO DAYS IN PHASE 0

FIGURE 10. PANEL THD: TWO DAYS IN PHASE 2

Power Factor

Power factor is the ratio of real power to apparent power in the circuit. For the open offices and private office 1, the power factor rarely deviates from 99% and never by much. The hall, though, has a power factor that will drop as low as 46% and maintain it for a period of time. The likely cause of the low power factor is the emergency light. This is evident in figure 11. The power factor of the emergency light drops much lower than the power factor of the regular lights.

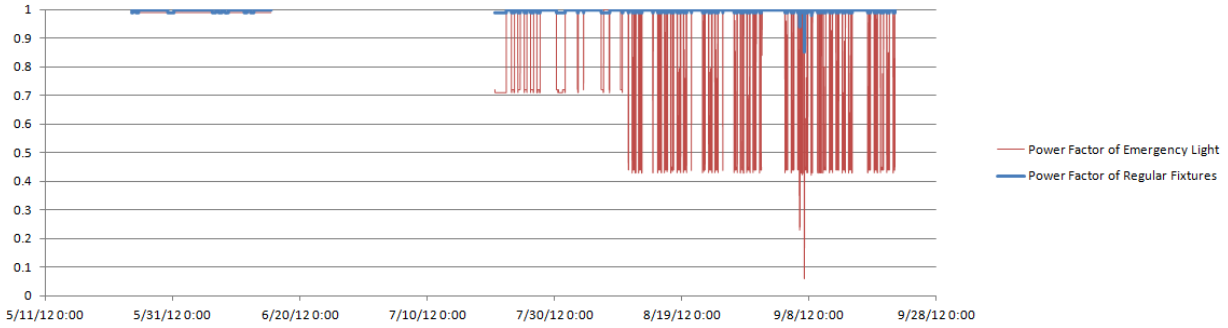

Figure 11. Hall Power Factor: Phases 0, 2, 3, and 4

Figure 12 shows the power factor for the panel. Emergency lights other than the one in the hallway are implicit in the plot, accounting for the even lower aggregate power factor.

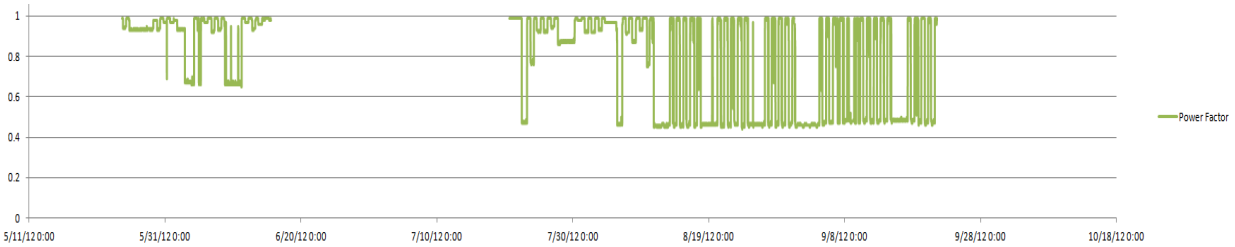

Figure 12. Panel Power Factor: Phases 0, 2, 3, and 4

Cost

The cost of each phase appears in Table 3, relative to the previous phase, the fluorescent phase, and the LED phase. The costs are derived from the documents in Appendix G. The energy saved in each phase with respect to the cost also appears in Table 4.

Table 3. Cost of Each Phase

Phase	Incremental Cost above Phase 0, Fluorescents	Incremental Cost above Phase 1, LEDs	Cost Between Phases
0. Fluorescents	-	-	-
1. LEDs	$47,178	-	$47,178
2. + Task Tuning	$65,401	$18,223	$18,223
3. + Sensors	$75,657	$28,479	$10,256
4. + Dimmers	$77,003	$29,825	$1,346

TABLE 4. ENERGY SAVED AT EACH PHASE COMPARED TO THE COST OF EACH PHASE

PHASE	kWH SAVED / $ SPENT FOR MEASURES FROM FLUORESCENTS	kWH SAVED/ $ SPENT FOR MEASURES FROM LED LIGHTS	kWH SAVED / $ SPENT FOR MEASURES BETWEEN PHASES
0. Fluorescents	-	-	-
1. LEDs	0.036	-	0.036
2. + Task Tuning	0.039	0.048	0.048
3. + Sensors	0.055	0.086	0.152
4. + Dimmers	0.055	0.085	0.059

Note: The kWh saved are for a three-week period which was the duration of each phase.

Evidently, the control changes involving the daylight and motion sensors (phase 3) are the most cost effective, if "upgrading" from the previous phase (task-tuning). Enabling dimming controls (phase 4) would not be reasonable Based on these computed values, individual dimming controls (phase 4) never improve the respective base case.

TABLE 5. PAYBACK PERIOD WITH UTILITY RATE OF $0.13878/KWH BASED ON PANEL ENERGY CONSUMPTION

INCREMENTAL ENERGY SAVINGS FROM PHASE 0	kWH SAVED /YR	PAYBACK PERIOD (YRS)
Phase 1	1693	>50
Phase 2	2572	>50
Phase 3	4135	>50
Phase 4	4214	>50
INCREMENTAL ENERGY SAVINGS FROM PHASE 1	**kWH SAVED /YR**	**PAYBACK PERIOD (YRS)**
Phase 2	879	>50
Phase 3	2443	>50
Phase 4	2522	>50
ENERGY SAVINGS BETWEEN PHASES	**kWH SAVED /YR**	**PAYBACK PERIOD (YRS)**
Phase 0 to Phase 1	1693	>50
Phase 1 to Phase 2	879	>50
Phase 2 to Phase 3	1563	47

The payback period for the retrofit lighting and control improvements evaluated in this study exceeds any reasonable time period that a commercial business would accept. This is due to the fact that the incumbent technology, fluorescent lighting, is already a very efficient source. The limited potential additional energy savings from installation of LED lighting cannot justify the significant additional expense of new LED light fixtures. The payback period would be much better if the prospective project were new construction. In that case, where the cost of new LED lighting and new fluorescent lighting are similar, the potential incremental cost of the LED lighting can be offset more easily by the energy savings.

The economic case for a retrofit of existing fluorescent lighting systems with new LED lighting and ALCS is poor due to the limited savings potential and relatively high cost. However, for new construction projects, LED lights and ALCS should be seriously considered.

Appendix H contains documents with project cost information and the cost analysis calculations.

EVALUATIONS

Based on the findings reported, all of the control changes improve upon full power LED lighting. Of note, the base cost of the wireless control system (phase 2, to enable task tuning) is the most costly, other than the cost for installing the LED lighting, and is required for all follow-on phases.

Beyond energy savings, other general benefits include extended lamp life due to reduced use, optimization of natural light in the workspace, and user-level lighting control. The user level control provides Class A office workers with more control over their work environment, something potentially valued.

Based on post-retrofit occupant surveys, most of the participants were satisfied with the controls provided to them. The surveys administered and results are in Appendix I. The installer reported that installation was slightly more difficult than installing fixtures without dedicated controls, saying, "We had to rewire each fixture to accommodate the Adura controls." The malfunctions of fixtures, dimmers, and remote controls during the test were the types of problems that occur with real world installations.

Few market barriers prohibit using LED lighting in combination with ALCS for new construction. LED prices are decreasing rapidly, and sensors and controls are becoming more available. The wireless, digital networks are the less accessible components that currently drive up the costs. However, cost effectiveness is a significant barrier to using the technology for a retrofit.

RECOMMENDATIONS

ALCS is recommended as a utility-approved energy savings measure for a variety of reasons: besides yielding proven energy savings, ALCS promotes increased flexibility in the user interface. ALCS can extend lamp and driver life. LED sources offer lighting distribution, color rendering, and color temperature which are comparable to or better than fluorescent sources.

The project payback associated with the implementation of fixtures and controls for this study is extremely long. The payback reflects costs associated with a pilot project and likely exceeds the payback that might be achievable in the marketplace today. However, costs must be mitigated to encourage these retrofits, at least during the current market transformation period. Utility incentives for ALCS could encourage more rapid market adoption.

Implementing occupancy and daylight sensors (phase 3) evidently produces the most savings based on the task tuning approach, which was implemented. If a more aggressive task tuning approach were implemented with each space individually tuned to user requirements or standard illuminance values, then the savings for phase 2 would increase. The savings from daylighting and occupancy sensors might not vary much from the levels measured in this study, but one would expect phase 4 (user control) savings to be reduced were more aggressive task tuning implemented. However, improving savings should not be pursued if the lighting quality is compromised and does not meet IES standards.

Admittedly, approximating the savings for an aggregate project is difficult, because few comprehensive ALCS projects have been implemented. Further refinement of the savings potential should be pursued, including a predictive approach and additional field studies.

Predictive. Savings estimates can be built-up from well-documented studies of component projects. Savings for LED replacements can be predicted by a comparison of input wattages calculated, multiplied by the fixture run time, either estimated or observed. The further reduction for task tuning can be calculated as a further percentage reduction based on the changed input wattage. Energy savings for daylight controls are variable. Energy savings for occupancy sensors are given by utility studies and widely used by utilities in support of incentive programs. Savings for occupancy sensors, for example, are predicted on a percentage basis depending on space type.

Additional Field Studies. While this project succeeded in demonstrating ALCS as an effective lighting solution, it lacked specificity in the individual results. For instance, control changes, such as occupancy and daylight sensors, were made in tandem. Further, the power data were aggregated into zones rather than separated by fixtures. Studies of individual sensors and individually monitored spaces, such as the cubicles by and away from the window, should be considered for more specific conclusions.

Studies should be conducted to further study individualized control, potentially the control of addressable fixtures using individual networked computers.

Integration of Savings. Ultimately, PG&E could assign an incentive measure code for ALCS, develop a database of like projects, and organize by lighting application, e.g., office or warehouse. Eventually, potential program participants could access the trend data of a comparable project and extrapolate or model from the data to approximate their own savings.

APPENDICES

APPENDIX A. ADURA SEQUENCE OF OPERATIONS

Advanced Lighting Evaluation at GSA Appraisers Office

Advanced Lighting Evaluation

GSA, with the support of PG&E and Enovity, has upgraded the lighting system in the Appraisers Office to modern, efficient LED fixtures installed with advanced wireless lighting controls. The purpose of this installation is to evaluate the performance, efficiency, and lighting quality of these advanced lighting and control products.

The lighting controls will be configured in three evaluation phases, with each phase enabling more advanced control capabilities. Each evaluation phase will be studied for three weeks.

A simple description of the controls operation in the current phase is presented below.

Phase 1 – Wireless Switching

July 23 to August 10

In Phase 1, the light fixtures will operate just as they did before the upgrade – controlled manually with a wall switch. The previous switches have been replaced with programmable wireless switches which can be used to turn the lights on and off. Additionally, the light output of the LEDs has been tuned to meet the office workspace lighting needs, creating a pleasant environment during the day or night.

Sequence of Operation

1. Press up on the wall switch to turn on the lights
2. Press down on the wall switch to turn off the lights

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A simple description of the controls operation in the current phase is presented below.

Phase 2 – Occupancy and Daylight Controls

August 13 to August 31

In Phase 2, the rooms will have automatic sensors added. Occupancy sensors will shut off the lights automatically when the space is vacant, and daylighting sensors will dim some of the light fixtures when there is natural daylight available.

Open Offices, Break Area, and Corridor – Sequence of Operation

1. An occupancy sensor will detect motion and automatically turn on the lights in the open office, break area, or corridor. The wall switch can also be used to turn on the lights in these spaces.
2. A daylight sensor will dim the lights along the windows when there is natural light available
3. Press down on the wall switch to manually turn off the lights
4. An occupancy sensor will switch off the lights when the space is vacant for several minutes

Private Offices - Sequence of Operation

1. Press up on the wall switch to turn on the lights
2. A daylight sensor will dim the lights along the windows when there is natural light available
3. Press down on the wall switch to manually turn off the lights
4. An occupancy sensor will switch off the lights when the space is vacant for several minutes[1]

[1] This "manual-on, auto-off" combination is commonly called "vacancy sensing"

Advanced Lighting Evaluation at GSA Appraisers Office

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The lighting controls will be configured in three evaluation phases, with each phase enabling more advanced control capabilities. Each evaluation phase will be studied for three weeks.

A simple description of the controls operation in the current phase is presented below.

Phase 3 – Manual Dimming and Personal Dimming Controls

September 3 and Onward

In Phase3, the wall switches will be programmed to provide manual dimming overrides. Occupants will be able to dim the lights down, or add more light. Additionally, the cubicle areas in the front office that do not receive natural daylight will receive personal dimming controls – wireless switches that can dim down or brighten the lighting immediately over the workstations.

Open Offices, Break Area, and Corridor – Sequence of Operation

1. An occupancy sensor will detect motion and turn on the lights in the open office, break area, or corridor
2. A daylight sensor will dim the lights along the windows when there is natural light available
3. Press and hold down on the wall switch to start dimming the lights, and let go of the switch when the desired light level is reached. All of the lights will dim together.
4. Press and hold up on the wall switch to start brightening the lights, and let go of the switch when the desired light level is reached. All of the lights will brighten together.
    a. The switch on the wall will brighten and dim all of the lights in the office area, but the wireless switches in the cubicles will only brighten or dim the lights directly above the cubicle.
5. Press down on the wall switch to manually turn off the lights
6. An occupancy sensor will switch off the lights when the space is vacant for several minutes

Private Offices - Sequence of Operation

1. Press up on the wall switch to turn on the lights
2. A daylight sensor will dim the lights along the windows when there is natural light available
3. Press and hold down on the wall switch to start dimming the lights, and let go of the switch when the desired light level is reached. All of the lights will dim together.
4. Press and hold up on the wall switch to start brightening the lights, and let go of the switch when the desired light level is reached. All of the lights will brighten together.
5. Press down on the wall switch to manually turn off the lights
6. An occupancy sensor will switch off the lights when the space is vacant for several minutes

APPENDIX B. PROJECT PHOTOS

Photo A (20120423_111030.jpg)

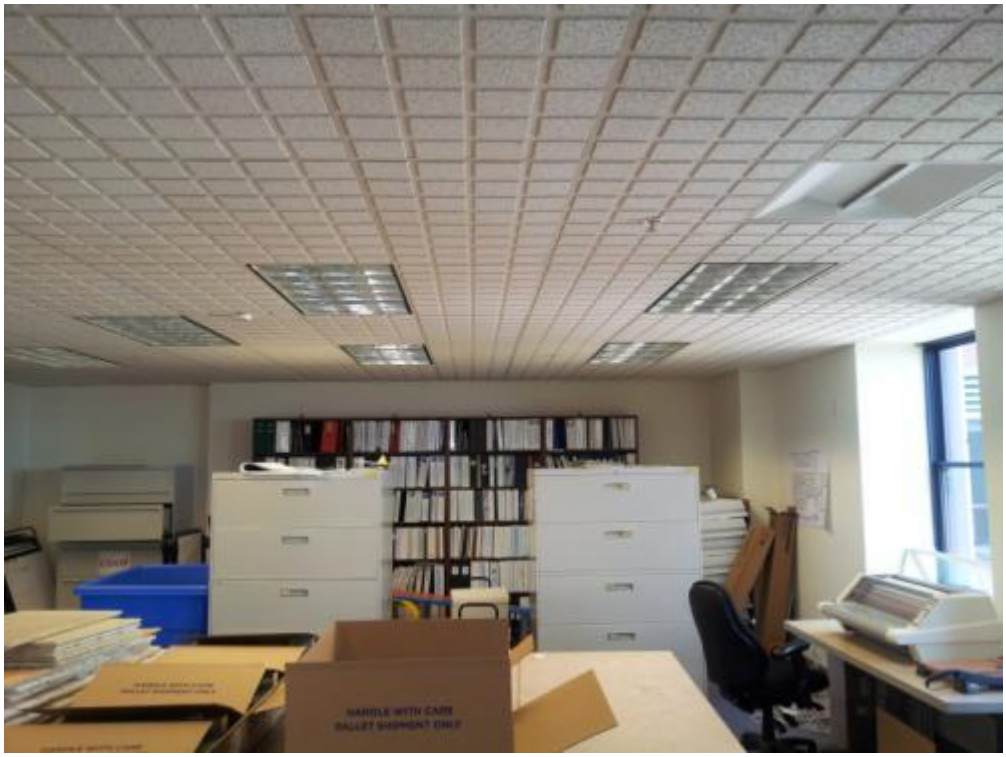

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Photo D (20120712_103553.jpg)

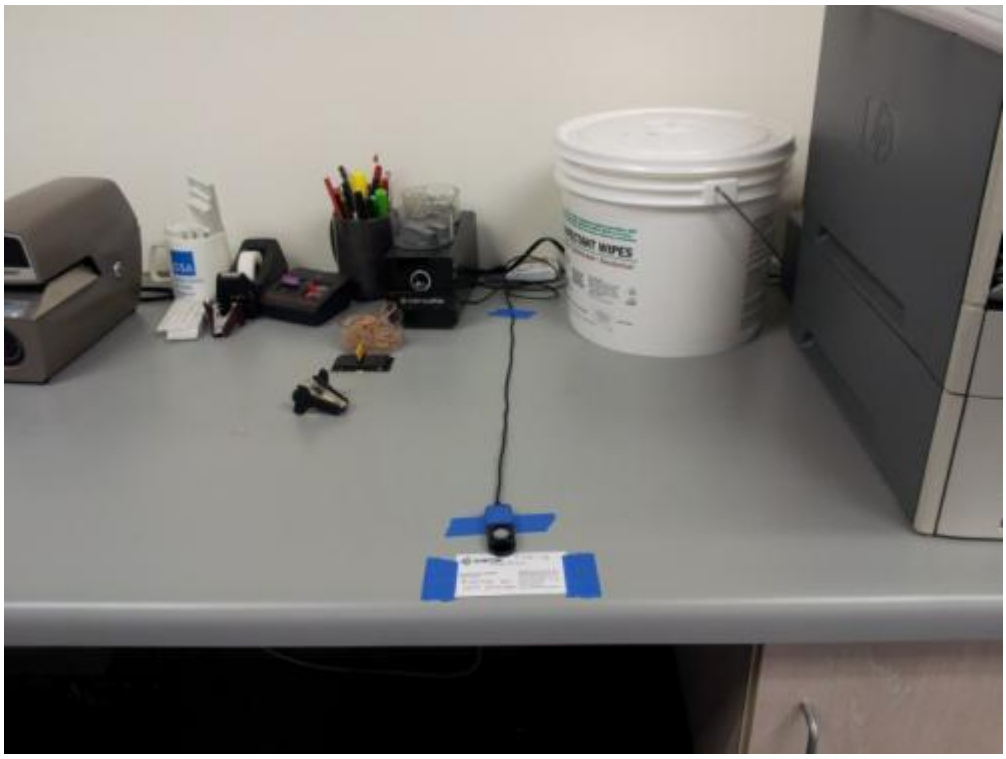

Photo E (Hallway.2.jpg)

Photo F (Hallway-Auto-50-1-2107967618-O.jpg)

Photo G (Hallway-Auto-100-1-2107968087-O.jpg)

Photo H (Hallway-Auto-off-1-2107968750-O.jpg)

Photo I (MDC_6549-2117990338-O.jpg)

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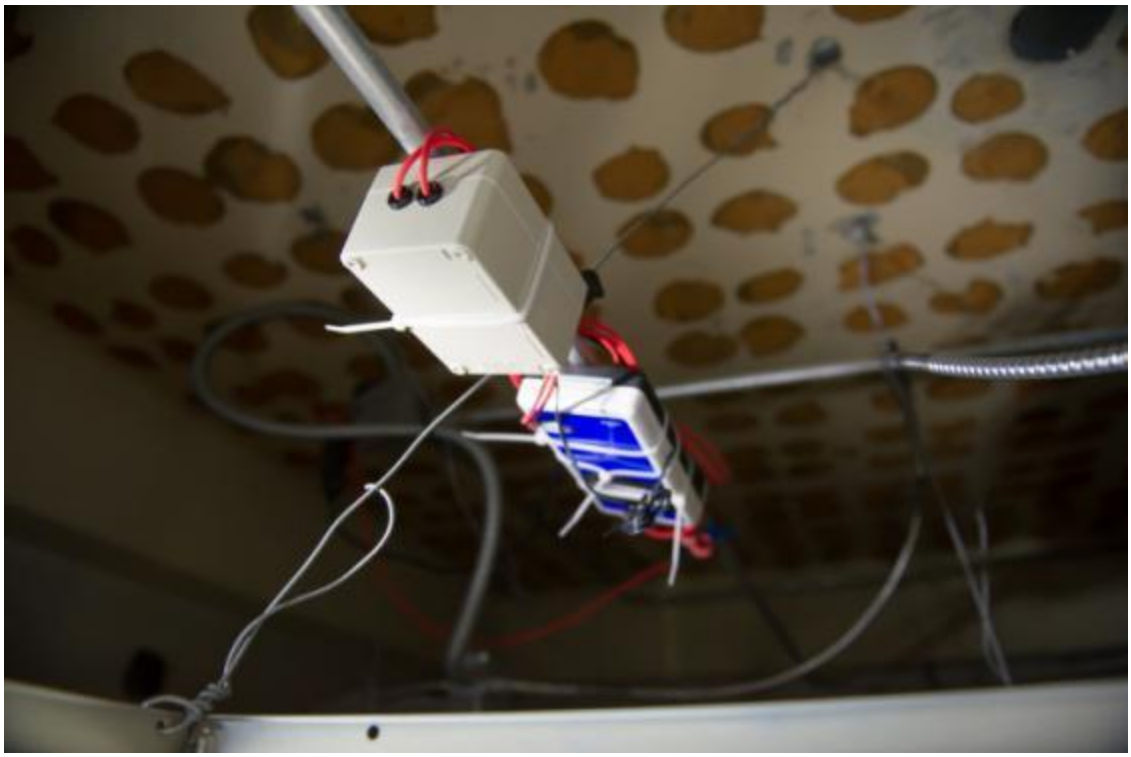

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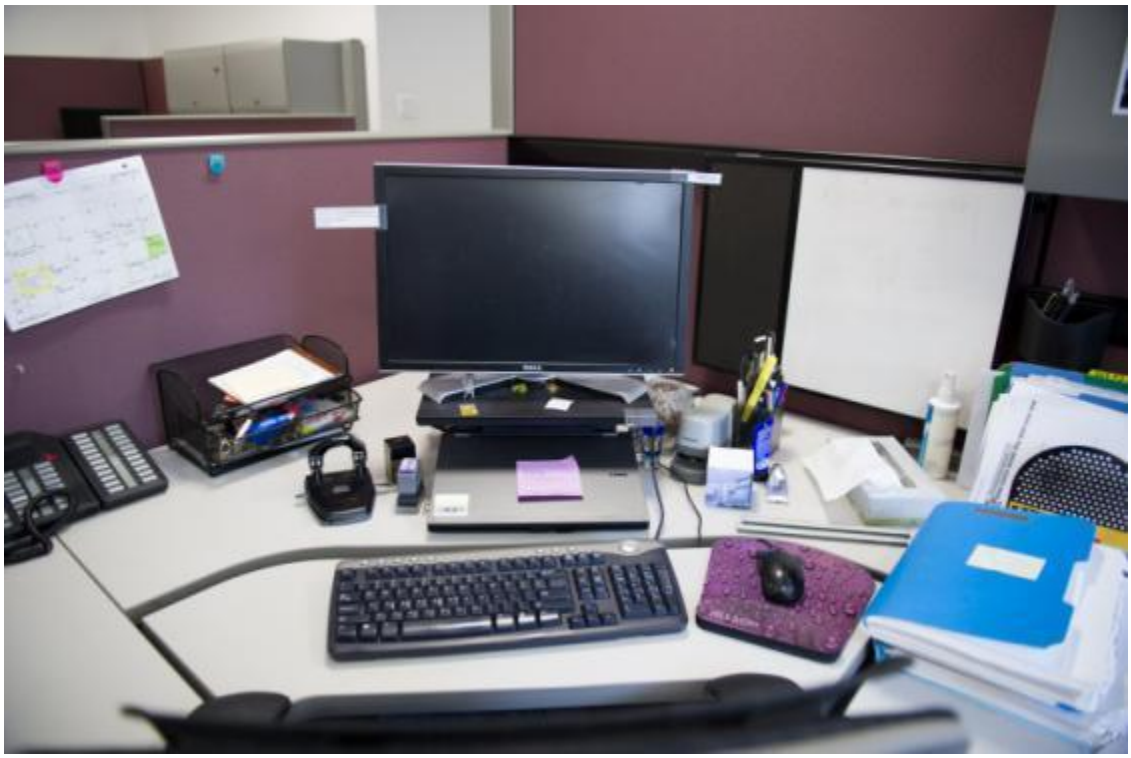

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Photo O (OpenOffice1.2.jpg)

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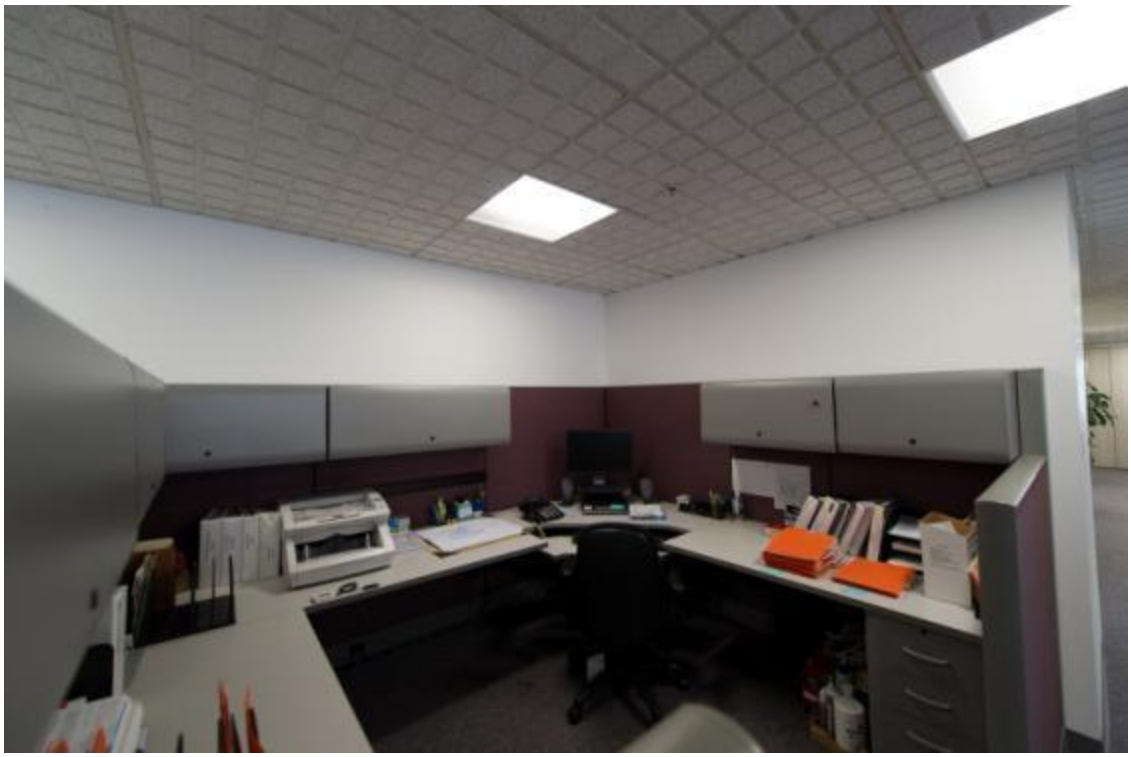

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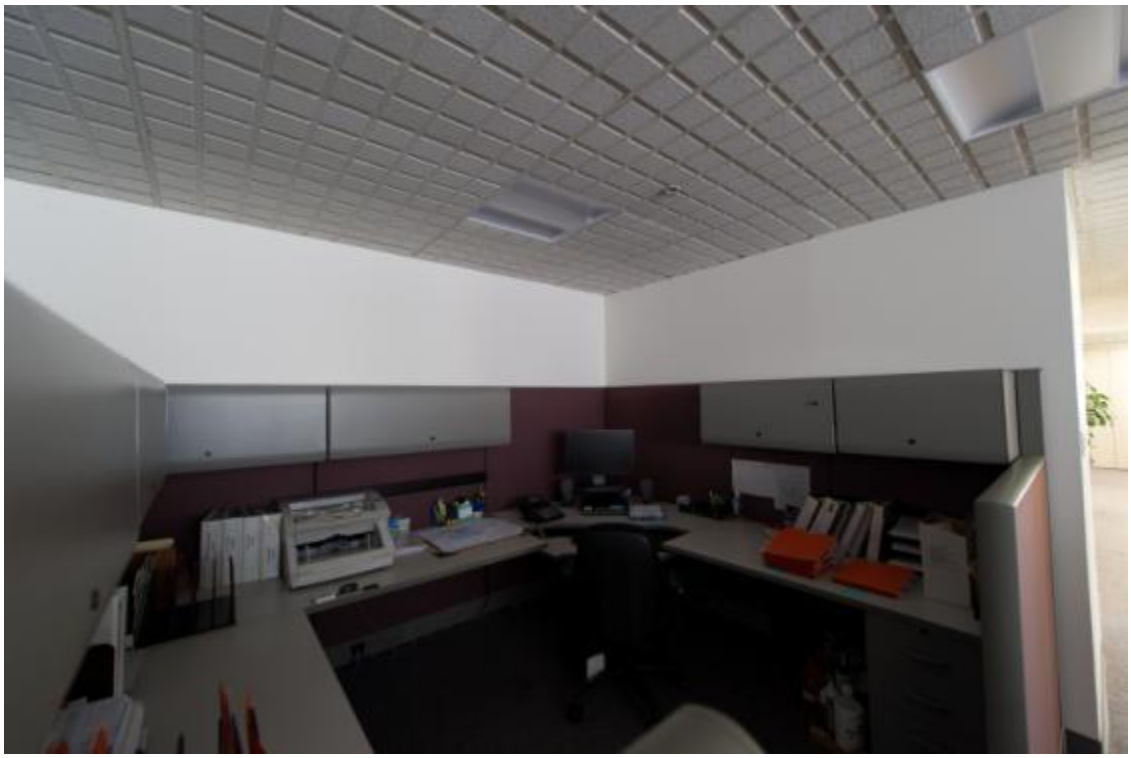

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Photo T (OpenOffice2-4k-100-1-2107961142-O.jpg)

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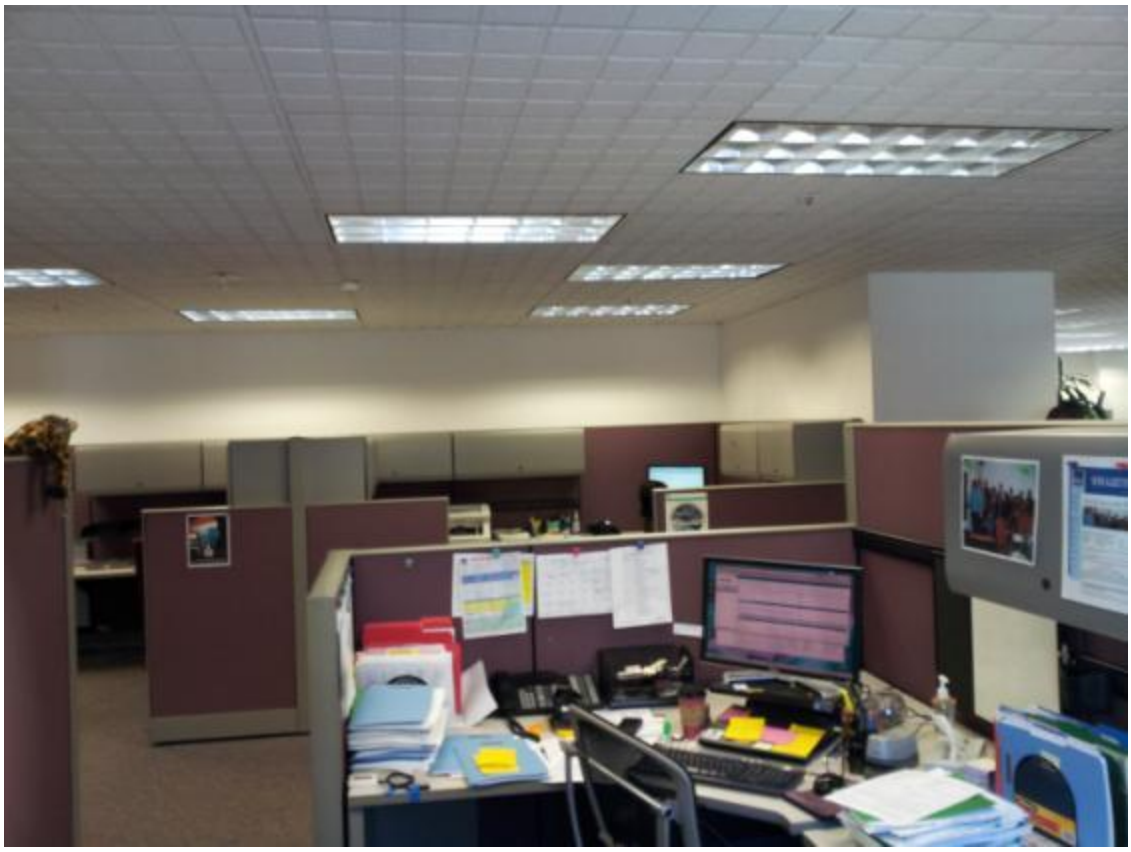
Photo V (OpenOffice2(south).1.jpg)



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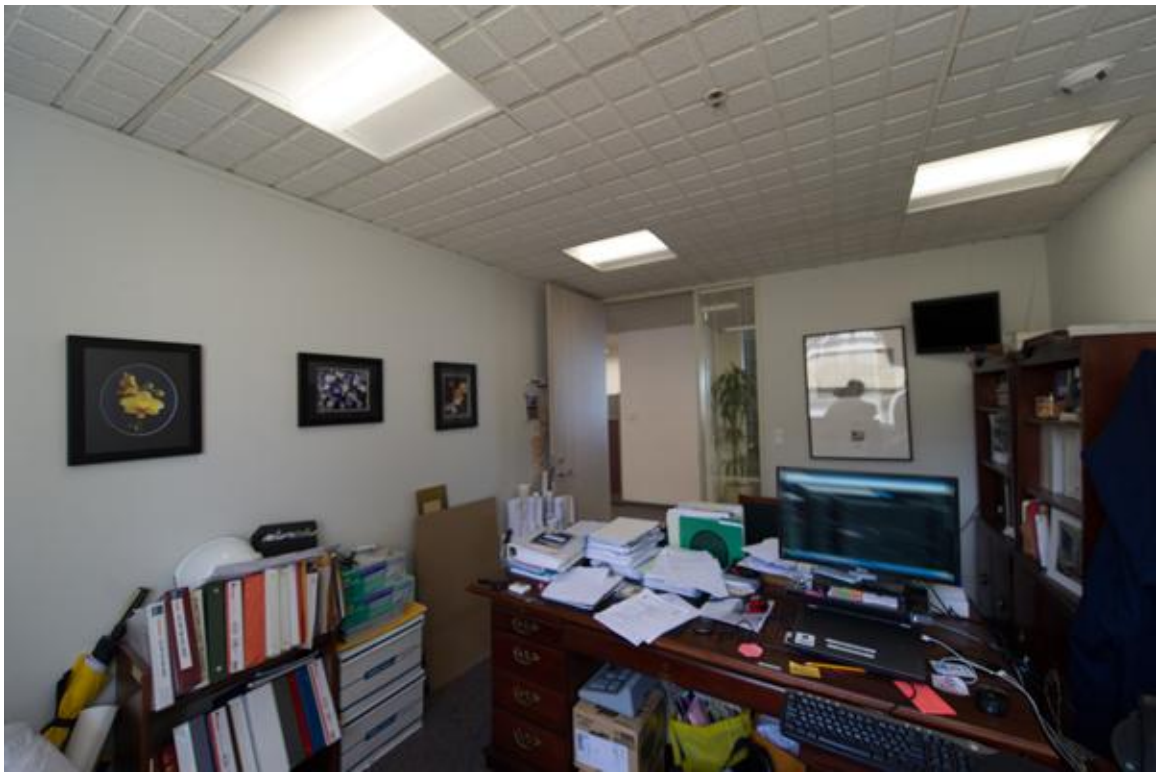

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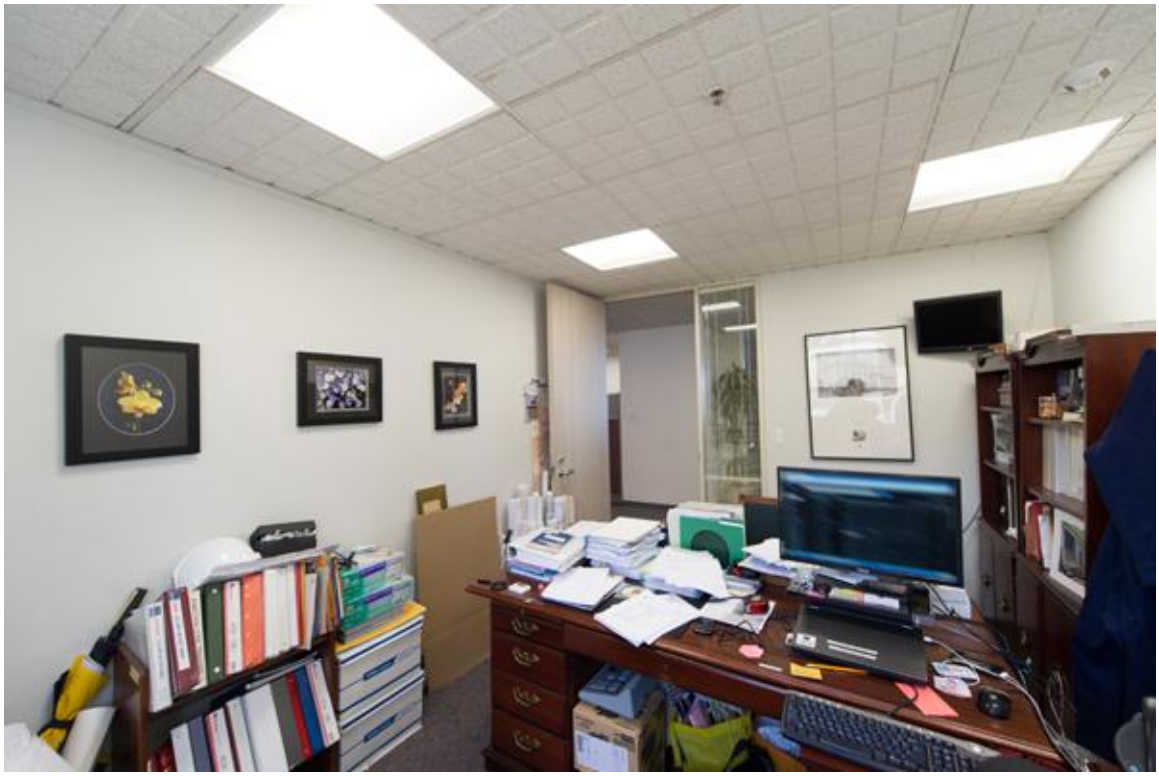

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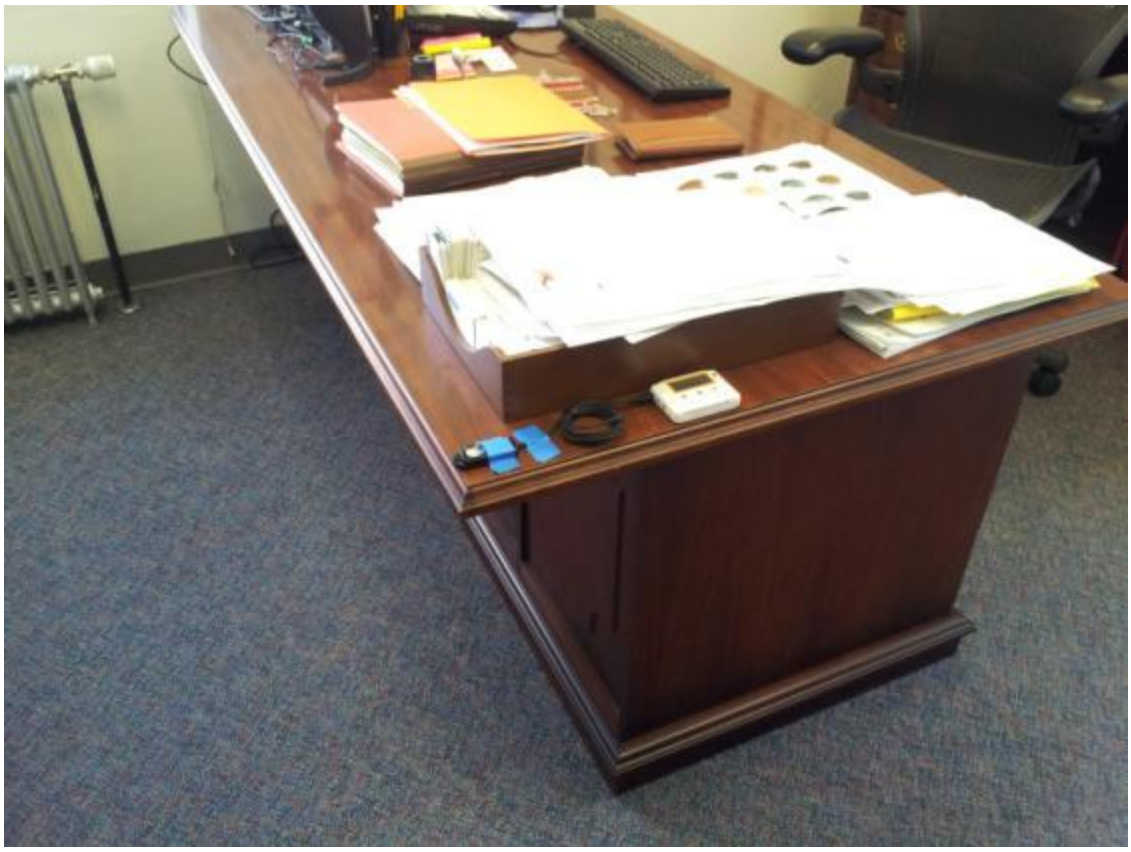

Photo AA (PrivateOffice1.2.jpg)

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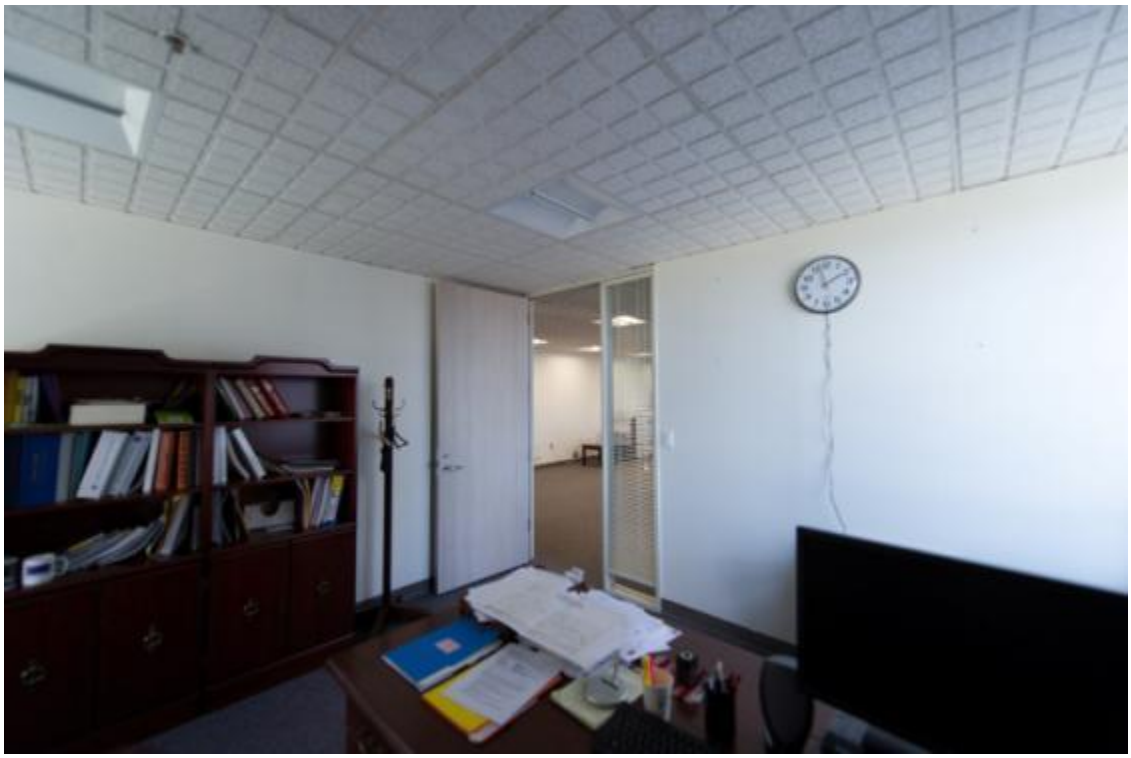


Photo AD (PrivateOffice1-Auto-off-2107978562-O.jpg)

APPENDIX C. MONITORING PLAN

Appraiser's Building Power and Lighting Monitoring Plan

Background
PG&E is performing an evaluation of LED lighting and wireless dimming technology at the Appraiser's building located at 630 Sansome Street in San Francisco. A project area has been established consisting of a suite occupied by US General Service Administration (GSA) personnel, located on the 10th floor. The general lighting for the suite is currently provided by a mixture of 2' x 2' and 2' x 4' linear fluorescent fixtures recessed into a grid t-bar ceiling. Fixtures are powered by two 20 Amp lighting circuits, fed from panel C10. The project work scope involves temporary replacement of the general lighting fixtures with new recessed 2' x 2' LED lighting fixtures that will be subject to wireless controls under various control strategies during the evaluation period.

Objective
The monitoring plan has been developed with the goal of measuring electrical and lighting characteristics both for the base case and for the case of each control strategy.

Worksteps
To accomplish the monitoring objectives, the following measurement sequences are indicated:

Aggregate Load Measurement
Separate out the lighting load from any other load for the two circuits to be tested. This will require a final evaluation of the general lighting for the entire suite. For all fixtures discovered not to be subject to the project (lobby track and wall wash fixtures will specifically be checked), spot measurements will be recorded for these fixtures for later use in data manipulation.

For the aggregated lighting load, continuously measure and record the power, energy, power factor, current, and voltage in five minute sampling intervals.

Power measurements will be performed using a Summit Technology PowerSight PS2500 Power Logger (PS2500 1), equipped with the line to DC option to be fed from the monitored circuit, which will be directly connected to circuits 1 and 2 using 100 amp current transformers (CTs). PS2500 1 will be located in the server room on or next to panel C10. The connections will be fed through a panel knockout and appropriate 90 degree conduit connection. All exposed connections will be concealed within the panel.

Work Area Load Measurement
A total of five distinct work areas will be monitored: two private offices, two open offices, and one corridor. Please see section, "Targeted Monitoring Areas" for test area details, including base and test case lighting.

For the light fixtures which serve each of the five work areas, continuously measure and record the power, energy, power factor, current, and voltage in five minute sampling intervals.

Power measurements will be performed using Summit Technology PowerSight PS2500 Power Loggers (PS2500 2 – PS2500 6). In the case of the private offices, PS2500 units will be directly connected via CT and voltage leads to the lead fixture (either at the fixture or associated junction box) which serves the switched area. The aforementioned approach will be used in the open area and corridor when possible. However, an alternate approach may be necessary

depending on how the existing fixtures are switched. The actual approach for these areas will be determined during a site visit prior to the installation of the M&V equipment.

Work Area Lighting Measurements
For the base case and each test case, illuminance measurements will be performed at five minute intervals on a continuous basis at the primary workspace in each target work area. Instantaneous spot measurements of correlated color temperature (CCT) and illuminance will be performed on a weekly basis.

Designated measurement locations will be identified and noted as an addendum to this monitoring plan. Measurement locations will be marked in the field to foster repeatability of the measurements.

Continuous illuminance measurements will be performed by five T & D TR-74Ui loggers. The measuring sensor will be placed on or as close as possible to the primary work surface without interfering with work needs of the area occupants. During the weekly data collection loggers will communicate wirelessly over a short distance to a handheld data collection device.

Spot measurements will be performed using a Konica Minolta CL-200A. Designated measurement locations will be identified and noted as an addendum to this monitoring plan.

Monitoring Timeline
Three weeks of baseline data will be collected both at the circuit level as an aggregate load and individually in the 5 workstations selected. If the current system is found to have existing controls or loads that can't be turned off, then the baseline data will be collected accordingly and the current conditions will be documented. Demand and energy savings will be determined based on difference between existing and proposed controls.

After completing the baseline data collection, the measurements will be repeated to collect data on the test case fixtures and controls based on the conditions below:

a. Lighting provided by the LED fixtures alone (Duration- three weeks)
b. LED + occupancy sensing + daylight harvesting. (Duration-three weeks)
c. LED + Individual control/dimming if available. (Duration- three weeks)
d. Finally, LED + all features would be enabled and a composite effect determined. (Duration-three weeks)

Target Monitoring Areas

The five targeted workstations are as follows:

- One private office located on the South side of the building with a South facing window and four existing 2' x 2' recessed linear fluorescent fixtures. Four 2' x 2' LED lighting fixtures are proposed for this area. This area is denoted as A1 in Appendix 1.

- One private office located in the North East corner with a North and an East facing window and three existing 2' x 2' recessed linear fluorescent fixtures. Three 2' x 2' LED lighting fixtures are proposed for this area. This area is denoted as A2 in Appendix 1.

- One corridor located at the East end of the floor and separates the private offices on the South side from the open area on the North side. This area has four existing 2' x 4'

recessed linear fluorescent fixtures, one of which is an emergency fixture. Depending on the fixture switching and wiring configuration for this area it may not be possible to monitor all fixtures and a reduced selection may be monitored. Four 2' x 2' LED lighting fixtures are proposed for this area. This area is denoted as A3 in Appendix 1.

- Two open office areas each consisting of two cubicles with eight 2' x 4' recessed linear fluorescent fixtures. One of these open office areas is on the south side of the building and has two windows. The other open office is located in the same open area adjacent to other cubicles. It is proposed to monitor four fixtures serving an individual cubicle in each area. However, depending on the fixture switching and wiring configuration for these areas it may not be possible to monitor only the four fixtures serving a cubicle and an increased selection may be monitored. A total of sixteen 2' x 2' LED lighting fixtures are proposed for these areas. These areas are denoted as A4 and A5 in Appendix 1.

Equipment
The consultant has selected the following equipment: Please refer to cutsheets in Appendix 2.

- 1 PowerSight PS2500 Power Logger w/HAO & LDC4
- 5 PowerSight PS2500 Power Logger w/LDC4
- 12 PowerSight HA100 Clamp-on 100 Amp probes
- 5 T&D TR-74Ui Luminance and UV Data Logger
- 1 T&D TR-57DCi Wireless Data Collector
- 1 Konica Minolta CL-200A Chroma Meter Pkg.

office

office

office

CIO #2

Hallway

CIO #1

(2) cubicles/open office

Server Room

Panel CIO

CIO #1

(2) cubicles/open office

PROVIDE POWER FOR NEW ANTENNA FROM EXISTING EXIT SIGN CIRCUIT

EXISTING EXIT SIGN

BUSH GRAIGWAY # 2

PROVIDE POWER FOR MODIFIED EXIT FIXTURES

office

NOTES:

1. ALL WORK SHALL BE DONE IN ACCORDANCE WITH THE PROVISIONS OF THE NATIONAL ELECTRICAL CODE.
2. CONTRACTOR AND FIELD SUPERVISOR SHALL BE CERTIFIED BY BUILDING INSPECTORS AND EQUIPMENT REQUIRED.
3. REMOVE AND REMOVE WIRE. KEEP ALL UNUSED EXISTING CIRCUITS BACK TO PANEL AND MARK ACCURATELY "SPARE"
4. [illegible]

100 Amp AC Current Probe

Order Number:

[HA100]

Summit Technology's HA100 Current Probe measures from 0.1 A_{RMS} to 100 A_{RMS} AC in a small form factor.

Specifications

- 0.1 to 100 Amps AC Current measurement

Accuracy

- +/- 2% of reading +/- 0.2 A_{RMS}

Dimensions

- Inside dimensions: 0.8 inch diameter
- Outside dimensions: 5.25 x 2.1 x 1.35 inches
- Cable length: 2 meters (6.5 feet).

Availability

The HA100 is available for immediate purchase from Summit Technology Inc. To order, specify **HA100**.

PowerSight® products are manufactured in the USA and sold by Summit Technology, Inc.

For more information on our products contact:

Summit Technology Inc.
2717 N. Main St., Suite 15
Walnut Creek, CA 94597-2747

Voice: 1-925-944-1212
Fax: 1-925-944-7126
Email: sales@SummitTechnology.com

PS2500
Power Logger
"The Premier Power Logger"

Order Number:

[PS2500]

Complete power monitoring and analysis in a simple basic package.

- **SureStart™** *for getting great results*
  Uses artificial intelligence to verify that the wiring, connections, and setup parameters are correct. Information is available on the front panel display. This unique program (patent pending) reduces the time to hook up voltage and current probes and makes sure that all your measurements are correct.
- **SureSense™** *for accurate current*
  Uses automatic current probe identification to set the input of the PS2500 to match each current probe in use. This makes sure that the current probe readings are correct.
- **SurePower™** *for reliable logging*
  The meter's operation is backed up by rechargeable batteries and has an option to power it directly from the voltage being monitored. Current probes that normally require batteries get their power from the PS2500. This guarantees that the PS2500 will log power as long as you need it to with no part failing you.
- **Measures 140 different parameters**
  Volts, amps, watts, power factor, frequency, THD, etc. Minimums, maximums, averages, and present values. The PS2500 measures parameters every second, regardless of the recording rate. This guarantees that you will have a true view of all of the data when the job is done.
- **Four current and three voltage channels**
  This allows the PS2500 to directly measure all phases and neutral in single, two-phase, three-phase, split delta, 2PT/2CT, DC, 45-66 Hz, 360-440 Hz, just about any situation you will ever encounter.
- **Clear display**
  View voltage, current, true power, apparent power and true power factor summaries without the use of a laptop
- **Wireless Communications** with Bluetooth technology.
- **Industry's Highest Safety Rating,** 600V CAT IV for connection at the service entrance.
- **Provision for Removable Memory** with SD upgrade.
- **Compatible with our product line**
  Use the same software, current probes (AC/DC, 0.01 to 5000 amps), voltage probes (AC/DC, 1 to 15,000 volts), and accessories.

Availability

The PS2500 is available now. To order, specify **PS2500**. PS2500 includes software, voltage leads, AC charging unit, and soft carrying case (everything except current probes) for $ 1,495. PowerSight® products are manufactured in the USA and sold by Summit Technology, Inc.

For more information on our products contact:

Summit Technology Inc.
2717 N. Main St., Suite 15
Walnut Creek, CA 94597-2747

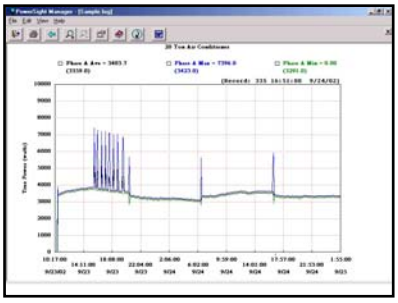
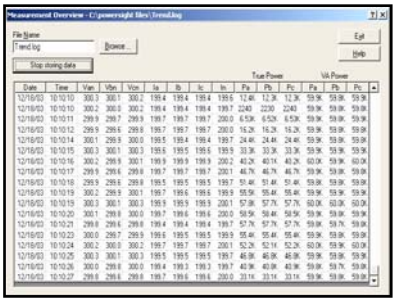
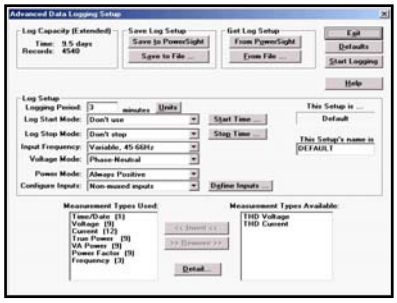
Voice: 1-925-944-1212
Fax: 1-925-944-7126
Email: sales@SummitTechnology.com

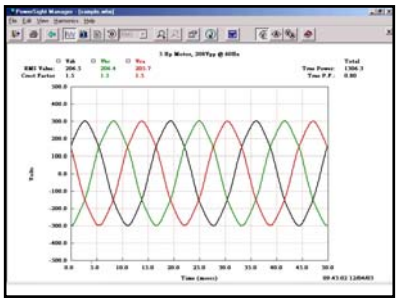
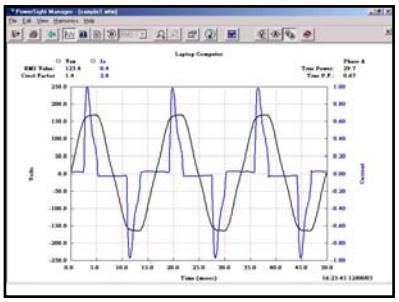
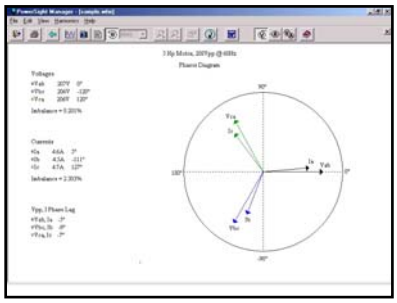
PS2500
Power Logger
"The Premier Power Logger"

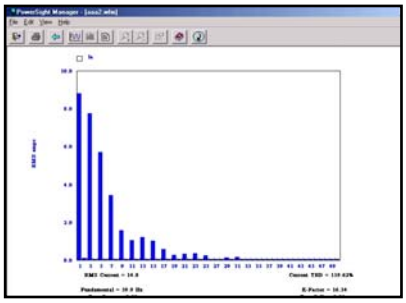
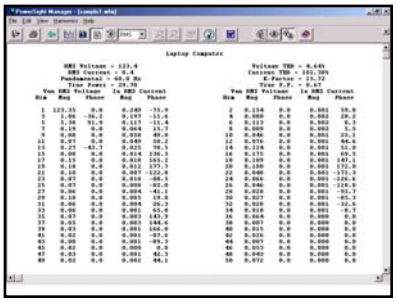
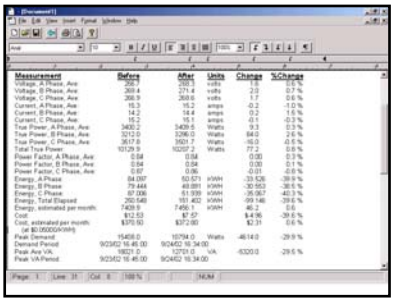
Order Number:

[PS2500]

PowerSight Manager Software (PSM) is a flexible, powerful, and easy to use power analysis software tool that is included with all orders for the model PS2500. It performs complete presentation and analysis of power consumption. Combined with our Report Writer software, it provides concise and compelling summaries including comparisons of performance.

Data Log Analysis	Data Trending	Custom Data Logging
		
Data Logs can be graphed/zoomed	Live Trend Data	Choose any of 60 variables

Waveform Analysis		Phasor Diagrams
		
Stored or Real-time Voltage and Current Waveforms		All Phase Relationships

Harmonic Analysis		Report Generation
		
Harmonic Contents as Graphs or Data		Choose any of 60 Variables

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Fax: 1-925-944-7126
Email: sales@SummitTechnology.com

Specifications

TR-74Ui Unit

Measurement Items	Illuminance	UV Intensity	Temperature	Humidity
Number of Channels	1 channel for each Measurement Item			
Unit of Measurement	lx, Klx	mW/cm²	°C / °F	%
Display Range of Cumulative Measurement	0 to 90,000,000 lx·h	0 to 62 W/cm²·h	–	–
Unit of Cumulative Measurement	Cumulative Illuminance: lx·h, Klx·h, Mlx·h	Cumulative Amount of Ultraviolet Light: mW/cm²·h, W/cm²·h	–	–
Refresh Interval	1 second (At a recording Interval of 1 second) 2 seconds (At a recording interval of 2 seconds or more)			
Recording Intervals	Select from 15 choices: 1, 2, 5, 10, 15, 20 and 30 seconds / 1, 2, 5, 10, 15, 20, 30 and 60 minutes *1			
Storage Capacity	Up to 8,000 readings (One reading is a set of data which includes Illuminance, UV Intensity, Temperature, and Humidity measurements.)			
Recording Modes	Endless / One Time			
LCD Displayed Items *2	Recording Status, Amount of Recorded Data, Communication Status, Recording Mode, Battery Life Warning, Current Readings (Illuminance / UV Intensity / Temperature / Humidity), Cumulative Measurements (Cumulative Illuminance and Cumulative Amount of Ultraviolet Light), Unit of Measurement			
Communication Interface	Wired: USB Communication, Serial (RS-232C) Communication Wireless: Infrared Communication			
Communication Time	When downloading 1 Unit of full data: USB Communication: about 45 seconds Infrared Communication: about 60 to 80 seconds			
Power	AA Alkaline Battery LR6 × 1			
Battery Life *3	About 6 months			
Dimensions / Weight of Main Unit	H55 × W78 × D18 mm (excluding protrusions) / about 62 g (including one AA battery)			
Operating Environment	Temperature: -10 to 60˚C / Humidity: 90%RH or less (no condensation)			

*1: For Illuminance and UV Intensity the average for the measured values taken during the recording interval are recorded, and for Temperature and Humidity the measured values at the instant are recorded.

*2: Up to four digits are valid for the Current Readings and Cumulative Measurements.

*3: Battery life varies depending upon the type of battery, the battery performance, the measuring environment, and the frequency of communication.

Illuminance UV Sensor ISA-3151

Measurement Items	Illuminance	Ultraviolet Light
Measurement Range	0 to 130,000 lx	0 to 30 mW/cm²
Measurement Resolution	Minimum: 0.01 lx	Minimum: 0.001 mW/cm²
Measuring Accuracy	10 to 100,000 lx: ±5% (At 25°C 50%RH)	0.1 to 30 mW/cm²: ±5% (At 25°C 50%RH) *1
Relative Spectral Response	Approximated to the CIE standard response function V (λ)	260 to 400 nm
Cosine Correction Characteristics (cos θ)	Within ±1.5% at 10°; Within ±3% at 30°; Within ±10% at 60°; Within ±30% at 80°	–
Operating Environment	Temperature: -10 to 60°C Humidity: 90%RH or less (no condensation)	
Storage Environment	Temperature: -10 to 60°C Humidity: 90%RH or less (no condensation)	
Conditions for Use	Do not expose to condensation, dampness, corrosive gases or organic solvents	
Sensor Dimensions	H23 × W65 × D12.6 mm	
Cable Length	1.5 m	

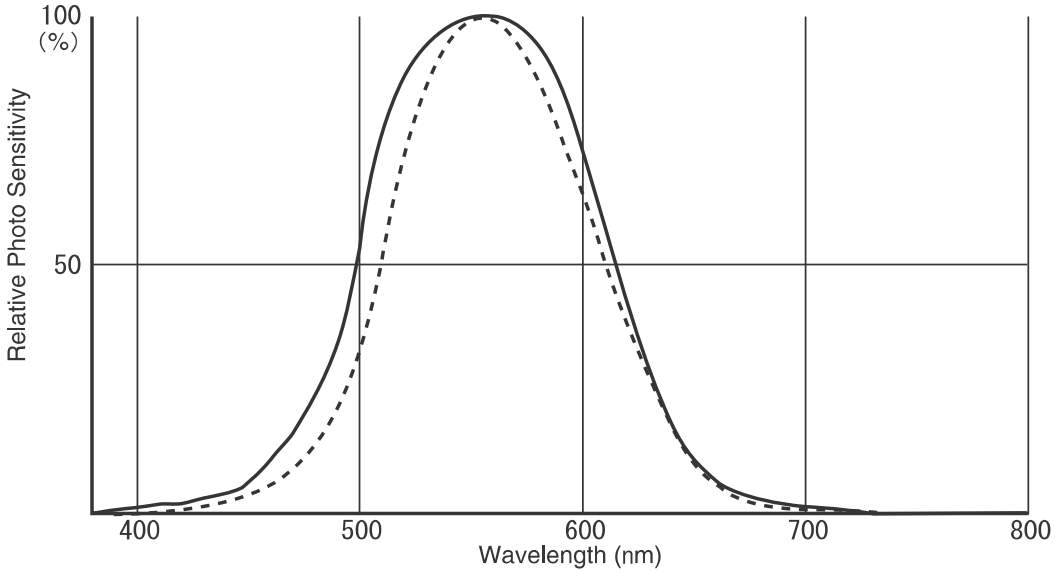
*1: Compared to the value measured by the T&D standard sensor for calibration under our calibration light source.

Temperature/Humidity Sensor THA-3151

Measurement Items	Temperature	Humidity
Measurement Range	0 to 55°C	10 to 95%RH
Measurement Resolution	0.1°C	1%RH
Measuring Accuracy	Avg. ±0.3°C	±5% (At 25°C 50%RH)
Sensor Response Time	About 7 minutes (90%)	
Humidity Hysteresis	–	±1%RH (30 to 90%RH)
Operating Environment	Temperature: 0 to 55°C Humidity: 90%RH or less (no condensation)	
Storage Environment	Temperature: 0 to 55°C Humidity: 90%RH or less (no condensation)	
Conditions for Use	Do not expose to condensation, dampness, corrosive gases or organic solvents	
Sensor Dimensions	H18 × W51.5 × D10 mm	
Cable Length	1.5 m	

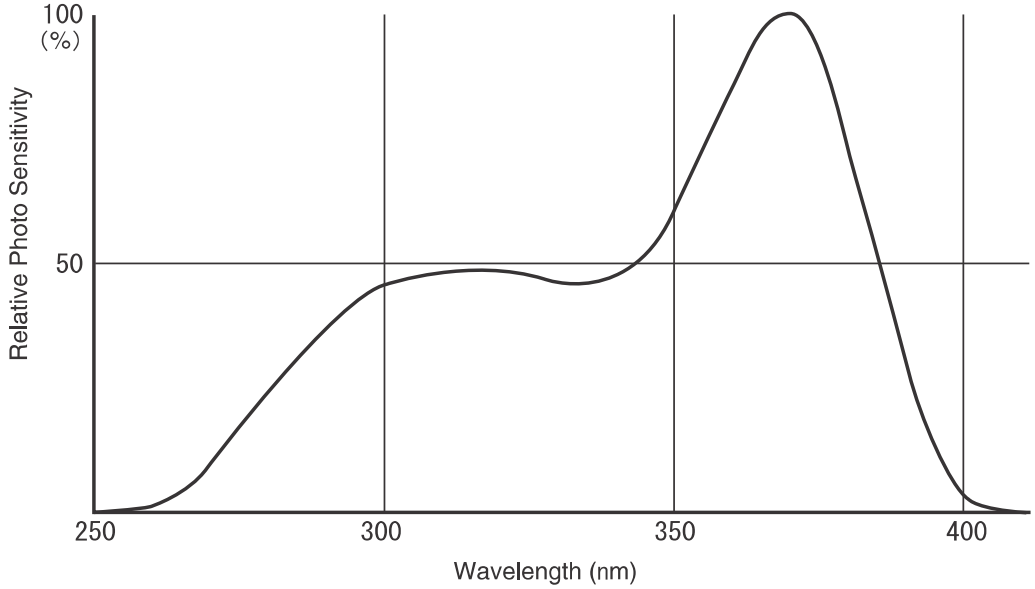
Relative Spectral Response Characteristics Graph (Illuminance)

Broken line: the CIE standard response function V (λ)
Solid line: ISA-3151



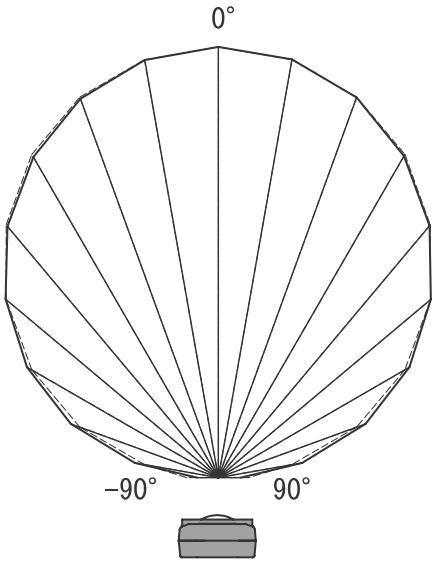
Relative Spectral Response Characteristics Graph (UV)

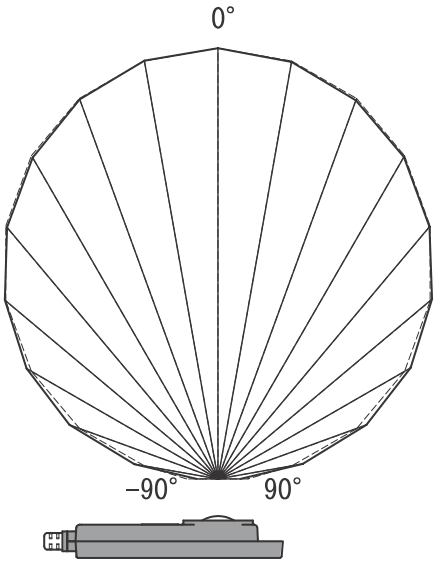
ISA-3151



Cosine Correction Characteristics (Illuminance)

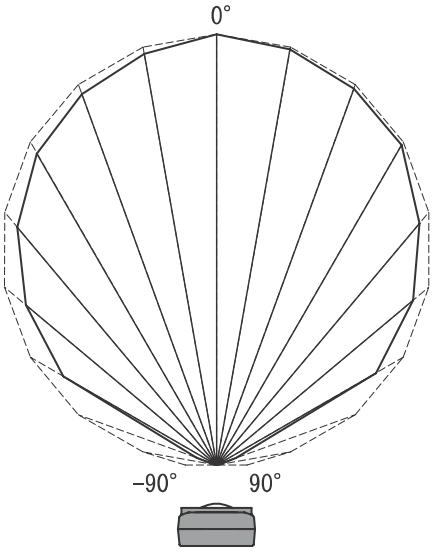
Broken line: cos θ
Solid line: Measurement Value

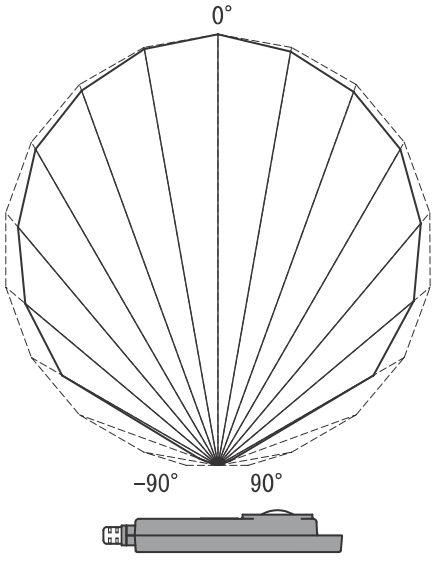




Cosine Correction Characteristics (UV)

Broken line: cos θ
Solid line: Measurement Values





"Illuminance UV Recorder for Windows" Operating Environment

Compatible OS	Microsoft Windows 7 32/64bit English Microsoft Windows Vista 32bit English Microsoft Windows XP 32bit (SP2 or above) English
Memory Capacity	Enough memory to stably operate Windows
Disc Capacity	More than 20 MB free space (More free space is necessary for data)
Monitor	SVGA (800 × 600) more than 256 colors

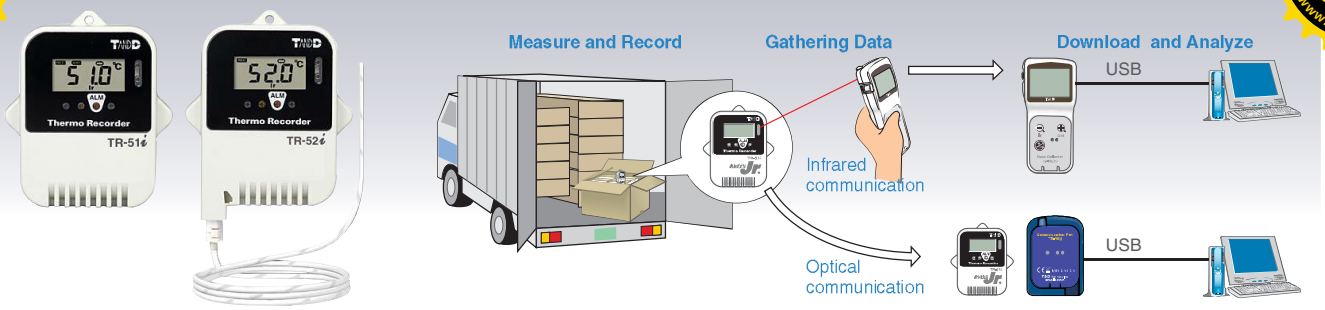
Compact Temperature Data Logging System

TR-5*i* Series

Infrared Interface
Easy-to-Read Display
Durable Waterproof Loggers

T&D Corporation

CE



Place Anywhere Compact Waterproof Type

The compact size allows it to be placed almost anywhere. Also, its durable body with waterproof and dustproof capacity makes it possible to be used in harsh environments.

TR-51i :

The TR-51i with an internal temperature sensor offers superior waterproof capacity and moderate response time; it is suitable for use in transportation and storage, as well as, in harsh environments.

TR-52i :

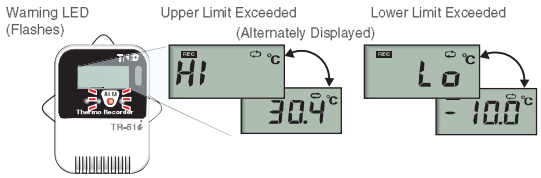
The TR-52i with an external temperature sensor is highly versatile and ideal for use in situations where a quicker response (compared to TR-51i) is required.

Wide Measurement Range: -60 to155°C

The TR-51i can measure and record temperature from -40°C to 80°C and the TR-52i can measure and record in the even wider range of -60°C to 155°C.

Warning Monitoring Function

Using the dedicated software "T&D Recorder for Windows (TR-5, 7xU)", you can make Upper / Lower Limits and Judgment Time settings for the TR-51i/52i. If a measurement exceeds one of the set limits, the warning LED and message will be displayed. Because the warning LED and message will remain ON until the data is downloaded, there is no way to miss any important warnings.



Storage Capacity of 16,000 Readings

One Data Logger can store up to 16,000 readings. At a recording interval of 10 minutes that would equal about 111 days, and at an interval of 60 minutes that would equal about 22 months of non-stop consecutive recording.

Note: * The dedicated software "T&D Recorder for Windows" provides 15 recording interval choices (from 1 second to 60 minutes) to meet your needs.

Low Energy Consumption Design

The low energy consumption design of the TR-5i series provides continuous operation for up to 4 years. When the battery needs to be replaced, the battery replacement mark will appear.

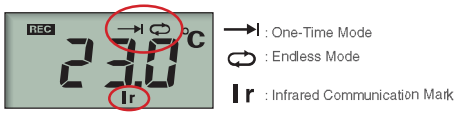
Estimated Battery Life:
When a new battery is being used and data downloading occurs four times a month (with infrared communication switched OFF)

Recording Interval	1 Second	2 seconds	5 seconds	10 seconds or longer
Battery Life	About 18 months	About 2 years	About 3 years	About 4 years

Note: * The battery replacement mark will appear based upon the calculation of battery use. It may appear sooner than noted above.
* Battery life varies depending upon frequency of communication, infrared communication settings, blinking of the warning LED, and measuring environments such as the ambient temperature.

Recording Settings Display

Recording mode (One-Time or Endless) and Infrared Communication settings will be displayed in the LCD.



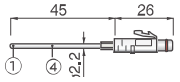
(The Infrared communication status is shown here)

① Thermistor ② Stainless pipe (SUS316) ③ Fluoropolymer Compaction Tube ④ Fluoropolymer Coated Electrical Wire ⑤ Fluoropolymer Coated Mold

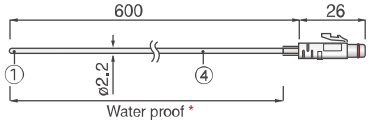
Fluoropolymer Coated Sensor

[Unit : mm]

TR-5101
Cable Length: 45mm (1.8in)
Thermal Time Constant:
Approx. 30 Sec. (in air)
Approx. 4 Sec. (in agitated water)



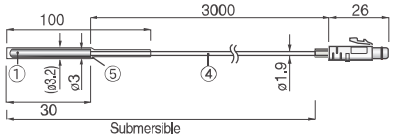
TR-5106
Cable Length: 0.6m (24in)
Thermal Time Constant:
Approx. 30 Sec. (in air)
Approx. 4 Sec. (in agitated water)



* Water Resistance: The fluoropolymer-coated section is waterproof.

Water Immersible Sensor

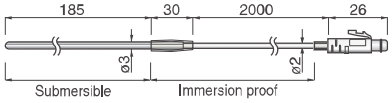
TR-5530
Cable Length: 3.0m (120in)
Thermal Time Constant:
Approx. 120 Sec. (in air)
Approx. 6 Sec.
(in agitated water)



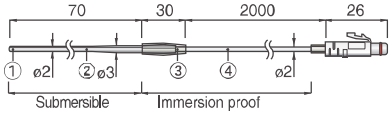
Stainless Protection Sensor

[Unit : mm]

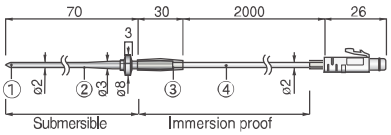
TR-5220
Cable Length: 2.0m (80in)
Thermal Time Constant:
Approx. 36 Sec. (in air)
Approx. 7 Sec. (in agitated water)



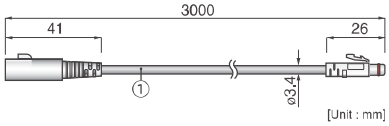
TR-5320
Cable Length: 2.0m (80in)
Thermal Time Constant:
Approx. 12 Sec. (in air)
Approx. 2 Sec. (in agitated water)



TR-5420
Cable Length: 2.0m (80in)
Thermal Time Constant:
Approx. 12 Sec. (in air)
Approx. 2 Sec. (in agitated water)



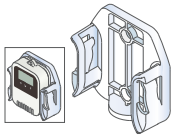
① Vinyl Coated Electrical Wire



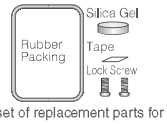
[Unit : mm]

Note: * An error of about +0.3°C occurs at normal temperature while an error of about +0.5°C will occur at around -50°C.

TR-05K3: Wall Attachment

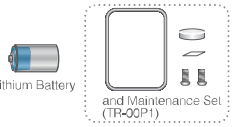


TR-00P1: Maintenance Set



A set of replacement parts for maintaining water resistance.

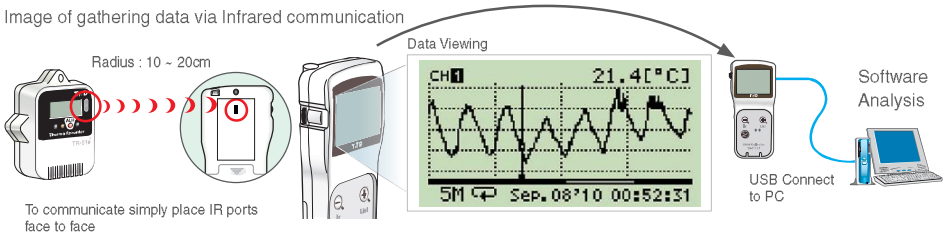
TR-11P2 : Battery Set



Easy Data Collection, Easy Graph Display

- Collect Data anywhere, at anytime; No PC necessary
- One Logger at full storage capacity can be downloaded via Infrared communication in 55 seconds or via optical communication in just 24 seconds
- The collected data can be immediately viewed on site and checked for warning occurrences
- The Data Collector can store recorded data from up to 16 loggers at full capacity
- All operations can be carried out with one hand
- Can also collect data from older versions of our Data Loggers

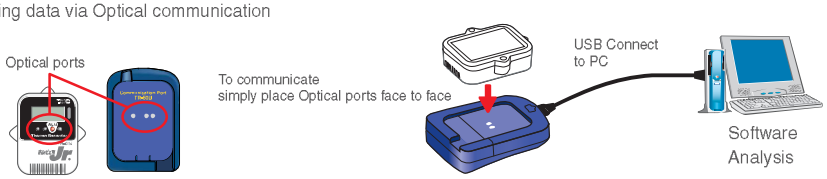
Image of gathering data via Infrared communication



High Speed Data Downloading Data

- Use for downloading data directly to a PC
- Download data from a Logger at full storage capacity in about 20 seconds
- Extremely lightweight at only 30 grams

Image of gathering data via Optical communication



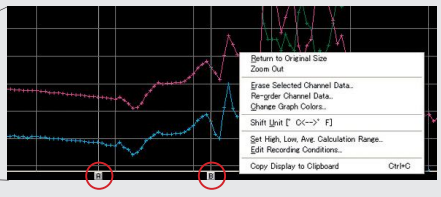
Free-of-Charge Software Included with PC Communication Interfaces

Software Updates and Info Available on Our Website

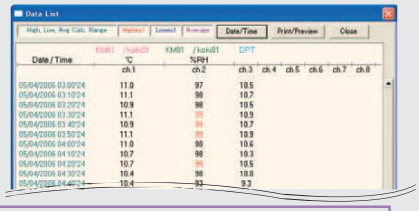
This free of charge software is bundled with the Data Collection Device. Our user-friendly software makes all types of settings a snap: from setting up recording conditions and warning monitoring to carrying out adjustments and other functions. The Graph Tools program intuitive operation allows the User to easily hide or view channels, zoom in and out on data, switch back and forth from °C to °F, and view data in table form.

Temperature / Humidity Graph

Enlarged View



View in Table Form

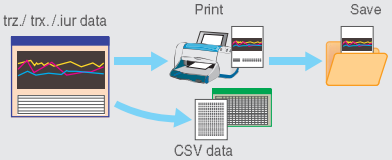


View in Table Form

Graph data can be easily viewed as a data list. The highest and lowest values are shown in easily distinguishable colors.

From Graph Editing to Data Analysis

It is possible to hide, re-order and delete channels, edit recording start times, and make changes to colors used for the graph scale lines, data lines and background. Also you can move the A and B cursor at the bottom of the graph to view data readings for those points and the calculated difference between the points.By saving graph data as CSV Format Text File data, that data can then be uploaded into common spreadsheet software for further data analysis.



Adjustment Settings for the TR-51i / 52i

The software enables you to use the measurement adjustment function to correct for TR-51i and TR-52i measurement inaccuracies.When using multiple measuring devices, this function allows the user to correct for inaccuracies found in measured values when compared to a standard measurement (the value measured by the standard device). Measurements can be adjusted and recorded based on a standard measurement. The software allows for adjustment settings to be made to Remote Unit measurements by simply selecting the adjustment method from either "1 Point Adjustment" or "2 Point Adjustment" and entering the values for "Before Adjustment" and "After Adjustment".

Device Name	TR-51i	TR-52i
Measurement Item	Temperature	Temperature
Number of Channels	1 Ch (Internal Sensor Type)	1 Ch (External Sensor Type)
Measurement Range	- 40 to 80˚C	- 60 to 155˚C
Unit of Measurement	˚C, ˚F	˚C, ˚F
Response Time (in 90% still air)	About 35 minutes	-
Measuring Accuracy	Avg. +/-0.5˚C	Avg.+/-0.3˚C: - 20 to 80˚C Avg.+/-0.5˚C: - 40 to - 20˚C 80 to 110˚C Avg.+/-1.0˚C: - 60 to - 40˚C 110 to 155˚C
Measurement Display Resolution	0.1˚C	
Recording Intervals	Select from 15 choices:1, 2, 5, 10, 15, 20 and 30 seconds / 1, 2, 5, 10, 15, 20, 30 and 60 minutes	
Storage Capacity	Up to 16,000 readings	
Recording Start Method	Immediate Start / Programmed Start	
Recording Modes	Endless / One Time	
LCD Displayed Items	Measured Temperature, Recording Status, Recording Mode Infrared Communication Status Battery Life Warning, Unit of Measurement, Full (Storage Capacity FULL), Unconnected Sensor Measurement Range Exceeded, Upper / Lower Limit Exceeded	
Communication Interfaces	Optical / Infrared Communication	
Infrared Communication	IrPHY 1.2 low power	
Communication Time	When downloading a Unit at full storage capacity: Optical Communication : about 25 seconds (TR-50U) about 150 seconds (other devices) Infrared Communication: about 55 seconds (TR-57DCi)	
Power (*1)	Lithium Battery (LS14250) / Lithium Battery (CR2)	
	About 4 years (2 years if it's been selected to "Permit" infrared communication)	
Waterproof Capacity	Immersion proof	Splash proof
Dimensions	H62 x W47 x D19mm (excluding protrusions and sensor part)	
Weight	About 54g (including battery)	About 55g (including battery / excluding sensor)
Operating Environment	- 40 to 80˚C When using Lithium Batteries (CR2) sold in stores : -20 to 60˚C	
Data Collection Devices	Data Collectors: TR-57DCi Communication Ports: TR-50U	

(*1) The included Lithium Battery (LS14250) is not sold in stores. Please purchase the "Optional Battery Set TR-11P2" for replacement.
(*2) Battery life varies depending upon measuring environment, frequency of communication, Unit settings, and battery performance.

For installation, it is necessary to have Administrator (Computer Administrator) rights.

Software Names	T&D Recorder for Windows (TR-5, 7xU)
Compatible OS	Microsoft® Windows® 7 32bit/64bit English Microsoft® Windows Vista® 32bit English Microsoft Windows® XP 32bit (SP2 or above) English
PC/CPU	A Stable Windows Operating Environment
Memory	A Stable Windows Operating Environment
Hard Disk	More than 30 MB of free space (Data will need more space)
Monitor	SVGA (800 x 600) more than 256 colors

Device Name	TR-57DCi
Compatible Devices	TR-51i / 52i, TR-51S / 52S, TR-51 / 51A / 52, TR-74Ui / 77Ui, TR-71U / 72U / 73U, TR-71S / 72S, TR-71 / 72, VR-71, RTR-501 / 502 / 503 / 574, RTR-51A / 52A / 53A, RVR-52A, RTR-51 / 52 / 52Pt / 53, RVR-52
Storage Capacity	Up to 256,000 readings 16 units of TR-51i at full storage capacity (16,000 readings x 1ch) 16 units of TR-71U at full storage capacity (8,000 readings x 2ch) 10 units of TR-73U at full storage capacity (8,000 readings x 2ch) 7 units of TR-74Ui at full storage capacity (8,000 readings x 4ch) When downloading units at non-full storage capacity, it can store and manage up to 250 downloading sessions.
Functions	Downloading Recorded Data, Viewing Saved Data in Graph Form, Recording Start Settings, Displaying Highest and Lowest Measurement
LCD Displayed Items	Operation Menu, Graph Display, Battery Life Warning Display, Calendar and Clock, Contrast Adjustment, Backlight
Power	AAA Alkaline Battery (LR03) x 2 (AAA Ni-Cd batteries or AAA Ni-MH batteries (1.2V) may also be used.) AC Adaptor (optional)
Battery Life	About 100 days at 1 hour of daily use * Battery life varies depending upon the type of battery, the measuring environment, the frequency of communication, and the ambient temperature in which it is used.
Data Backup	About 1 month (Saved data will be erased if all battery power is lost.)
PC Communication Interfaces	USB Communication, RS-232C Communication 19,200 bps
Data Logger Communication Interfaces	RS-232C Communication: 9,600 to 19,200 bps Optical Communication: 2,400 to 19,200 bps Infrared Communication
Communication Time	- Between PC and TR-57DCi USB Communication (16,000 readings x 1ch): approx. 12 seconds USB Communication (8,000 readings x 4ch): approx. 24 seconds RS-232C Communication (16,000 readings x 1ch): approx. 22 seconds RS-232C Communication (8,000 readings x 4ch): approx. 42 seconds -TR-5i Series Optical Communication (16,000 readings x 1ch): approx. 24 seconds Infrared Communication (16,000 readings x 1ch): approx. 55 seconds -TR-7Ui Series Infrared Communication (8,000 readings x 2ch): approx. 55 seconds Infrared Communication (8,000 readings x 4ch): approx. 77 seconds -TR-5S Series Optical Communication (16,000 readings x 1ch): approx. 24 seconds
Dimensions	H125mm x W58mm x D23.8mm (excluding protrusions)
Weight	About 110g (including two AAA batteries)
Operating Environment	Temperature: 0 to 50˚C Humidity: 90 RH% or less (no condensation
Accessories	US-15C (USB communication cable / USB-A plug<->USB mini-B plug) x 1 TR-6C10 (Serial communication cable / mini-RS<->mini-RS) x 1 AAA Alkaline Battery (LR03) x 2 User's Manual (Warranty) x 1, Software (CD-ROM) x 1

Device Name	TR-50U
Compatible Devices	TR-51i / 52i, TR-51S / 52S, TR-51 / 51A / 52
PC Communication Interfaces	USB Communication: USB 1.1
Communication Time	When downloading units at full storage capacity: TR-51i /52i, TR-51S/52S: About 20 seconds (19200bps) TR-51A / 52 : About 160 seconds (2400bps)
Dimensions	H80mm x W56mm x D16.5mm (excluding protrusions)
Weight	About 30g
Operating Environment	Temperature: -10 to 60 ˚C Humidity: less than 90%RH (No condensation)
Accessories	US-15C (USB communication cable / USB-A plug<->USB mini-B plug) x 1 User's Manual (Warranty) x 1, Software (CD-ROM) x 1

Caution regarding safety
For safe operation carefully read instructions before using this unit.

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2011. 05. 16304710003D

Daylight Zone 1

Daylight Zone 1

Daylight Zone 2

Daylight Zone 3

Gateway

Cellular Modem

E	Installed B1 Corelite lighting fixture with Adura dimming relay LC1RD-KO. **E** - **Emergency**
#2	Installed A1 Cree lighting fixture with Adura dimming relay LC1RD-KO. #1 and #2 – circuits at the Server Room El. Panel
	EnOcean wall switch
	EnOcean switch, used as PR
	EnOcean occupancy sensor PIR
	Adura sensor interface with EnOcean, SIAC-EN
	Daylight sensor, WattStopper LS290c
	Occupancy sensor, WattStopper WT-2205
	Occupancy sensor, WattStopper WT-605
	Adura sensor interface with WattStopper, SIAC-L2
	Ch 1 — Ch 2

enovity inc

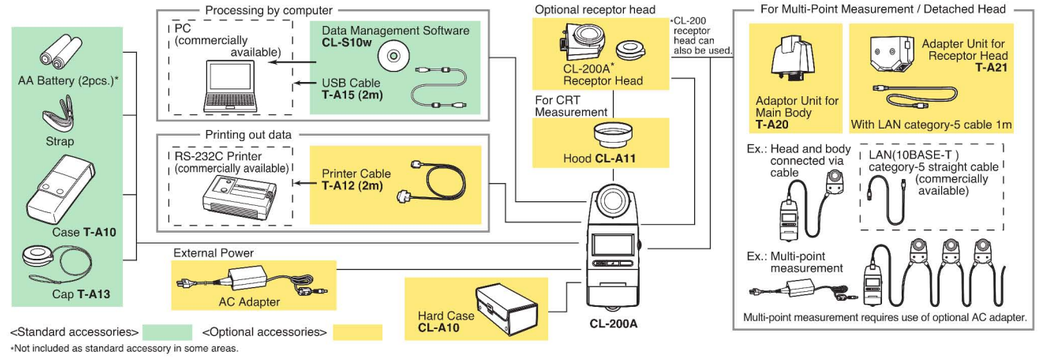
Enovity Inc.
100 Montgomery St. Suite 600
San Francisco, CA 94104
Phone: (415) 974-0390
Fax: (415) 974-0399

US General Services Administration
630 Sansome St., Suite 1080
San Francisco, CA

630 Sansome LED Installation

As Built

SYSTEM DIAGRAM



<Standard accessories> <Optional accessories>

•Not included as standard accessory in some areas.

Main specifications of Chroma Meter CL-200A

Model	Chroma Meter CL-200A
Luminance meter class	Conforms to requirements for Class AA of JIS C 1609-1: 2006 "Illuminance meters Part 1: General measuring instruments"
Relative spectral response	Closely matches CIE Standard Observer curves $\bar{x}(\lambda)$, $\bar{y}(\lambda)$, and $\bar{z}(\lambda)$ Within 6% (fi') of the CIE spectral luminous efficency $V(\lambda)$
Cosine response (f_2)	E_V: Within 3%
Receptor	Silicon photocell
Measuring function	Tristimulus values: XYZ Chromaticity: E_Vxy; $E_Vu'v'$; E_V, Dominant wavelength, Excitation purity Correlated color temperature: $E_VT_{CP}\Delta uv$; T_{CP}(JIS method; available only with CL-S10w) Color difference: Δ(XYZ), $\Delta(E_Vxy)$, $\Delta(E_Vu'v')$, $\Delta E_V\Delta u'v'$(Target: 1)
Other function	User calibration function, Data hold function, Multi-point measurement (2 to 30 points)
Measuring range	0.1 to 99,990 lx, 0.01 to 9,999 fcd (Chromaticity: 5 lx, 0.5 fcd or above) in four automatically selected ranges (lx or fcd is switchable)
Accuracy*	E_V (Linearity): ±2%±1digit of displayed value xy: ±0.002
Repeatability*	E_V: 0.5%+1digit (2σ), xy: ±0.0005
Temperature drift	E_V: ±3% ±1digit of displayed value, xy: ±0.003
Humidity drift	E_V: ±3% ±1digit of displayed value, xy: ±0.003
Response time	0.5 sec. (continuous measurement)
Computer interface	USB
Printer output	RS-232C
Display	4-significant-digit LCD with back-light illumination
Operating temperature/ humidity range	-10 to 40˚C, relative humidity 85% or less (at 35˚C) with no condensation
Storage temperature / humidity range	-20 to 55˚C, relative humidity 85% or less (at 35˚C) with no condensation
Power source	2 AA-size batteries / AC adapter AC-308 (optional; for 1 to 10 receptors) or AC adapter AC-311 (optional; for 1 to 30 receptors)
Battery life	72 hours or longer (When alkaline batteries are used) in continuous measurement
Dimensions	69×174×35mm (2-6/16×6-14/16×1-7/13in.)
Weight	215g (7.6 oz.) not including batteries

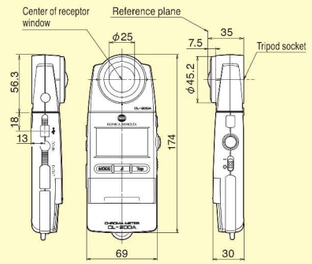
* 800 lx, Standard Illuminant A measured

Main specifications of Data Management Software CL-S10w

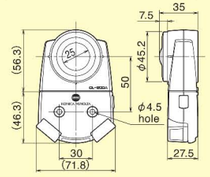
Type	Add-in for Excel® * Excel is required to use this add-in.
Operating environment	One of the following environments with Excel® installed: Windows® XP + Excel® 2003 (English, Japanese, or Simplified Chinese) Windows® 7 + Excel® 2010 (English, Japanese, or Simplified Chinese) * For details on system requirements for above versions of Windows®and/or Excel®, refer to their respective specifications. * Languages in parenthesis ( ) are the OS language. * Not compatible with 64-bit versions of Office 2010.
Compatible instruments	CL-200A, CL-200* * Some functions not usable with CL-200.

DIMENSIONS (Units:mm)

With receptor head attached to main body



With Adapter Unit attached to receptor head



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- Screens shown are for illustration purpose only.

SAFETY PRECAUTIONS

For correct use and for your safety, be sure to read the instruction manual before using the instrument.

- Always connect the instrument to the specified power supply voltage. Improper connection may cause a fire or electric shock.
- Be sure to use the specified batteries. Using improper batteries may cause a fire or electric shock.

Certificate No : LRQ 0960094/A
Registration Date : March 3, 1995

Certificate No : JQA-E-80027
Registration Date : March 12, 1997

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KONICA MINOLTA

Ideal for measuring color temperature

Chroma Meter CL-200A

Even measures new light sources such as LED lighting and organic EL lighting

A compact, lightweight instrument with a detachable receptor. Includes convenient, easy-to-use software.

Giving Shape to Ideas

De facto industry standard for measuring color temperature!

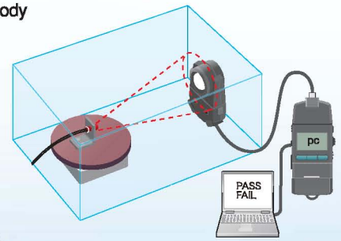
Compact and easy to carry

The CL-200A's compact body fits in your palm. Battery-powered so it can be taken along and used anywhere.

Detachable receptor head

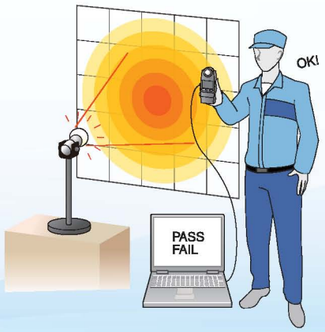
The receptor head can be detached and then connected to the main body using a normal LAN cable*, making it easy to install the sensor in an inspection system.

* Optional Adapter Units required for receptor head and main body



Data transfer using main body buttons

When using the CL-200A with Data Management Software CL-S10w (included), measurements can be taken and data transferred to Excel® using the main body buttons as well as computer keys.



Excel® add-in software included

Data Management Software CL-S10w (Standard accessory)

Easy, convenient Excel® add-in

Measurement data from the CL-200A can be transferred directly into Excel®. The transferred data can then be managed freely within Excel®.

Includes LED ranking function

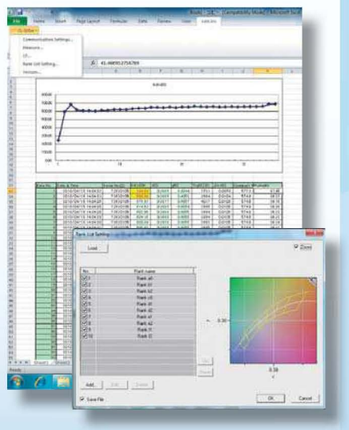
Color variations, the top topic in the LED industry, can be quantified and a ranking function is also provided.

JIS correlated color temperature

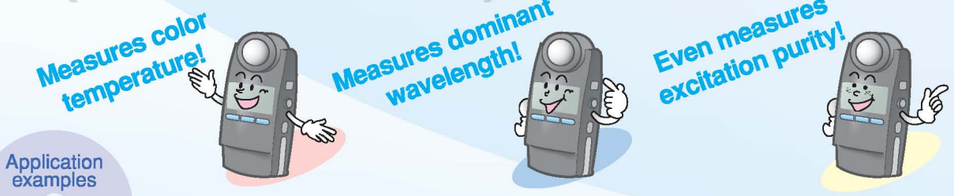
Correlated color temperature is determined using the equations defined by JIS (Japanese Industrial Standards).

Multi-point measurement and user calibration also possible

Multi-point measurement management using up to 30 receptor heads is possible.
User calibration function enables compensation of measurement values to match a desired standard. Calibration can be performed by two methods: Single-point calibration or RGB calibration.



Can also measure illuminance (JIS AA class)



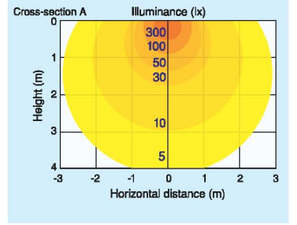
Application examples

For lighting production and adjustment

When using various types of light sources in a room or open space, it is sometimes necessary to check the color of the lighting.
By using the CL-200A, it is possible to adjust the lighting color so that the food in a restaurant looks delicious.

For evaluating light source characteristics

Evaluation of the light distribution of LED illumination modules or the illuminance distribution of lighting fixtures can be evaluated.



For color-viewing cabinet maintenance

A color-viewing cabinet like that shown at left is used in industries such as the printing industry to visually evaluate finished work under controlled conditions. This color-viewing cabinet provides illumination at a specific illuminance and color temperature by using fluorescent lamps, halogen lamps, etc. The CL-200A can be used for the daily maintenance and control of these lamps as well as to indicate when replacement is needed.

For projector light-source research and color inspection

The CL-200A can be used to measure the white balance and uniformity of microprojectors, etc. with internal LED light sources. The ability to connect multiple receptors using LAN cables enables measurement of not only a single point in the center, but up to a maximum of 30 points over the entire projected area.

For LED billboard development and maintenance

The CL-200A enables quality control of the LED modules for digital signage to be performed easily. If modules with different color tones are used together, the billboard will look mottled, but by measuring the chromaticity and color temperature of modules using the CL-200A and selecting modules based on measured values, billboard uniformity can be achieved.

For accurate measurements of color temperature, use the CL-200A!

Measurement accuracies of CL-200A and photographic color meter

When measuring light sources with non-continuous spectrums such as LEDs, etc., accurate illumination color temperature is particularly required. The CL-200A can measure color temperature accurately.

CL-200A

The CL-200A has sensors that closely match the color-matching functions defined by the CIE (International Commission on Illumination), enabling precise color measurement. The measurement results can be displayed in various color notations such as "Correlated color temperature and ⊿uv" according to the application.

Photographic color meter

In order to take more beautiful pictures, it is sometimes necessary to attach filters in front of the camera lens to compensate for the color of the light illuminating the subject. A photographic color meter is a meter used to select the appropriate filters, with the sensitivity of its sensors adjusted to match that of the film or digital camera sensor. In addition, because it uses photographic color temperature, which is calculated based mostly on the blue/red balance of the illumination, large errors may occur if it is used to measure light sources with non-continuous spectrums.

[Actual measurement data for daylight-color LED bulb]

	Measured color temperature	Color-temperature difference from standard-instrument measured value
Our company's standard instrument	5045	0
CL-200A	5011	-34
Photographic color meter	5600	555

Color temperature and correlated color temperature

Color temperature

When an ideal blackbody* is heated, it begins to emit light, and as the temperature increases the color of the emitted light changes from red to yellow to white. Since the color of the emitted light is determined by the temperature of the blackbody, the color of the light emitted by the blackbody can be expressed as the absolute temperature of the blackbody (in Kelvin). This color notation scale is called "color temperature". For example, a 7000K color would be the color of the light emitted by a blackbody heated to 7000K. Figure 1 shows the color of light emitted by a blackbody at various temperatures plotted on an xy chromaticity diagram. This curve is called the "blackbody locus"; "color temperature" expresses a color on this blackbody locus.

Correlated color temperature

Since the color of white light emitted by illumination equipment and displays is generally close to the blackbody locus, the color of such light sources is normally expressed using "color temperature".
However, the color of such light sources is not directly on the blackbody locus. Because of this, a way to enable similar color expression for colors within a larger region close to the blackbody locus was devised. This is called "correlated color temperature", and the larger region is shown by the isotherms on the xy chromaticity diagram in Figure 2.
To accurately express the correlated color temperature of a light-source color, it is necessary to state not only the correlated color temperature but the difference from the blackbody locus, normally in terms of ⊿uv.

*Blackbody
An ideal radiator. A body which completely absorbs all incident electromagnetic radiation. Although a perfect blackbody does not actually exist, coal is a familiar object that acts similarly.

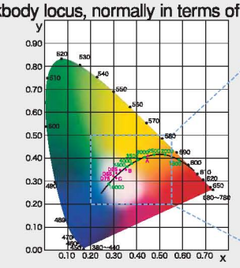


Figure 1: Blackbody locus on xy chromaticity diagram

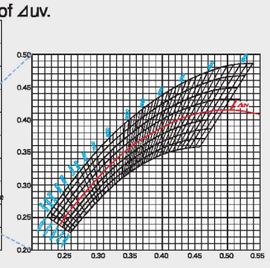


Figure 2: Closeup of blackbody locus on xy chromaticity diagram showing correlated color temperature region

General Reference Information
Measurements in the LED manufacturing process

When made from blue LED and phosphor

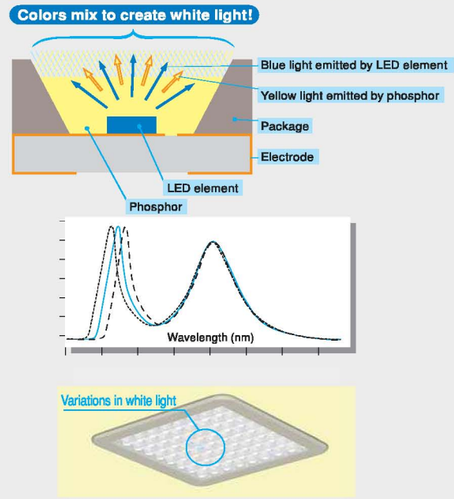
The blue light emitted by the LED mixes with the yellow light emitted by the phosphor to create white light.

Problem:

Since the spectral emission distribution of the blue light emitted by the LED varies for each unit, variations in the resulting white light will occur. Since usually LED lamps use several LEDs, control of color mixing is necessary.

General solution:

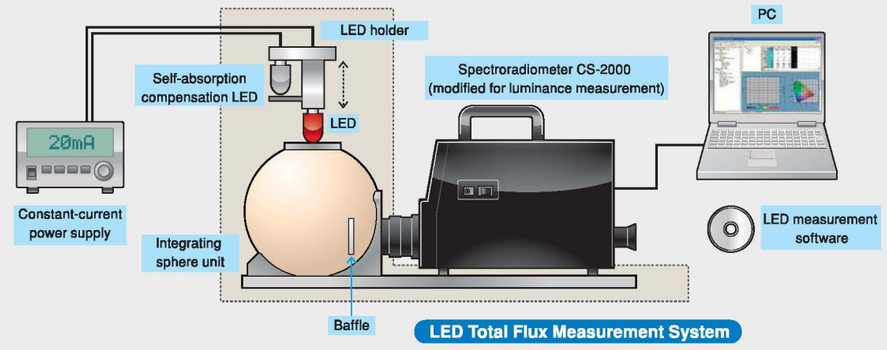
① Measure the spectral emission characteristics of each LED element and rank them accordingly.
② Measure the emission characteristics of the phosphor and rank accordingly.
③ Combine the ranked LED elements and ranked phosphor materials to achieve the desired white light.
④ Inspect the output light quality of the final assembled white LED lamp.



How the CL-200A can help:
The CL-200A can measure the chromaticity from the phosphor and also inspect the output light quality of the final assembled white LED lamp.

LED total flux measurement system

- This system combines our top-of-the-line Spectroradiometer CS-2000 modified for illuminance measurement with an LED total flux measurement adapter to create an LED measurement system that utilizes a spectral measuring instrument conforming to CIE 122-1996 as the receptor. The total flux emitted in all directions by the LED is diffused by the integrating sphere and received for measurement by the spectroradiometer.
- This system conforms to CIE 127:2007.
- Since the spectral response of the receptor matches the CIE spectral luminous efficiency function V(λ), there is no need to perform troublesome color correction.
- To enable accurate measurements, a self-absorption compensation function is provided to compensate for the reduction in integrating sphere output due to self absorption of the light source when it is lit inside the integrating sphere.



PowerSight®

PS2500 Power Logger | PS3500 Power Analyzer

Smallest, Safest, Easiest to Use

Everything you need for complete single and three-phase power and energy analysis

PS2500 features

Simple, foolproof data logging

- the perfect instrument for basic power studies
- 4 current & 3 voltage channels
- optional harmonics

PS3500 features

Complete power/energy analyzer

- great for handheld studies and long-term data logging
- control from keypad or PC
- view individual harmonics in display

Bluetooth™	Wireless communications
SureStart™	Technology that eliminates connection errors
PowerSight Manager™	PC software simplifies setup and built-in Report Writer produces complete, concise reports
CAT IV Rated	For safe connections to 600 VAC service
SD Card Slot	Store more data on removable memory cards

PS2500 Power Logger | PS3500 Power Analyzer

Two Powerful Choices

The PS2500 and PS3500 are inexpensive yet versatile, handheld power monitors. Both provide a complete solution for the process of performing power studies - from setup, to data gathering, to issuing a comprehensive final report. Both are excellent choices for power studies; the PS3500 offers more measurements and features that are accessible through the keypad. Note their contoured, rubberized grip that fits securely and comfortably in the hand. They are lightweight (only 1.1 lb.), compact and rugged, — ideal for field work!

AC & DC Power Measurements

Both are equipped with 4 current and 3 voltage channels to measure voltage, current, and power on all phases as well as neutral currents for single-phase, two-phase, three-phase, split-delta, 2PT/2CT, DC, 45-66 Hz, and 360-440 Hz applications.

Comprehensive Logging Capabilities

Both allow for logging of voltage and current, power usage and energy consumption in kWh. They have ample internal memory for monitoring up to months at a time. These units measure, record, and log: V, I, W, VA, VAR, PF, Hz, THD, – all simultaneously. You can audit individual loads or entire facilities, measure and profile circuit capacity, check load panel imbalance, track harmonic distortion and more.

SD Memory Card Slot

With inexpensive Secure Digital memory cards logging times can be extended and multiple surveys can be saved. SD cards offer an alternative download method to a PC. Whenever an SD card is inserted data is always saved automatically to the card. A card can be swapped after pausing and then monitoring resumed. Cards can be taken to a PC thus avoiding the need to take a PC to the meter in the field.

Bluetooth Communications

Each unit communicates wirelessly to a PC via Bluetooth so there's no need to connect a cable and be "tethered" to a PC! On a nearby PC screen a few feet away, real-time waveforms, phasors and harmonic spectra can be displayed. Also, from a few feet away, you can remotely control a PowerSight monitor *wirelessly*.

PC Software & Report Generator

All PowerSight monitors include PowerSight Manager PC software for data analysis. This software can display individual graphical logs, zoom and expand for detail, print, and export data to a spreadsheet file. The automatic Report Writer compiles the survey data into tables and graphs in just seconds to eliminate tedious manual cutting and pasting. The report is editable so you can insert your conclusions and recommendations. The comparison mode is ideal for comparing surveys such as "before and after" adding new loads or making circuit changes, or verifying the financial savings after implementing energy savings measures.

Safety First!

Both are **CAT IV** rated, the most stringent safety rating for handheld test equipment. Thus, the PS2500 and PS3500 are deemed safe for connection to up to 600 V service anywhere in a facility.

No More Connection Errors or Wasted Surveys

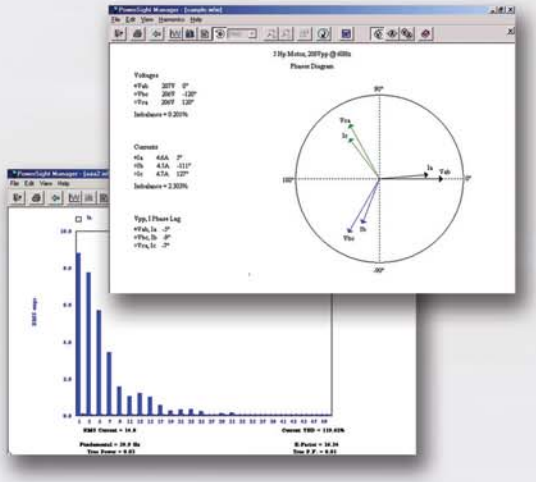
Our patented, built-in SureStart™ intelligence checks your voltage and current connections and advises you before you begin monitoring.

Going Green?

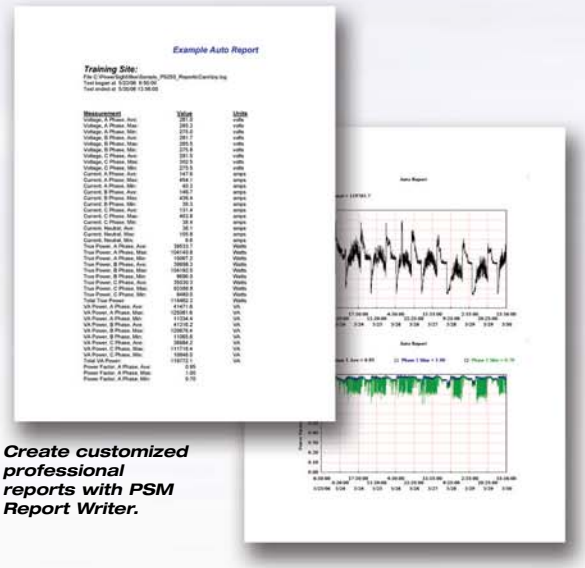
First start with a PowerSight monitor to identify energy savings opportunities. Find out how much energy you are using – and when. Implement a solution and monitor again to verify. Get the results the way you want, in watts or in dollars.

Going Solar or Wind-Powered?

PowerSight meters are smart and tell you when you are consuming power and when you are generating and sending power back to the grid.



Display waveforms, phasors, and harmonic spectra on your PC.



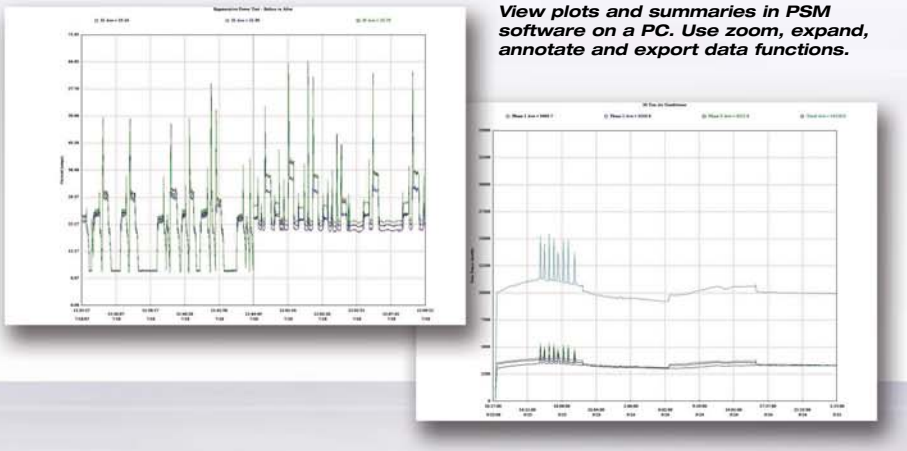
Create customized professional reports with PSM Report Writer.

Power Quality Analyzers

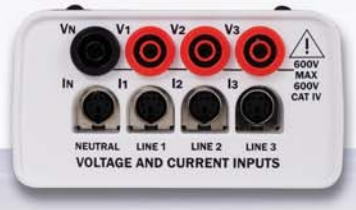
...Smallest, Safest, Easiest to Use!

Comparison Chart

	PS2500	PS3500	Recommendation
Keypad	Two keys. On/Off key and Next key. Each press of Next scrolls through a list of real-time meter values, similar to a multimeter. Next also controls Start/Stop of monitoring.	25-button keypad with individually labeled keys for immediate viewing of real-time values like a multimeter without scrolling. The keypad can program setup and control Start/Stop of monitoring.	Choose the PS3500 if you often perform spot checks or make handheld multi-meter measurements and prefer using a labeled keypad instead of scrolling through a list.
Display Functions	Certain functions are only available on the PC, including: THD, individual harmonic content, VAR, KWh, cost, frequency, duty cycle, displacement power factor, phase lag angle, peak demand power, and peak demand period. The PS2500 display is not backlit.	More functions are available directly on the meter display, including: min/max/ average summaries, THD, individual harmonic content, VAR, kWh, cost, frequency, duty cycle, displacement power factor, phase lag angle, peak demand power, and peak demand. period. The PS3500 display is backlit.	Choose the PS3500 to get additional measurement functions on the meter display or to immediately view a summary of results after monitoring instead of having to download to a PC. The backlit display of the PS3500 is better for low light conditions.
PC Setup	Setup is via the PC only and saved to the meter. Meter can be turned off and taken to the field. Monitoring Start/Stop can be controlled on meter or by a PC. Changing the setup for the PS2500 requires a PC.	Either the PC or the keypad can be used to program the meter. Setup and Start/Stop of monitoring can be performed in the field with or without a PC.	PS2500 setup is done only via a PC. Choose the PS3500 if programming the setup with or without a PC offers you more flexibility. You can change setup anytime from the PS3500 keypad; no PC is needed on site.
Demand Power KWh, and Cost Summary	Generated in the PSM software and can be viewed only on a PC.	Available in the meter display from the keypad or can be viewed in the PSM software on a PC.	Both perform logging. Choose the PS3500 if you prefer using the meter's keypad buttons to view a summary of energy measurements in the display without having to download to a PC.
Duty Cycle (% On/Off)	Not available	Available	Choose the PS3500 for duty cycle measurements.
Transient Disturbances	Not available	Available on one channel. Transient count, worst magnitude and duration.	Choose the PS3500 for logging of transient disturbances.
Harmonics	Optional. Displayed on PC only in PSM software.	Included. Displayed on meter or on PC	Both log THD. The PS3500 is better suited to handheld measurements.
Cost	Lowest	Low	Both are good value. Choose which features are important to you.
Role or mode of application	Better suited as an economical, easy-to-use power logger; logging is its main role. Best suited for applications needing a logger that is brought back to a PC for analysis and reports. Has fewer handheld operation and meter display functions.	Very good for logging and better for spot checks and handheld measurements like a multimeter. More display functions are available in PS3500.	Choose the PS2500 for an economical data-logger. Choose the PS3500 if, in addition to logging, you often need to perform spot checks or hand-held measurements like a multimeter and prefer using the meter's keypad instead of scrolling through a list.



View plots and summaries in PSM software on a PC. Use zoom, expand, annotate and export data functions.



Voltage and current connections for both single and three-phase measurements.

PS2500 Power Logger | PS3500 Power Analyzer

Specifications

Size: 3.88" (9.86 cm) W x 7.72" (19.61 cm) L x 1.58" (4.01 cm) D; In handheld region: 2.14" (5.44 cm) deep at top end

Weight: 1.1 lb. (0.5 kg)

Operating Range: 32 - 122 degrees F (0 - 50 degrees C)
Relative humidity to 70% (non-condensing)

Power Requirement: 12 VDC @ 500 mA, wall-mount power supply included (specify 120 V or 240 V). Internal Ni-Cad battery operates 8-10 hours after full charge.

Measurement Rate: Analyzes two cycles per second of each voltage and current input at 16 µs; uses 130 samples per cycle @ 60 Hz. All measurements updated once per second

Voltage Measurement Ranges:
1-600 Vrms steady-state (direct input); 1- 600 Vdc
or 600–5,000 Vrms with 5 KVP probes,
or 600–15,000 Vrms with 15 KVP probes.

Display Range: 1-6 MV (using input ratios)
Meter Display Resolution: 1V (PS2500); 0.1V (PS3500)
Accuracy: 0.5% of reading ±0.3 Vrms

Current Measurement Ranges:
With HA5: 0.02 - 5 A
With HA100: 0.1 - 100 A
With HA1000: 1 - 1000 A
With FX3000: 10 – 3000 A
With FX5000: 100 - 5000 A
With DC600: 5 - 600 A DC

Display Range: 1 mA - 6 MA (using input ratios)
Meter Display Resolution: 1A (PS2500); 0.1A (PS3500)
Accuracy: 0.5% of reading plus accuracy of probe
Phasor diagram: via PC
Imbalance: via PC

Frequency Measurement:
Range: DC, 45 - 66 Hz, 360 - 440 Hz fundamental
Display on meter: (PS3500 ONLY)
Accuracy: ±0.5%

Harmonics Measurement: 45 - 3000 Hz (50th harmonic @ 50/60 Hz, 7th @ 400 Hz); (HAO option needed with the PS2500)

THD Accuracy: 1%; Displays THD and individual harmonics through 25th harmonic of all signals on PS3500 only. PowerSight Manager software displays harmonics through 50th harmonic for both units on a PC; (HAO option needed with the PS2500)

Power, Energy, Cost, Power Factor:
VA, VAR, True Power Factor (TPF), Displacement Power Factor (DPF), Phase Lag Angle, Energy kWh, Energy cost in $, Waveform snapshot

Display Range: 1 watt - 60 MW (using input ratios)
Accuracy: 1% plus accuracy of current probe
Transient Detection: one channel (PS3500 ONLY)

Logging Period (resolution)
User selectable from 1 second — 99 minutes

Logging Duration (length of monitoring session)
User selectable up to 2 years according to memory allocation

Other Features:
Crest Factor, K Factor, Peak Demand Period, Peak Demand of Peak Demand Period.

Duty cycle, On/Off cycle %, avg On time, avg Off time (PS3500 ONLY)

SureStart™ checks connections for error free monitoring
Backlit Display (PS3500 ONLY)
Wireless communications: Bluetooth
SD memory card slot to 2GB
CE 600V Cat IV
Keypad control of functions (PS2500: 2 keys; PS3500: 25 keys)
Programming and set-up with PC (required for PS2500)
Setup of operating parameters in the field without PC (PS3500 ONLY)
Review of max/min/avg of measurements in meter display (PS3500 ONLY)
Spanish language user interface (PS3500 ONLY)
Regenerative power measurement mode (alternating consume/generate)
Two CT power measurement mode, open delta measurement mode
wye, 3-wire delta, 4-wire delta measurement modes
Data Exportable to Excel
Compatible with SafeConnect™ accessory
Report Writer Software, summary or comparison, w or w/o graphs, text editable
Long-term monitoring via external 12 V battery
Derive operating power off power being monitored with LDC accessory

Non-intrusive monitoring of appliances: with 120ADP accessory

Internal Data Retention: 8 years

HA5 0.02 A to 5 A AC
HA100 0.1 A to 100 A AC
Accuracy: 2%,
Size: 5.25" x 2.1" x 1.35" for conductors up to 0.8" diameter

HA1000
1 A to 1000 A AC
Accuracy: 0.5%,
Size 9" x 4.4" x 1.75" for conductors up to 2.13" diameter

DC600
5 A to 600 A DC;
5 A to 400 A, DC/AC
Accuracy ±1A ±2%, 5A to 400A; ±1A ±3%, 400 A to 600 A DC
Size: 7.68" x 2.6" x 1.34" for conductors up to 1.18" diameter

FX3000
10 A to 3000 A AC
FX5000 100 A to 5000 A AC
Both models: Accuracy 2%,
Size 24" long for conductors up to 7.5" diameter

Complete, pre-packaged systems
Systems are equipped with your choice of clamp-on or flexible current probes, voltage leads, plug-in charger unit, PC software and instruction manual.
Other options available: 5 KV and 15 KV medium voltage probes; soft carry case; weatherproof operating case; line-to-DC converter.

PowerSight®

Summit Technology
2717 N. Main St., Suite 15
Walnut Creek, CA 94597-2747
Phone: 925-944-1212 Fax: 925-944-7126
www.powersight.com
Email: sales@powersight.com

APPENDIX D. TESTED PRODUCTS CUT SHEETS

CORELITE™

DESCRIPTION

The Corelite Z3 LED combines the internally developed Linear LED platform from Cooper Lighting with the high sense of style and superior brightness management that characterizes the CoreLite Class RZ family. The proprietary LED platform delivers a soft, diffuse volume of pure white light that carries the general character of a fluorescent source while simultaneously eliminating unsightly socket shadows and the hassle of luminaire maintenance. A guaranteed system life of 50,000 hrs combined with exceptional efficacy make the Z3 LED the ultimate solution to satisfy the most stringent energy requirements with an ultra-light carbon footprint.

Catalog #		Type
Project		
Comments		Date
Prepared by		

SPECIFICATION FEATURES

A ... Construction
Low profile housing constructed of die formed 20 gauge cold rolled steel with integral 20 gauge gear tray.

B ... Reflectors
Precision tooled, high reflectance sheet metal which allows for easy access to driver compartment from below ceiling plenum.

C ... Shielding
High light transmission frosted prismatic acrylic lens with UV inhibitors minimizes lamp image and ensures efficient light distribution. Lenses secured to housing via injection molded inserts for easy lamp access.

D ... Electrical
Fixture equipped with proprietary Cooper LED modules available in 3000, 3500 or 4000k with a CRI plus or minus 85. Removable module features aluminum extrusion providing exceptional thermal management. Modules are driven using universal voltage switch mode LED drivers. Fixture and modules certified to UL and CUL standards. A 0 to 10V dimming control is available (standard).

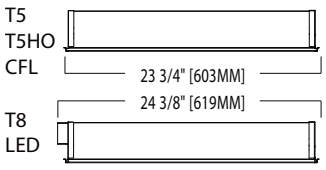
E ... Finish
Fixture housings are high reflectance white using electrostatically applied polyester powder coat paint.

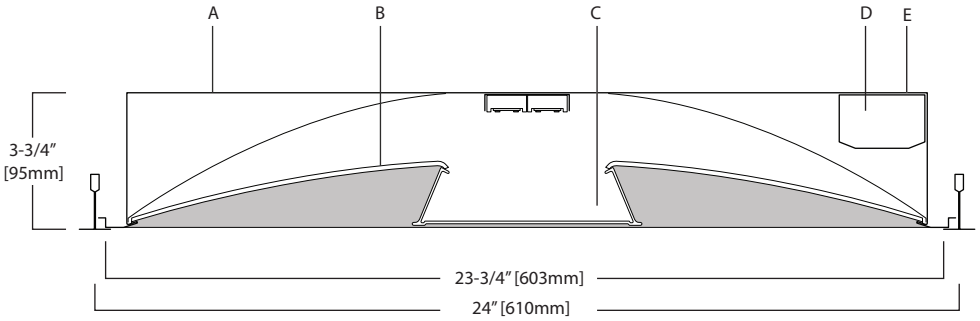
Mounting
Standard flange design works with most lay in ceiling types. Integral pryout tabs secure luminaire to ceiling grid from above. Fixture offers tie in locations for tie wire on all corners, consult local code for appropriate tie wire recommendations.

Note: Concealed Ceiling
Class R may be installed into inaccessible ceilings (sheet rock, wood panel, etc.). This is achieved with the Metalux DFW series drywall frame-in kit, ordered separately from Metalux. Specify CC for the Corelite Ceiling Type. Specify the following part numbers separately, from Metalux: For 2x2, order Metalux part DF-22W-U.

2x2 Class R and RZ LED Light Level Outputs			
Light Level	Wattage	Lumens (delivered)	Efficacy (LPW)
1	34W	2740	80.2
2	44W	3480	78.8

Alternate Dimensions - 2x2





CLASS Z3
Linear Prismatic Lens

LED

2'x2' Recessed
3-3/4" Depth

ORDERING INFORMATION

Sample Number: Z3-WL-1L30-1C-UNV-22-T1

Series
Z3: Class Z3

Reflector
W: White

Shielding
L: Linear Prismatic Lens

Light Level
1: Light Level 1
2: Light Level 2

Color Temperature
L30: LED 3000K
L35: LED 3500K
L40: LED 4000K

Number of Circuits
1: 1 Circuit

Wiring [1]
C: Standard Circuit
D: Dimming / Step Dimming
E: Emergency
T: Nightlight
Y: Daylight

Voltage [1]
120: 120V
277: 277V
347: 347V
UNV: Universal (120V-277V)

Size
22: 2' x 2'

Ceiling Type
T1: 1" Grid, Slot-Grid, 9/16" Tegular
T9: 9/16" Grid
CC: Concealed Ceiling

Options [1]
AR: Air Return
CP: Chicago Plenum
NY: New York City Construction
W6: 6' Whip Flex
W12: 12' Whip Flex

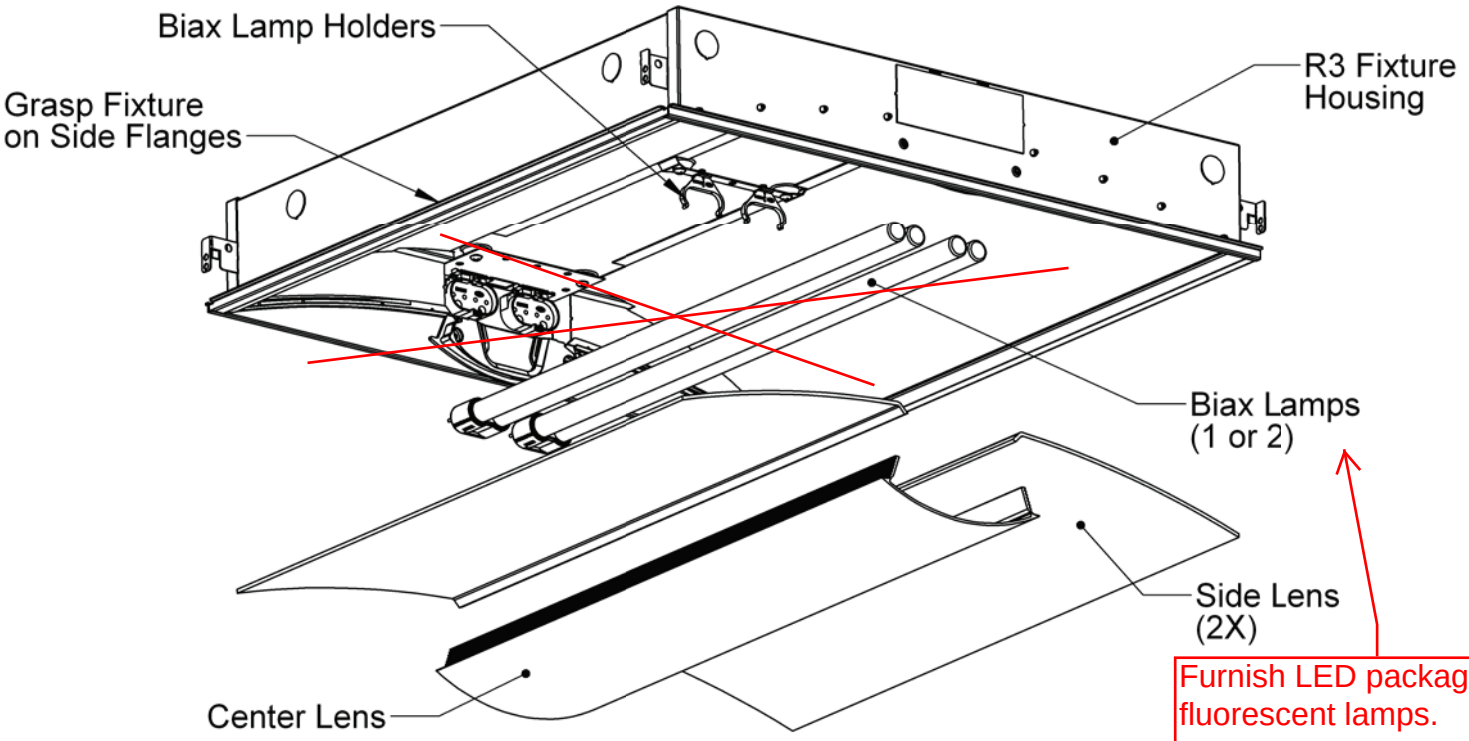
Notes: 1 Not all options available. Please consult your Cooper Lighting Representative for availability. Specifications and dimensions subject to change without notice.

Submit photometric test report.
RNM 5/15/12

R3 Ultra Shallow Fully Luminious Fixture
1 & 2 Lamp Biax
2' x 2' ; 2' x 4' Housing Sizes

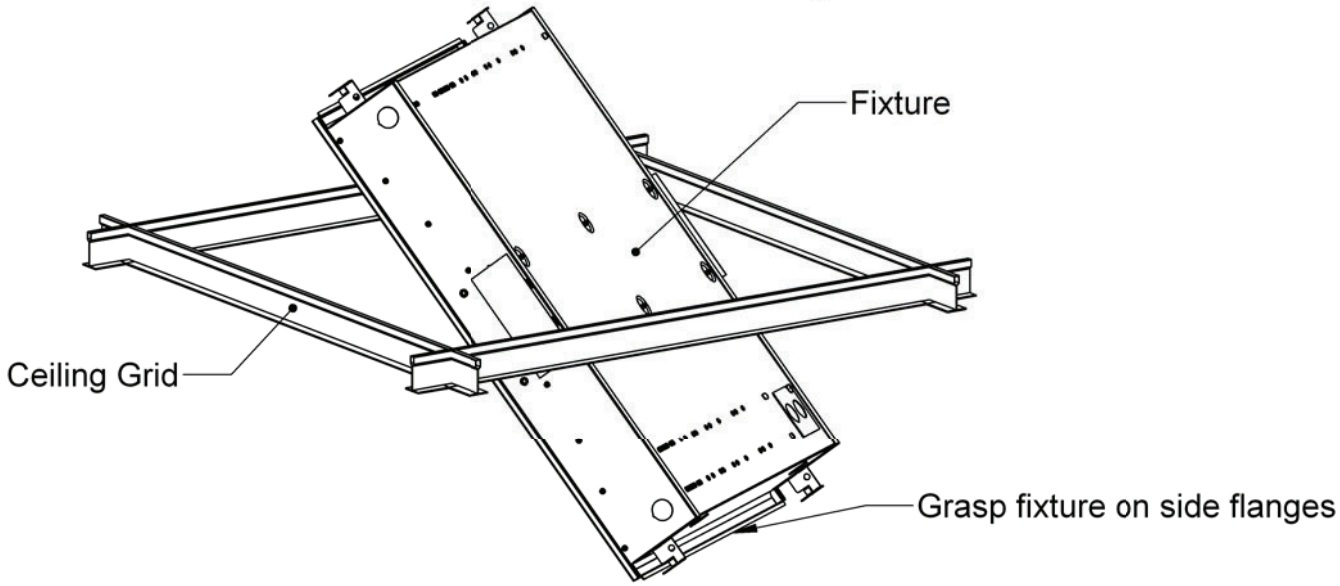
Warning: Before starting any work ensure that all sources of power are turned off. All work must meet local/national codes and be performed by a certified electrician. **Do not** mount fixtures vertically.

Exploded View and Part Call-out



Furnish LED package not fluorescent lamps.
RNM 5/15/12

Installing Fixture into Ceiling Grid



1. Firmly grasp fixture USING CLEAN GLOVES from sides, do not push or lift from center or side lens. Fingerprints can stick to proprietary reflective coating and can be very difficult to remove. If fingerprints are discovered, immediately wipe clean using Isopropyl alcohol on a clean rag.
2. Carefully angle and lift fixture into ceiling grid.

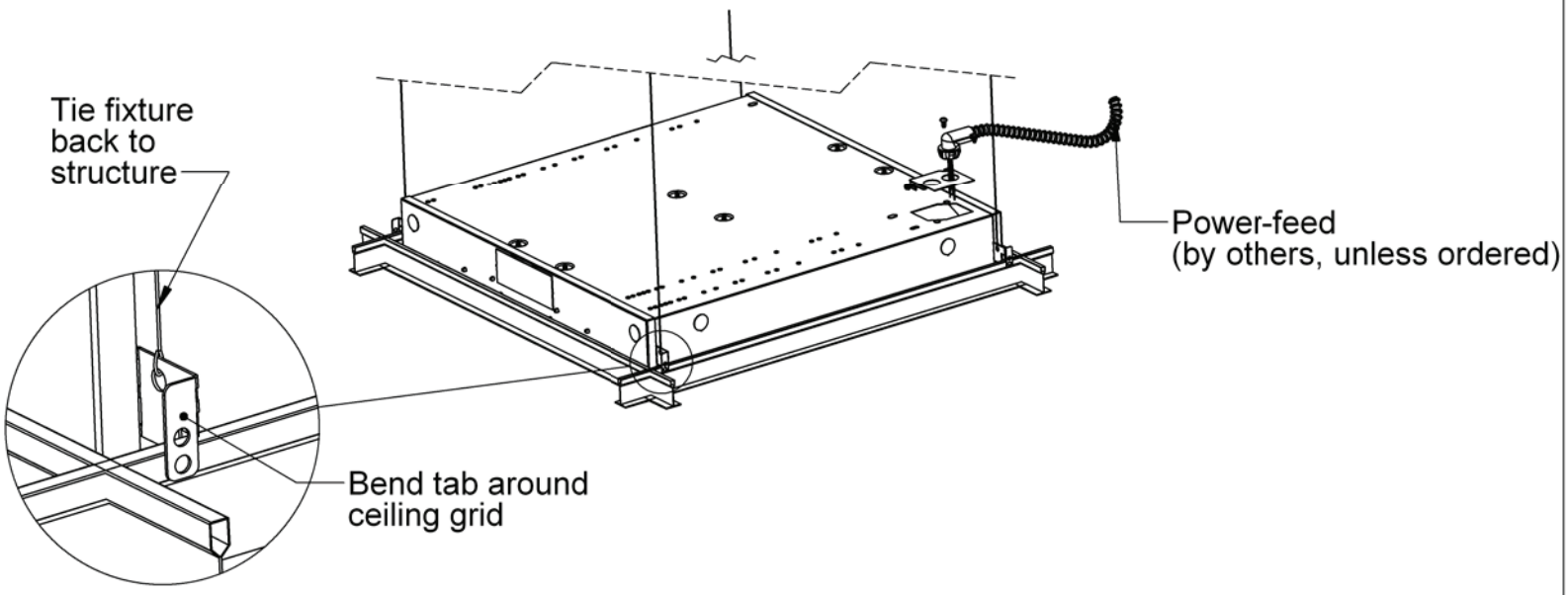
Corelite
4675 Holly Street
Denver, CO 80216
P: 303-393-1522
www.corelite.com

Cooper Lighting
1121 Highway 74 South
Peachtree City, GA 30269
P: 770-486-4800
www.cooperlighting.com

R3 Ultra Shallow Fully Luminious Fixture
1 & 2 Lamp Biax
2' x 2' ; 2' x 4' Housing Sizes

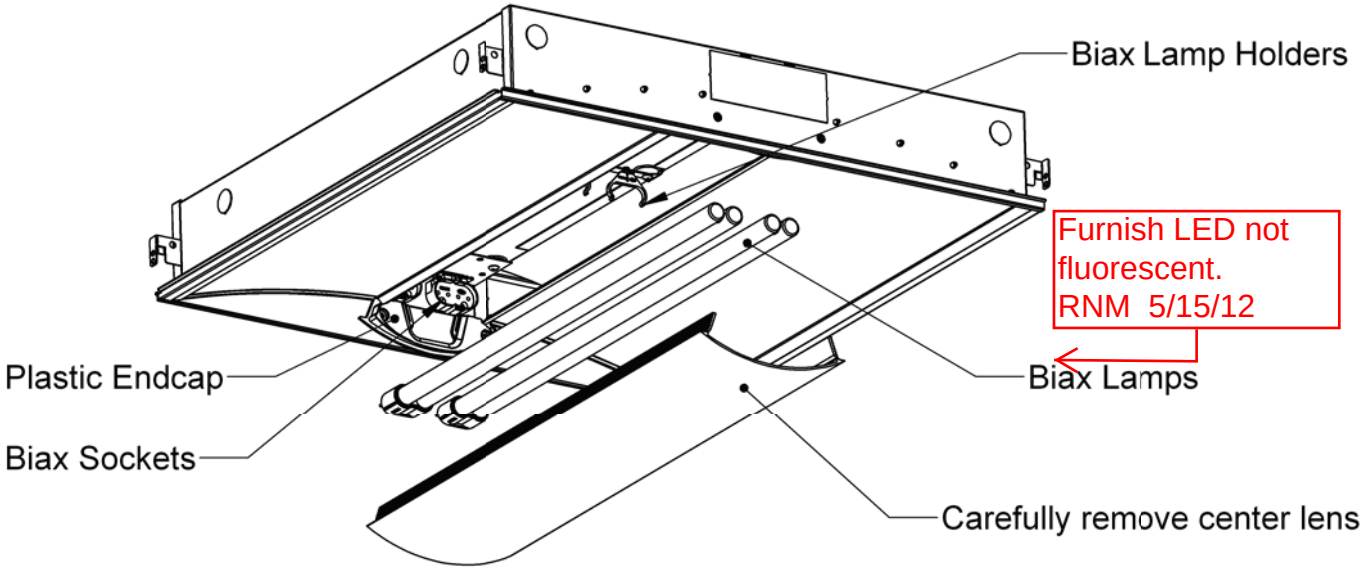
Warning: Before starting any work ensure that all sources of power are turned off. All work must meet local/national codes and be performed by a certified electrician. **Do not** mount fixtures vertically.

Wiring and Securing the Fixture



1. Bend tabs around ceiling grid and tie fixture back to structure per local code.
2. Remove wiring cover plate from fixture and connect power feed conduit.
3. Ensure all wires are properly connected, place wires and connections into fixture and replace cover plate.

Installing Lamps into Fixture



1. Gently remove center lens from fixture and store in a safe place.
2. Press lamp contacts into sockets at one end of fixture until lamp snaps into place.
3. Gently press lamp into biax lamp holder
4. Snap lens back into place around plastic end caps.

Corelite
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www.cooperlighting.com

CR22™ RECESSED TROFFER

CREE TRUE WHITE TECHNOLOGY

PRODUCT DESCRIPTION

The CR22™ troffer design is compact and efficient for spaces requiring high efficiency, high quality general purpose lighting. Powered by Cree TrueWhite® Technology, the CR22 troffer delivers high efficacy and world class CRI.

Ideal applications include office spaces, major retail stores, education, government, healthcare, and hospitality. Anywhere bright, beautiful, uniform light is required for general purpose lighting. Its high performance is coupled with affordability, making it the best solution for any lay-in project.

PERFORMANCE SUMMARY

The CR22 troffer is designed to deliver an optimal amount of light with typical luminaire spacing.

Utilizes Cree TrueWhite® Technology

Temperature Controlled Cooling

Made in US

Efficacy: 90 LPW

Delivered Light Output: 2000, 3200 Lumens

Input Power: 22, 35 Watts

CRI: 90

CCT: 3500K, 4000K

Input voltage: 120-277 VAC

Warranty: 5 Years

Lifetime: Designed to last minimum 50,000 hours

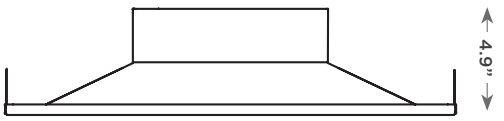
Dimming: Step Level to 50%, 0-10V Dimming to 5%*

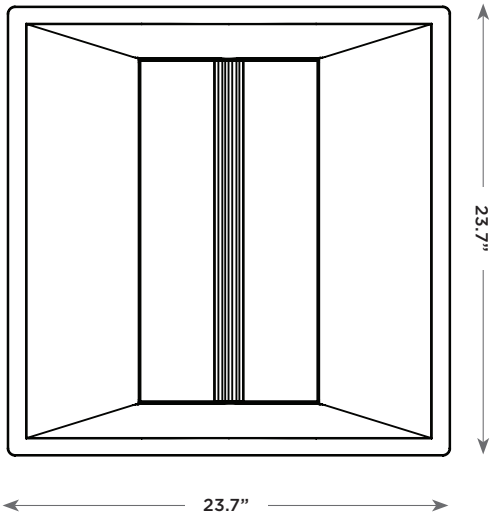
Mounting: Recessed

Dimensions: L **23.7”** x W **23.7”** x H **4.9”**

Weight: max 15lbs.

CR22
2’x2’ Troffer





ORDERING INFORMATION

Examples: **CR22-20L-35K-S**

C22				S	
Product Series & Size	**Lumen Output**	**Color Temperature**	**Voltage**	**Control**	**Options**
CR22 2’x2’	**20L** 22W 2000 Lumen - 90 LPW **32L** 35W 3200 Lumen - 90 LPW	**35K** 3500 Kelvin **40K** 4000 Kelvin	**Blank** 120 -277 Volt (Standard)	**S** Step Dimming to 50% **10V** 0-10V Dimming to 5%*	**CP** Chicago Plenum* **EB** Emergency Backup*

*Target Availability: Late 2011

CR22™ RECESSED TROFFER

CREE TRUE WHITE TECHNOLOGY

PRODUCT SPECIFICATIONS

Cree TrueWhite® Technology

A revolutionary new way to generate white light with LEDs, this technology delivers high efficiency with beautiful color characteristics by mixing the light from unsaturated yellow and red LEDs. Active color management maintains superior color consistency over time and temperature. Every fixture is tuned as a complete system to the optimal color point before shipment, ensuring fixture-to-fixture color consistency.

Room-Side Heat Sink

An innovative thermal management system designed to maximize cooling effectiveness by integrating a unique room-side heat sink into the diffusing lens. This breakthrough design creates a pleasing architectural aesthetic while conducting heat away from the LEDs in a temperature controlled environment. This enables the LEDs to consistently run cooler, providing significant boosts to lifetime, efficacy, and color consistency.

Optical System

Proprietary optical system utilizes a unique combination of reflective and refractive optical components to achieve a uniform, comfortable appearance. Pixelation, color fringing, and direct view of unshielded LEDs are eliminated. Lower reflector finished with a textured high reflectance white polyester powder coating creates a comfortable visual transition from the diffuser to the ceiling plane. Optimal distribution of light balances the delivery of high illuminance levels to horizontal surfaces with an ideal amount of light to vertical surfaces.

Electrical System

Integral, high efficiency driver and power supply.

Nominal Power Factor = 0.9

Dimming: Step Dimming to 50%

Battery Backup: Consult factory

Temperature Rating: Designed to operate in temperatures 35°C and below room side and plenum side.

Regulatory & Voluntary Qualifications

Suitable for damp locations.

UL Listed

cUL (Consult Factory)

Lifetime

Designed to last minimum 50,000 hours.

Construction & Materials

Durable 20 gauge steel housing with standard troffer access plate for electrical installation. Field replaceable light engine integrates LEDs, driver, power supply, thermal management, and optical mixing components. Optional t-bar clips and holes for mounting support wires enable recessed or suspended installation. Individual fixtures may be mounted end to end for a continuous row of illumination.

UPGRADES & ACCESSORIES (SOLD SEPARATELY)

EJBCR: Expanded size junction box for through wiring.

EQCR/4: Earthquake/Hurricane Clips

DGA-22: Drywall grid adaptors

SMCR22: Surface Mount

APPLICATION REFERENCE

Open Space - Sample Applications

Grid Spacing	Size	Performance				
		Lumens	Wattage	LPW	w/ft²	Actual fc
8x8	2x2	2000L	22W	90	0.35	28
		3200L	35W	90	0.55	44
8x10	2x2	2000L	22W	90	0.28	23
		3200L	35W	90	0.44	37
10 x 10	2x2	2000L	22W	90	0.22	20
		3200L	35W	90	0.35	31
10 x 12	2x2	2000L	22W	90	0.19	16
		3200L	35W	90	0.29	25

10' ceiling: 80/50/20 reflectances; 2.5' workplane, open room
LLF: 1.0 Initial
Open Space: 50' x 40' x 10'

Corridor - Sample Applications

Corridor Spacing	Size	Performance			
		Lumens	Wattage	LPW	Actual fc
8' on center	2x2	2000L	22W	90	17
		3200L	35W	90	27
10' on center	2x2	2000L	22W	90	14
		3200L	35W	90	22
12' on center	2x2	2000L	22W	90	12
		3200L	35W	90	18
14' on center	2x2	2000L	22W	90	10
		3200L	35W	90	16

10' ceiling: 80/50/20 reflectances; light levels on the ground
LLF: 1.0 Initial
Corridor: 6' wide x 100' long

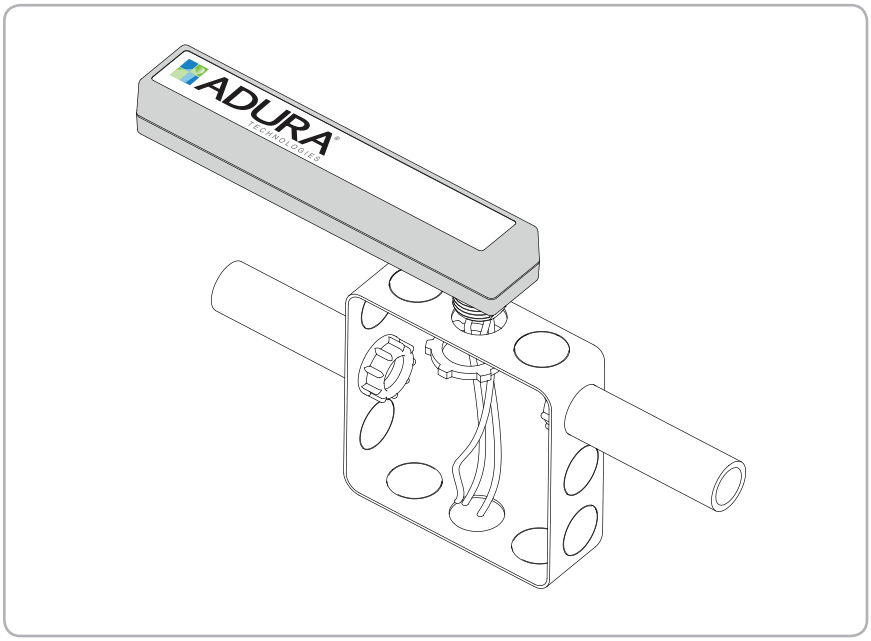
Cree LED Lighting Morrisville NC 27560 USA

CreeLEDLighting.com **P 1.919.287.7700 F 1.919.407.5451**

CREE® LED Lighting

Wireless Light Controllers

Outlet Box Application



Adura's wireless Light Controller product family combines stand-alone intelligence with wireless intelligent network communication. The Light Controller makes it cost-effective to control individual fixtures or small groups of fixtures. Lights are on at the desired level when needed and off when not needed.

The Light Controller is the point of control for a flexible wireless network in which lights can be easily configured to respond to one or multiple priorities. The device achieves energy savings not previously possible with control restricted to electrical circuits.

The Light Controller incorporates wireless RF technology using the ZigBee® standard for fail-safe communication. By forming a self-healing, adaptive mesh network that maintains connectivity, communication is assured even in difficult environments.

Available Models

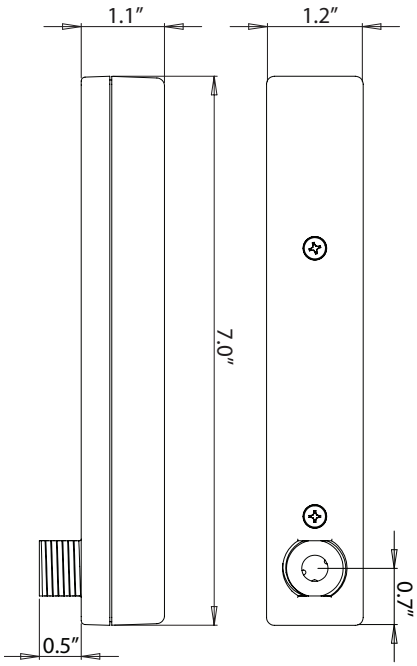
Catalog Number	Description	Number of Relays	Dimming (0-10VDC)
LC-KO-1R	Light Controller, Single Relay	One	No
LC-KO-2R	Light Controller, Two Relay - allows sequenced control of two ballasts or a bi-level ballast	Two	No
LC-KO-1RD	Light Controller, Single Relay With Dimming - provides dimming and on/off control to 0-10 VDC dimming ballasts (5 ballasts maximum)	One	Yes (5 ballast maximum)

ADURA LIGHT CONTROLLER FEATURES

- Individually addressed
- Microcontroller with real time clock responds to the highest priority command
- Automatic schedules are downloaded and saved in the Light Controllers
- Monitors/measures energy consumption of controlled lighting
- Non-volatile memory retains information during power failures
- Integrated internal antenna
- UL 916 and 2043 listed
- Compliant with FCC Part 15
- 5 year warranty

TECHNICAL

Dimensions



ABOUT ADURA TECHNOLOGIES

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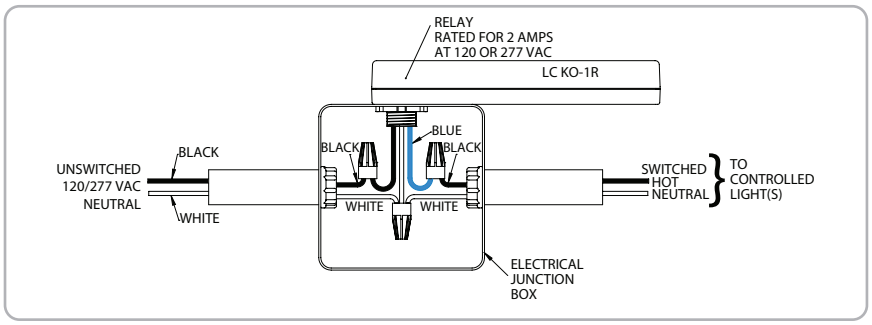
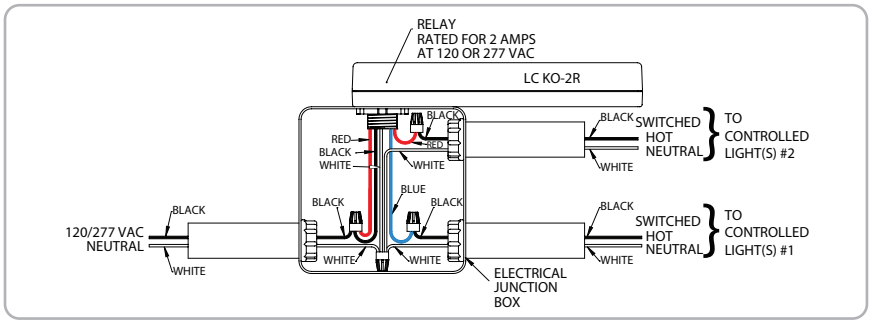
- **Most cost-effective:** Utilizing wireless technology platform and distributed controls technology, providing the most cost-effective solution from design, installation, commissioning and reconfiguration through life cycle management.
- **Energy management solution:** Distributed control system to monitor and control energy and carbon usage for energy savings, load curtailment and environmental responsibility.
- **Best in class:** Solution that meets or exceeds government and private standards for energy efficiency and carbon reduction.

Wiring Diagram

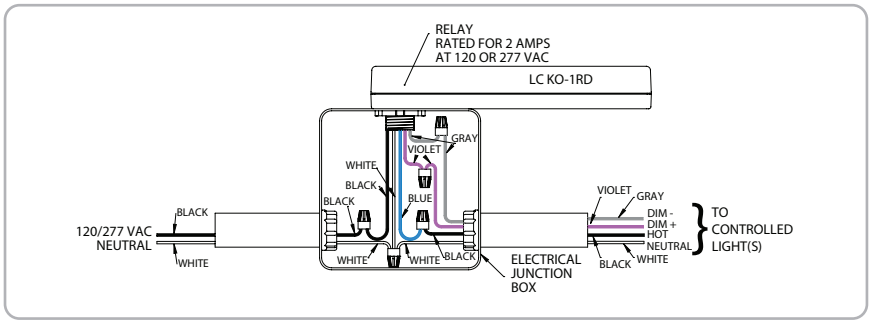
LC-KO-1R



LC-KO-2R



LC-KO-1RD



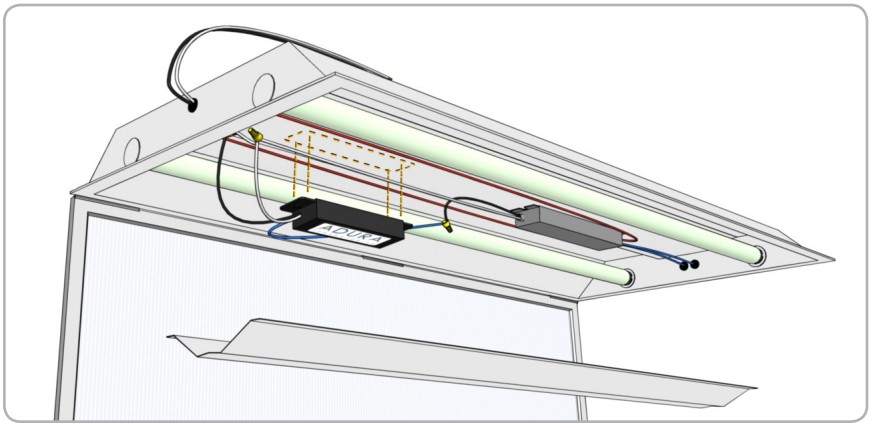
Specifications

Input Voltage	120/277 VAC	Voltage measurement	2% accuracy full scale
Input Frequency	60 Hz	Current measurement	2% accuracy full scale
Relay(s)	Normally open, SPST, zero crossing control	Operating Environment	-4 to 140 deg F (-20 to 60 deg C)
Max Switched Current (each relay)	2A Ballast/ 2A Tungsten	Memory	Configuration programming stored in non-volatile memory
Enclosure	Recyclable plastic	Wires	10″ long, rated for 600 VAC, 18 AWG
Radio Frequency	2.4 GHz	Mounting	Mounts into a 1/2″ knockout on an electrical box. Secures with supplied lock nut.
RF Transmission Output Power (Average)	+12 dBm		

ADURA TECHNOLOGIES
22 Fourth St, 10th Floor, San Francisco, CA 94103
1-888-828-8281 / www.aduratech.com

Wireless Light Controllers

Linear Fixture Application



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The Light Controller incorporates wireless RF technology using the ZigBee® standard for fail-safe communication. By forming a self-healing, adaptive mesh network that maintains connectivity, communication is assured even in difficult environments.

Available Models

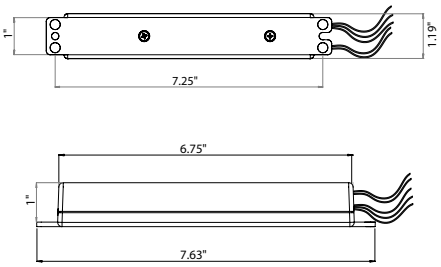
Catalog Number	Description	Number of Relays	Dimming (0-10VDC)
LC-1R	Light Controller, Single Relay	One	No
LC-2R	Light Controller, Two Relay - allows sequenced control of two ballasts or a bi-level ballast	Two	No
LC-1RD	Light Controller, Single Relay With Dimming - provides dimming and on/off control to 0-10 VDC dimming ballasts (5 ballasts maximum)	One	Yes

ADURA LIGHT CONTROLLER FEATURES

- Individually addressed
- Microcontroller with real time clock responds to the highest priority command
- Automatic schedules are downloaded and saved in the Light Controllers
- Monitors/measures energy consumption of controlled lighting
- Non-volatile memory retains information during power failures
- Slim profile design for easy mounting within the ballast cavity of lighting fixtures
- Integrated internal antenna
- UL 916 listed
- Compliant with FCC Part 15
- 5 year warranty

TECHNICAL

Dimensions



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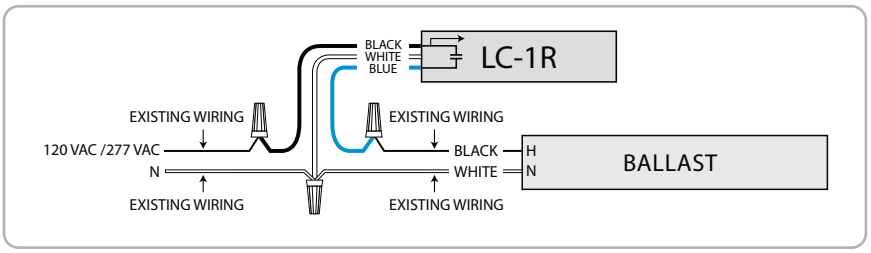
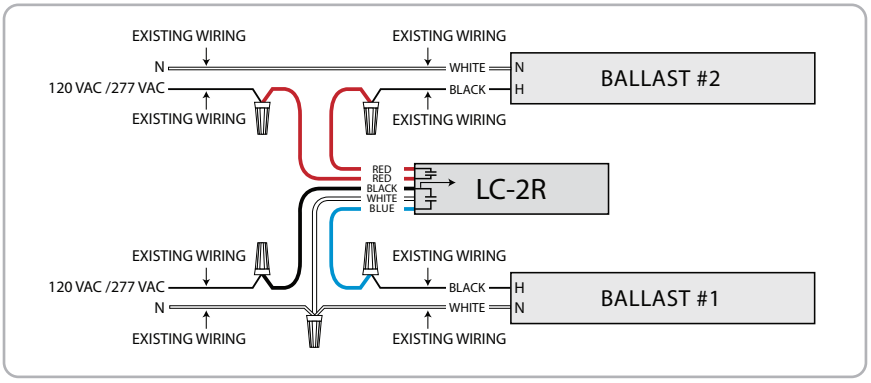
- **Energy management solution:** Distributed control system to monitor and control energy and carbon usage for energy savings, load curtailment and environmental responsibility.
- **Best in class:** Solution that meets or exceeds government and private standards for energy efficiency and carbon reduction.

Wiring Diagram

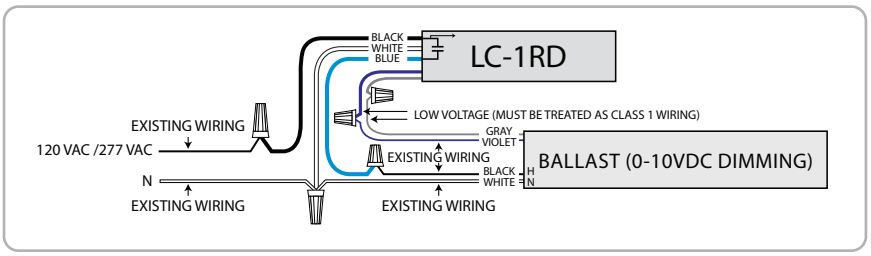
LC-1R



LC-2R



LC-1RD



Specifications

Input Voltage	120/277 VAC	Voltage measurement	2% accuracy full scale
Input Frequency	60 Hz	Current measurement	2% accuracy full scale
Relay	Normally open, SPST, zero crossing control	Operating Environment	-4° to 158° F (-20° to 70° C)
Max Switched Current	5A Ballast/ 5A Tungsten	Memory	Configuration programming stored in non-volatile memory
Enclosure	Recyclable plastic	Wires	24" long, rated for 600 VAC, 18 AWG
Radio Frequency	2.4 GHz	Mounting	Screw mounted inside a UL-rated fixture or enclosure rated for the application
RF Transmission Output Power (Average)	+12 dBm		

ADURA TECHNOLOGIES
22 Fourth St, 10th Floor, San Francisco, CA 94103
1-888-828-8281 / www.aduratech.com

Sensor Interface for Line Voltage Occupancy Sensors

Adura's Sensor Interface adds wireless capability to industry standard line voltage occupancy sensors. This provides flexible control zoning and the ability to incorporate multiple control strategies in a cost-effective manner. Occupancy sensing can be combined with other control strategies, such as smart scheduling, demand response and wall control.

The Sensor Interface incorporates wireless RF technology using the ZigBee® standard for fail-safe communication. By forming a self-healing, adaptive mesh network that maintains connectivity, communication is assured even in difficult environments.

Available Models

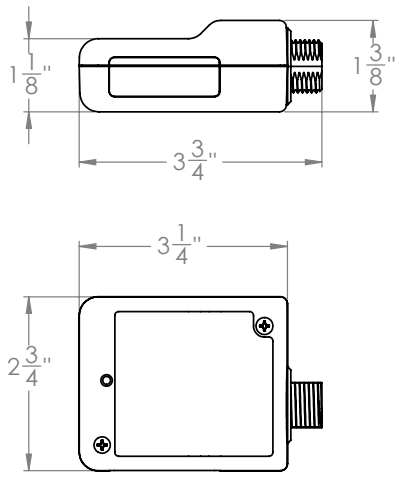
Catalog Number	Description
SIAC-H1	Sensor Interface - 1 Input Channel for Line Voltage Sensing
SIAC-H1-C	Conformally coated for corrosion resistance

ADURA SENSOR INTERFACE FEATURES

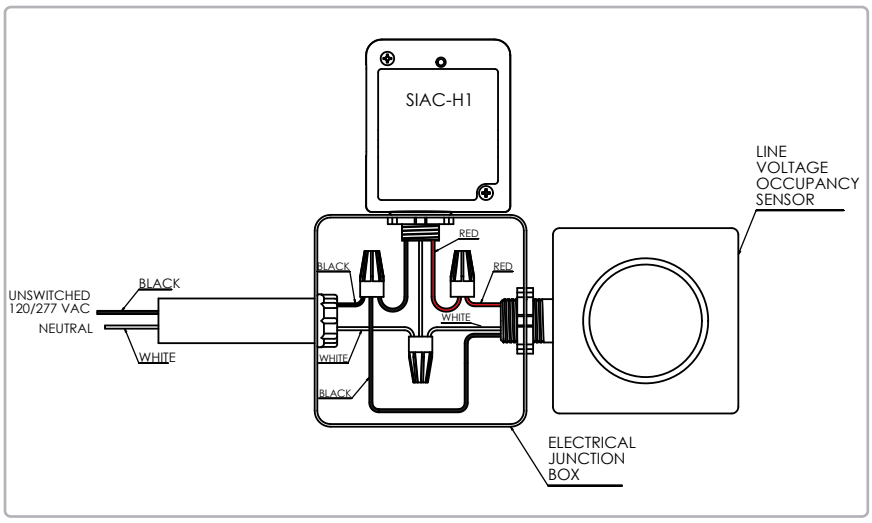
- Transmits data from line-voltage occupancy sensors onto Adura's wireless network
- Works with multiple occupancy sensor technologies (ultrasonic, PIR or dual technology)
- One channel to monitor a single occupancy sensor
- Inputs are protected against over-voltage and surges
- Suitable for mounting on an electrical junction box
- Non-volatile memory retains device settings during power outage
- UL 2043 (plenum rated) listed
- Compliant with FCC Part 15
- 5 year warranty

TECHNICAL

Dimensions



Wiring Diagrams



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- **Energy management solution:** Distributed control system to monitor and control energy and carbon usage for energy savings, load curtailment and environmental responsibility.
- **Best in class:** Solution that meets or exceeds government and private standards for energy efficiency and carbon reduction.

Specifications

Input Voltage	120/277 VAC	**Enclosure**	Recyclable plastic
Maximum Current	10 mA	**Operating Environment**	-4 to 158 deg F, dry location or -20 to 70 deg C
Sensor Input Channel	120/277 VAC signal	**Memory**	Configuration programming stored in non-volatile memory
Radio Frequency	2.4 GHz	**Wires**	8" 600 VAC plenum rated, 18 AWG conductors
RF Transmission Output Power (Average)	+5 dBm	**Mounting**	Mounts into a 1/2" knockout on an electrical box and secures with supplied locknut

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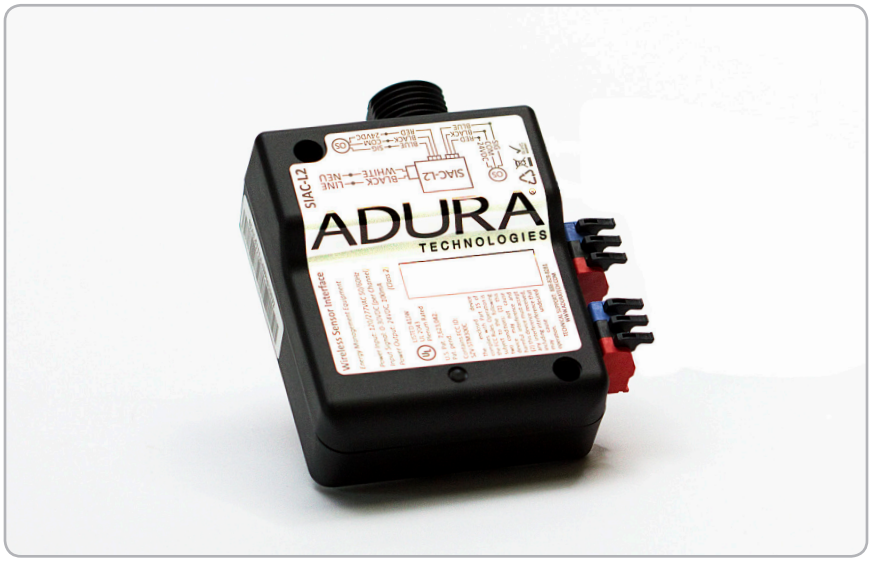
Sensor Interface for Low Voltage Sensors



Adura's Sensor Interface adds wireless capability to industry standard low voltage occupancy sensors and photo sensors. This provides flexible control zoning and the ability to incorporate multiple control strategies in a cost-effective manner. Occupancy sensing and daylighting can be combined with other control strategies, such as smart scheduling, demand response and wall control.

The Sensor Interface incorporates wireless RF technology using the ZigBee® standard for fail-safe communication. By forming a self-healing, adaptive mesh network that maintains connectivity, communication is assured even in difficult environments.

Available Models

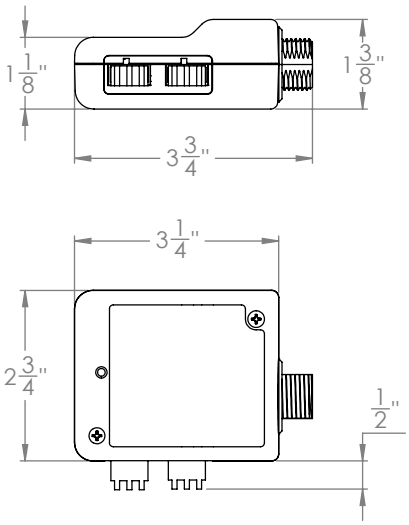
Catalog Number	Description
SIAC-L2	Sensor Interface - 2 Input Channels for Low Voltage Sensing
SIAC-L2-C	Conformally coated for corrosion resistance

ADURA SENSOR INTERFACE FEATURES

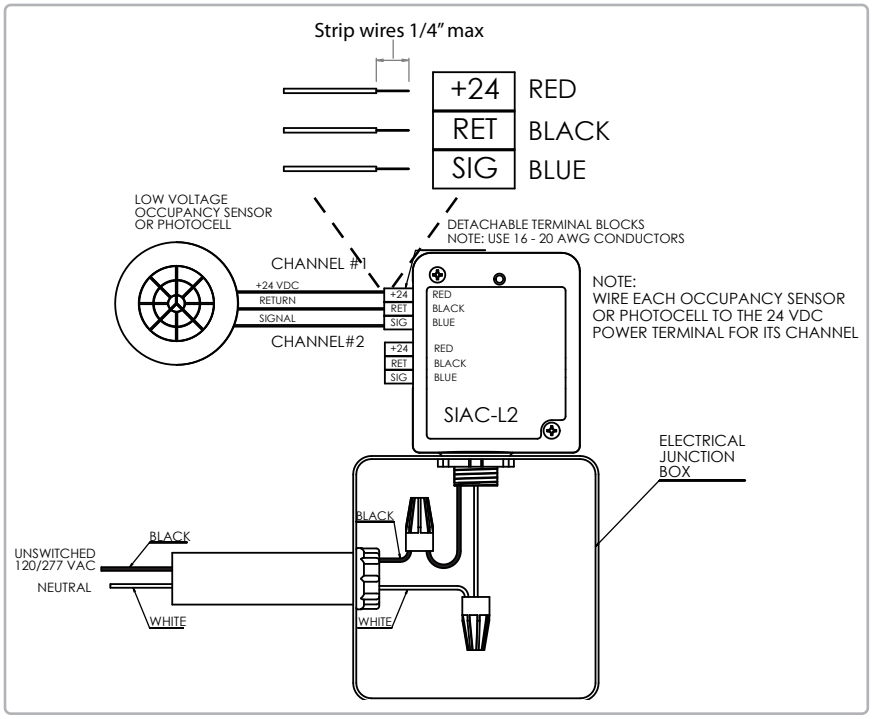
- Transmits data from low-voltage occupancy sensors and photocells onto Adura's wireless network
- Works with multiple occupancy sensor technologies (ultrasonic, PIR or dual technology), as well as 0-10 VDC photocells
- Provides 24VDC power for occupancy sensors or photocells
- Two independent channels to monitor multiple occupancy sensors or photocells
- Detachable snap-lever terminals for rapid, tool-free connection to low-voltage sensor wiring
- Suitable for mounting on an electrical junction box
- Non-volatile memory retains device settings during power outage
- UL 2043 (plenum rated) listed
- Compliant with FCC Part 15
- 5 year warranty

TECHNICAL

Dimensions



Wiring Diagrams



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- **Best in class:** Solution that meets or exceeds government and private standards for energy efficiency and carbon reduction.

Specifications

Input Power	120/277 VAC 50 mA max current draw	**Enclosure**	Recyclable plastic
Sensor Power Supply	50 mA @ 24VDC (each Channel) Class 2 Rated	**Operating Environment**	-4 to 158 deg F, dry location or -20 to 70 deg C
Sensor Input Channels	0 - 30 VDC signal	**Memory**	Configuration programming stored in non-volatile memory
Sensor Input Terminals	16-20 AWG, solid or stranded 1/4" strip length	**Wires**	8" 600 VAC plenum rated, 18 AWG conductors
Radio Frequency	2.4 GHz	**Mounting**	Mounts into a 1/2" knockout on an electrical box and secures with supplied locknut
RF Transmission Output Power (Average)	+5 dBm		

ADURA TECHNOLOGIES
22 Fourth St, 10th Floor, San Francisco, CA 94103
1-888-828-8281 / www.aduratech.com

■AC to DC LED Power Supply 48 Watts

Applications

LED Signage / Channel Letter
LED Architectural Lighting
LED Commercial Industrial Lighting
LED General Luminaire

Inrush seems high. What is the inrush for 25 fixtures on one circuit?

Efficiency seems low. Is this acceptable to DOE-SSL?

Indicate the Model #.

Features

c UL us pending CE IP66

The NEMA standard for 0-10VDC dimming is Violet and Gray.
RNM 5/15/2012

Compatible with 1 ~ 10V Dimming Controller
available in Constant Current or Constant Voltage
suitable for Dry, Damp Locations, meet IP66
RoHS, Reach Compliant, UL8750,UL1012,cUL,FCC CE(EN55015,EN61347)
Three Years Warranty

Specifications

AC Input Range : 90~290Vac / 0.8~0.4A / 47~63Hz	DC Output Ripple / Noise p-p : 5% (Typical)
Input Inrush Current : <35A/115Vac,<70A/230Vac	Operation Temp. : -25 ? ~ +50? , Tc : 80 ?
Leakage Current :<0.75mA / 230Vac , Surge Immunity Test : 4KVac	Storage Temp. : -40 ? ~ +85?
Power Factor : >0.92 at 50% ~ 100% load,115Vac and 230Vac	MTBF(@50?) : >50,000 Hours,MIL-217F
Total Harmonic Distortion (THD) : 20% Max.	Safety : UL8750,UL1012,CUL , FCC B
Efficiency : 15V/ 83%,24V/ 85%,48V/ 87% at 115Vac full load.	CE (EN55015 ,EN61547,EN61347,EN61000-3-2 class C)
Protection : OCP,SCP,OVP,OTP (limit-CC) - Auto Recovery	Case Dimension : 142 (L),47(W),32(H)mm
Load Regulation : +/-5%	Weight :300 Grams typ.

Model Listing

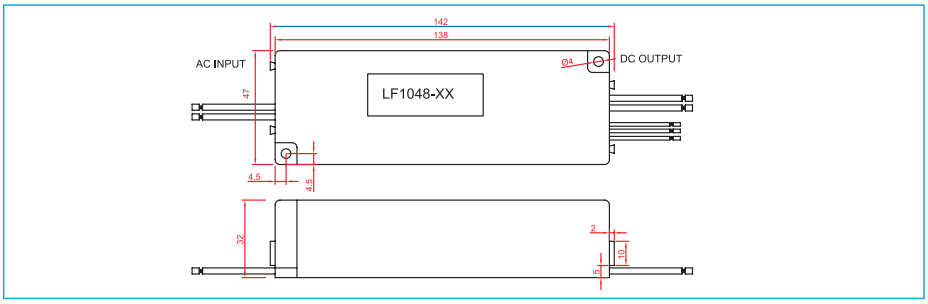
Model	Constant Voltage MODE			Constant Current MODE		Max. Watts
	Output Volts	V-Adjust (±5%)	Current (min.~max.)	I -Adjust (±5%) (Note)	Forward Volts(Vf)	
LF1048-15	15V(12V)	9 ~ 16.5V	280 ~ 2800/3500mA	1400 ~ 2800/3500mA	8 ~ 16.5V(12V)	42W
LF1048-24	24V(20V)	15 ~ 26.4V	200 ~2000/2400mA	1000 ~2000/2400mA	12 ~ 26.4V(20V)	48W
LF1048-36	36V(28V)	24 ~ 39.6V	150 ~1350/1700mA	700 ~1350/1700mA	18 ~ 39.6 (28V)	48W
LF1048-48	48V(40V)	36 ~ 52.8V	100 ~1000/1200mA	500 ~1000/1200mA	30 ~ 52.8V(40V)	48W
LF1048-88	N/A			300 ~ 750mA	40 ~ 88V	53W
LF1048-160	N/A			200 ~ 420mA	60 ~ 160V	53W

Note: The Constant Current Mode can be set from 50% to 100% / Max. Amps to meet user requirements.

Model Information

LF1048 - XX-Cnnnn-DDDD
1048 = Single DC Output , 53 Max.Watt. XX = Voltage Output, 15 = 15V, 24 = 24V, 48 = 48V.
Cnnnn = (Optional or blank)Constant Current Output , C3500=3500mA,C2200=2200mA....,C0350= 350mA.
DDDD = (Optional or blank)For Constant Current (Current mode) or Constant Voltage (PWM model, 200Hz),
1631 = On/OFF AC Step Dimming,T1:100%,T2:65%,T3:35%,T4: 15% lighting(on/off timing 1.5 Sec.)
010V = 1 ~ 10V Dimming Control, Green (Dim-),Purple(Dim+),Yellow(10Vdc/10mA),VR(10K-100KÙ).
Dimming CTL. 10Vdc output can connect maximum of 20 sets in paralled.

Mechanical Drawing



LEVITON

LevNet RF Self-Powered Wireless Solutions

Dimmer Modules

RF Constant Voltage LED Dimmer

Constant Voltage LED Dimmer
(without wireless capability)

0-10V RF Dimmer

Self-powered wireless technology means no new wiring is required. Leviton LevNet RF Self-Powered Wireless Solutions are easy to install and maintenance-free, reducing ongoing manual work and material costs while reducing energy. EnOcean® technology allows energy harvesting LevNet RF Transmitters to operate indefinitely without the use of batteries. The kinetic motion of a switch actuation, light on a solar cell or temperature differentials in the environment provide power to LevNet RF Transmitters, allowing zero-maintenance wireless devices. The LevNet RF line includes a broad range of products that operate in the uncrowded 315MHz radio frequency (RF) band offering greater transmission range (50-150 feet) than other wireless technologies with minimal competitive traffic.

enocean® alliance
No Wires. No Batteries. No Limits.

LevNet RF Dimmer Modules receive signals from LevNet RF Sensors, Switches and Transmitters to control lighting. Self-powered wireless technology eliminates control switch wiring making them the ideal solution for retrofits and new construction. Installation is quick and easy with no additional wiring required. It takes only minutes to install and configure.

APPLICATIONS

- Retrofits
- New construction
- Conference rooms
- Classrooms
- Lounges/Lobbies
- Private offices
- Executive offices
- Restrooms
- Daycare facilities
- Multimedia areas

Leviton Mfg. Co., Inc. Lighting Management Systems
201 N. Service Rd. Melville, NY 11747-3138 Tech Line: 1-800-824-3005 Fax: 1-800-832-9538 www.leviton.com/lms

PRODUCT DATA

CONSTANT VOLTAGE LED DIMMER (WSD02-010 | WSD02-020)

Available with or without RF capabilities, the LevNet RF Constant Voltage LED Dimmers deliver 65,000 pulse width modulation (PWM) dimming steps to provide seamless and continuous dimming through all light levels. The RF LED Dimmer (WSD02-010) responds to wireless switches and other transmitters. Both models can dim and turn OFF lights based on signals from wired sensors detecting occupancy or available natural light. A single transmitter can control an unlimited number of RF Dimmers in range. The RF LED Dimmer also functions as a repeater.

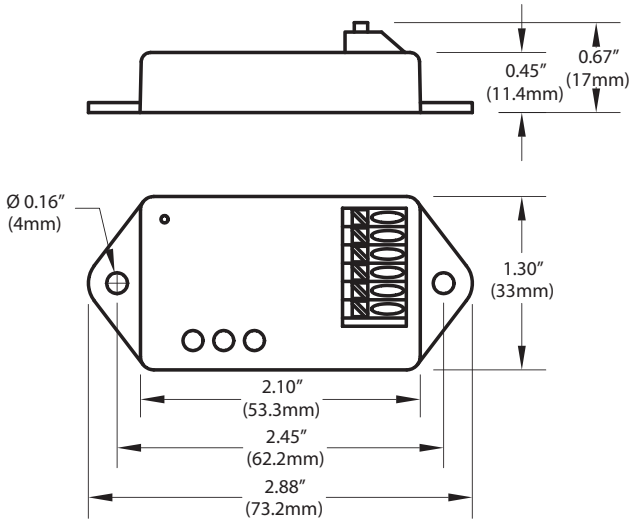
0-10V RF DIMMER WITH ON/OFF CONTROL AND SENSOR INPUT (WSD01-001)

The LevNet RF 0-10V RF Dimmer responds to wireless switches and transmitters to control dimmable LED power supplies, dimmable fluorescent ballasts or actuators. The Dimmer can also turn OFF or dim lights based on signals from wireless or wired sensors detecting occupancy or available natural light. A single transmitter can control an unlimited number of 0-10V Dimmers in range. The 0-10V Dimmer also functions as a repeater.

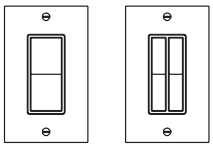
FEATURES

- **Power consumption:** save 70% over other wireless technologies
- **Long operation:** with a 50-150' range, LevNet RF provides the longest reliable range in the industry
- **Easy-to-use:** programs in seconds; run zero switch-leg or traveler wires
- **Reliable operation:** error checking ensures Receiver only responds to appropriate Transmitters on all packet transfers
- **Save energy:** connect the LED Dimmer or dimming Receiver to a LevNet RF Sensor or program all lights to respond to a single master Switch
- **Ultra smooth 65,000 step dimming**: architectural lighting, load shedding, manual-ON/OFF and auto-OFF controls and DIM or ON/OFF control of PWM LED lights
- **Control the way you want it:** control the LevNet RF Dimmer Modules with a variety of devices – Self-Powered Wireless Switches, Occupancy Sensors, Light Sensors and more

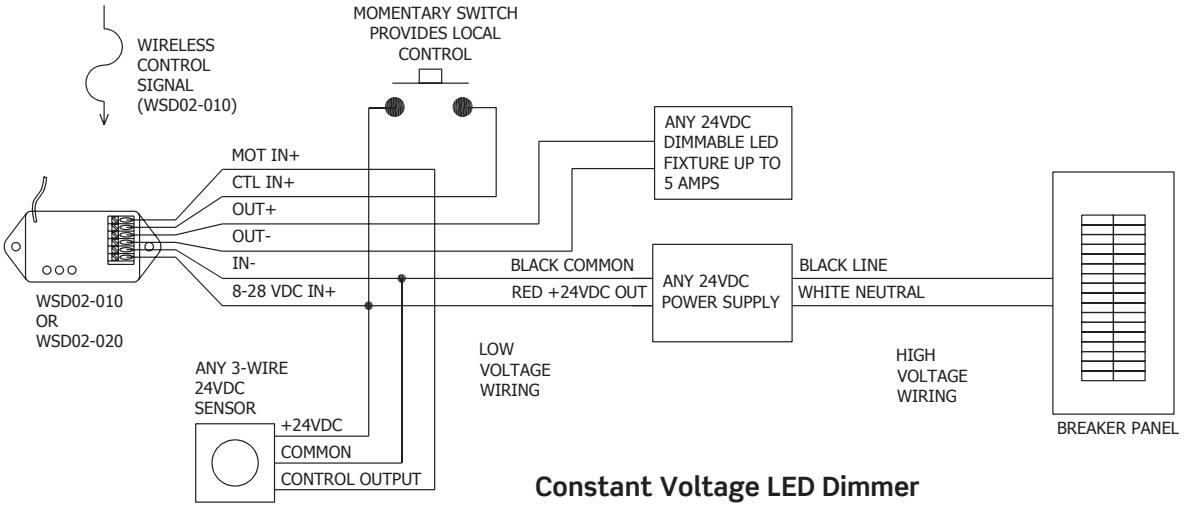
DIMENSIONS



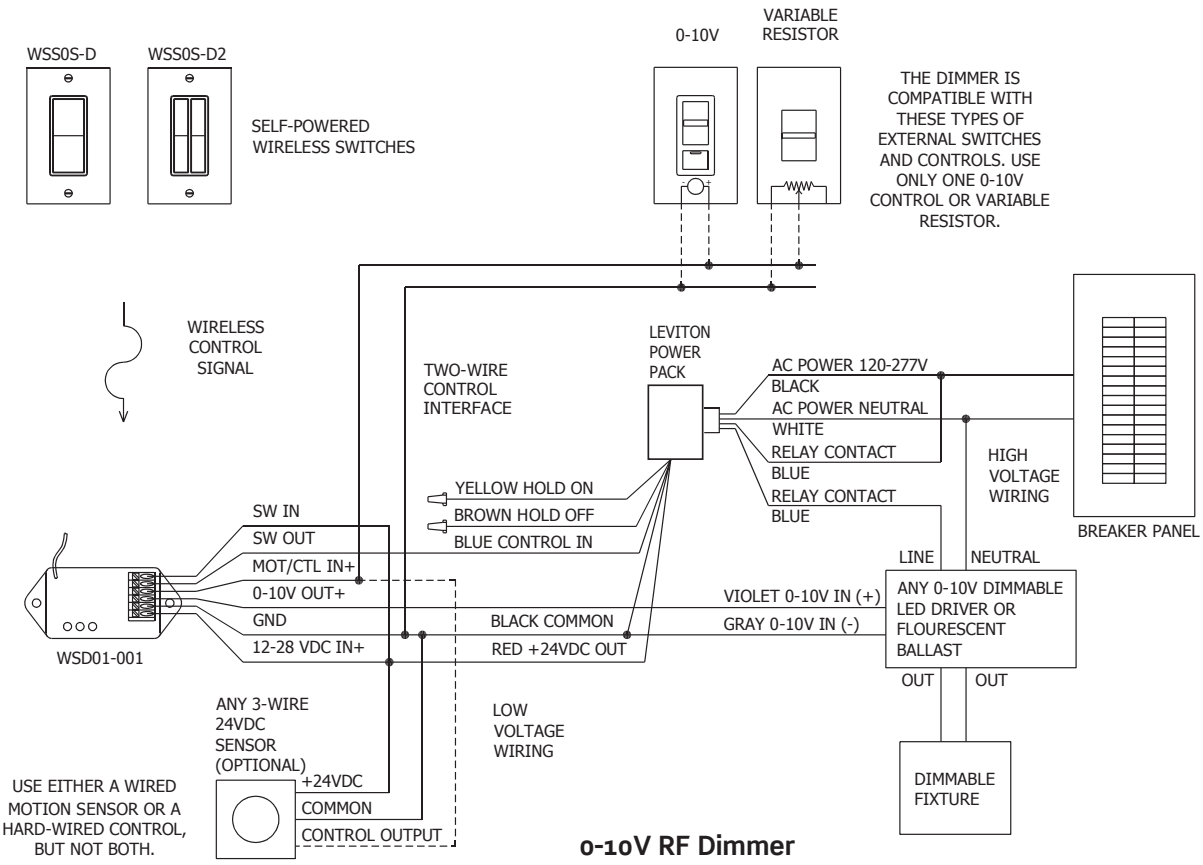
WIRIING DIAGRAMS



SELF-POWERED
WIRELESS SWITCHES



Constant Voltage LED Dimmer



0-10V RF Dimmer

Leviton Mfg. Co., Inc. Lighting Management Systems
201 N. Service Rd. Melville, NY 11747-3138 Tech Line: 1-800-824-3005 Fax: 1-800-832-9538 www.leviton.com/lms

LEVITON®

SPECIFICATIONS

	RF CONSTANT VOLTAGE LED DIMMER (WSD02-010)	CONSTANT VOLTAGE LED DIMMER (WSD02-020)	0-10V RF DIMMER (WSD01-001)
Range	50-150 feet	-	50-150 feet
Frequency	315MHz	-	315MHz
Memory	Stores up to 30 Transmitter IDs	-	Stores up to 30 Transmitter IDs
Power Supply Input Rating	8-28VDC, 40mA (not incl. load current)		12-28V, 40mA
Sensor Input Rating	0-28VDC, <1V is Low, >3V is High		
Output Rating	Constant voltage 0-28VDC, 5A max		4mA, 0-10V Output
Output Rating, Switched Output	-		5A DC, Isolated, 30VDC Max
Input Channels	1 Motion Detector / Sensor Input 1 Wired Control Switch		1 Motion Detector / Sensor Input
Output Channels	1 Output PWM Dimming		1 Output 0-10V, 1 Switch Output
Operating Temperature	-13°F to 140°F (-25°C to +60°C)		
Storage Temperature	-40°F to 140°F (-40°C to +60°C)		
Dimensions	2.88" W x 1.30" H x 0.67" D (73mm x 33mm x 17mm)		
Radio Certification	FCC Certified for Wireless Communication (U.S.), I.C. Certified (Canada)	-	FCC Certified for Wireless Communication (U.S.), I.C. Certified (Canada)

ORDERING INFORMATION

CAT. NO.*	DESCRIPTION
WSD02-010	RF Constant Voltage LED Dimmer with Wireless Capability
WSD02-020	Constant Voltage LED Dimmer (without wireless capability)
WSD01-001	0-10V RF Dimmer with ON/OFF Control and Sensor Input

*Made in USA, ARRA and Buy American compliant.

LEVITON SPECIFICATION SUBMITTAL	
JOB NAME:	CATALOG NUMBERS:
JOB NUMBER:	

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Leviton Manufacturing of Canada, Ltd.
165 Hymus Boulevard, Pointe Claire, Quebec H9R 1E9 • Telephone: 1-800-469-7890 • FAX: 1-800-563-1853

Leviton S. de R.L. de C.V.
Lago Tana 43, Mexico DF, Mexico CP 11290 • Tel. (+52) 55-5082-1040 • FAX: (+52) 5386-1797 • www.leviton.com.mx

Visit our Website at: www.leviton.com/lms

LEVITON

OSP/OSA Power Pack Series

Provides low voltage power and line voltage control for Leviton Occupancy Sensors

Containing both a 24VDC supply and a 20A line voltage relay for most models, the Leviton compact Power Pack provides low voltage power and line voltage control for Leviton Occupancy Sensors. Versions include Auto-ON and Manual-ON inputs for occupancy sensors, Hold-ON and Hold-OFF capabilities, and a local input for momentary or maintained dry contact switches.

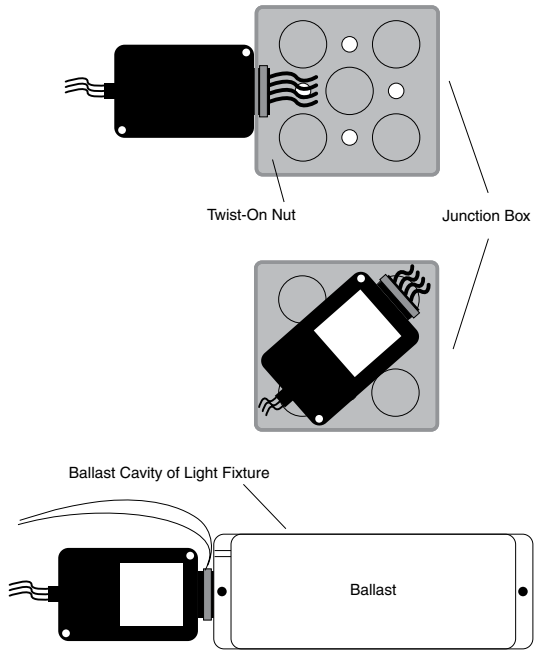
The internal relay can control up to 20A for 120, 230, 277VAC or 347VAC ballast loads and 120VAC incandescent loads. The OSP Power Pack Series is also used to supply power to the OSA Add-A-Relay model. The Power Pack conveniently mounts in a knockout hole of a standard junction box. The unit can be placed inside or outside the junction box with a simple twist-on nut.

APPLICATIONS

Use a Leviton Power Pack with Leviton Occupancy Sensors in the following applications.

- Classrooms
- Conference rooms
- Anywhere optimal lighting and energy savings are desired
- Load shed/Interface hold-OFF applications
- Retail hold-ON/bypass applications
- OSP20
  - Multi-circuit switching
  - Ceiling access lighting and energy management controls
- OSP20-RD
  - Interface to BAS/BMS and HVAC
- OSP20-RDH
  - Bi-Level or A/B lighting
  - Shared emergency lighting
  - Inexpensive 3-Way switching
- OSA20
  - Expanding circuit switching capacity
  - Cost conscious mixed voltage solutions

EASY MOUNTING



OSP/OSA Power Pack Series

Leviton Mfg. Co., Inc. Lighting & Energy Solutions
201 N. Service Rd. Melville, NY 11747-3138 Tech Line: 1-800-824-3005 Fax: 1-800-832-9538 www.leviton.com/les

PRODUCT DATA

FEATURES

OSP20-0D0/OSP20-ND0

- Self-contained transformer and relay
- Internal voltage regulator – regulated 24VDC current, 150mA output
- Fast installation - mounts inside or outside junction box, or inside fluorescent ballast cavity with a simple twist-on nut
- Single or multiple luminaire control
- Zero crossing circuitry
- UL 2043 Plenum Rated
- Companion Add-A-Relay provides additional capacity (OSA20-R00)
- NAFTA compliant (OSP20-ND0)
- Made in USA compliant (OSP20-DA0)

OSP20-RD0/OSP15-R30/OSP20-NH0

Includes the same features as the OSP20-0D0, plus:

- Dry contact relay for combined sensor control of lighting and heating/air conditioning
- Dry contact for designing controlled closure
- Form A relay for interface to Building Automation/ Management Systems (BAS/BMS)
- NAFTA compliant (OSP20-NH0)
- Made in USA compliant (OSP20-RAD)

OSP20-RDH/OSP20-RNH

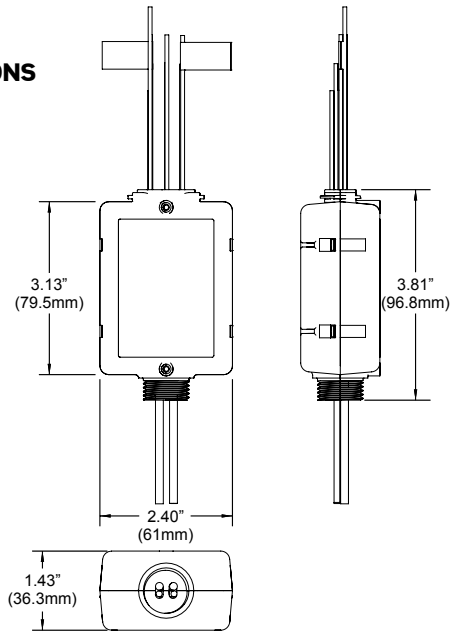
Includes the same features as the OSP20-RD0, plus:

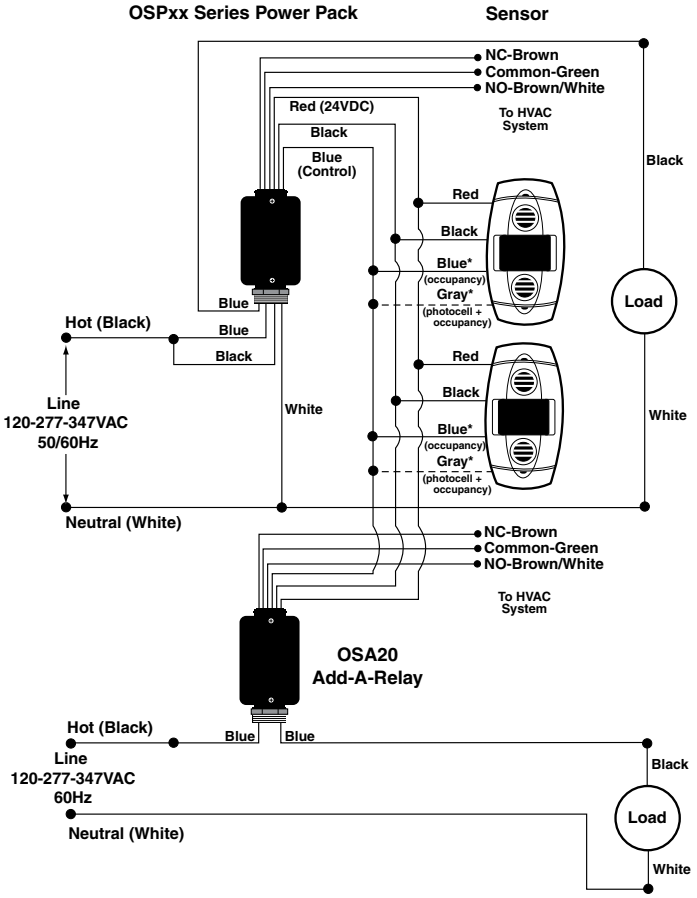
- Auto-ON and Manual-ON inputs for occupancy sensors
- "Hold-ON" input – when activated, unit is always ON regardless of any other input
- "Hold-OFF" input – when activated, unit is always OFF regardless of any other input
- Local inputs for momentary or maintained dry contact low voltage switching
- Robust mechnical batching relay designed to perform as a Form C normally closed device
- Increased power supply output to 255mA
- Upon loss of power, latching relay maintains current state (closed or open)
  - H.I.S. >(High In-rush Stability)
  - Heavy duty zero crossing circuitry
- Robust mechanical latching relay
- NAFTA compliant (OSP20-RNH)
- Made in USA compliant (OSP20-RAH)

OSA20-R00/OSA20-RN0

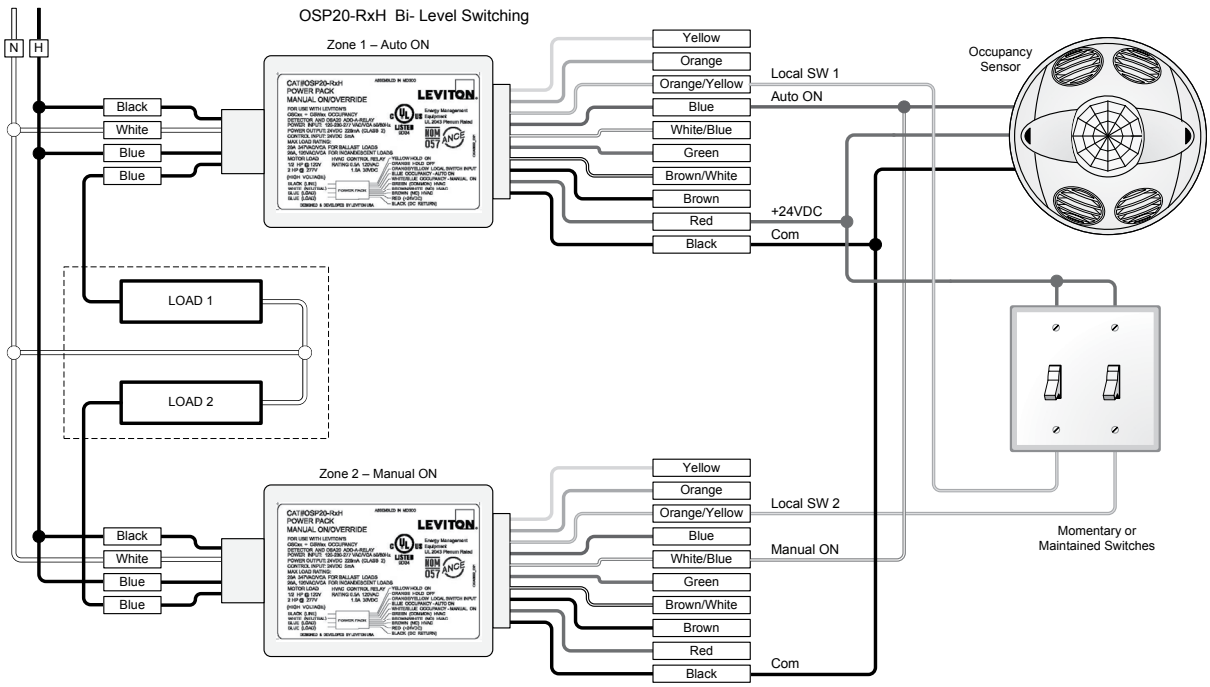
- 15A relay can be added to any OSP20 power pack for flexible design
- For design flexibility when cost conscious
- Inexpensive solution for mixed voltage lighting design
- Used for expanding circuit switching capacity
- Use OSP20 power packs for Emergency Lighting circuits and OSA20 Add-A-Relays for inexpensive control of normal lighting
- NAFTA compliant (OSA20-RN0)
- Made in USA compliant (OSP20-RA0)

DIMENSIONS





OSP20-RxH Bi-Level Switching



WIRING DESIGNATIONS

SIGNAL TYPE	COLOR	GAUGE
LINE VOLTAGE WIRES		
Line 120-230-277VAC (OSP20-RX0)	Black	18AWG
Neutral	White	18AWG
Load	Blue	14AWG
Load	Blue	14AWG
CLASS 2 WIRES		
Power (24VDC)	Red	22AWG
DC Return	Black	22AWG
Occupancy Auto-ON	Blue	22AWG
Occupancy Manual-ON	Blue/White	22AWG
Hold-ON	Yellow	22AWG
Hold-OFF	Orange	22AWG
Local Switch Input	Yellow/Orange	22AWG
SIGNAL TYPE	**COLOR**	**GAUGE**

HVAC WIRES		
Dry Contact Common	Green	22AWG
Dry Contact NO (Normally Open)	Brown/White	22AWG
Dry Contact NC (Normally Closed)	Brown	22AWG

- All wires rated at 105°C, 600V insulation.
- Class 2 wires are Teflon jacketed, for plenum applications.
- Dry Contact wiring is Class 1 and Class 2 rated.

POWER PACK CAPACITY FORMULA

Leviton power packs can be used to provide power to one or more occupancy sensors. Since current consumptions of occupancy sensors may vary, the best way to ensure you order the correct number of power packs and add-a-relays is by using this formula:

# of sensor Model As X Sensor A current consumption rating	+	# of sensor Model Bs X Sensor B current consumption rating	+	# of Add a Relays X 50mA	< 150mA per power pack

DESCRIPTION	CURRENT CONSUMPTION
OSC04-I, OSC15-I, OSWHB-I, OSWLR-I, OSWWV-I	20mA
OSC05-M, OSC05-U, OSW12-M	30mA
OSC10-M, OSC10-U	40mA
OSC20-M, OSC20-U	32mA
OSA20-R00 Add a Relay	50mA

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SPECIFICATIONS

ELECTRICAL	
Line Voltage	120-230-277 VAC
Relay Rating	HVAC Relay: 0.5A @ 120VAC, 1.0A @ 30VDC
ENVIRONMENTAL	
Operating Temperature Range	32°F to 104°F (0°C to 40°C)
Relative Humidity	0% to 90% non-condensing, for indoor use only
OTHER	
Construction	Case: high impact, UL rated plastic Relay: class B (130°C) insulating material; silver alloy contacts Wire: 6" leads, 18AWG input; LV connections: 7" leads 22AWG
Dimensions	2.400"H x 3.811"W x 1.432"D (60.96mm x 96.80mm x 36.37mm)
Listings	UL/CUL Listed, FCC Certified, NOM Certified, and meets ASHRAE 90.1 requirements
Color	Black
Warranty	Limited Five-Year Warranty

ORDERING INFORMATION

DESCRIPTION	CAT. NO.	POWER INPUT	RELAY RATING	CONTROL INPUT	POWER SUPPLY OUTPUT
Power Pack	OSP20-0D0	120-230-277VAC, 50/60 Hz	20A fluorescent/incandescent @ 120V, 20A fluorescent @ 230-277V; 1HP @ 120V, 2HP @ 240V	5mA, 24VDC	150mA, 24VDC
Power Pack with Dry Contact Relay	OSP20-RD0	120-230-277VAC, 50/60 Hz	20A fluorescent/incandescent @ 120V, 20A fluorescent @ 277V; 1HP @ 120V, 2HP @ 240V; HVAC: 0.5A @ 120VAC, 1A @ 30VDC	5mA, 24VDC	150mA, 24VDC
Power Pack with Dry Contact Relay	OSP15-R30	347VAC, 60 Hz	15A fluorescent @ 347V; 1HP @ 120V, 2HP @ 240V; HVAC: 0.5A @ 120VAC, 1A @ 30VDC	5mA, 24VDC	120mA, 24VDC
Add-A-Relay Unit with Dry Contact Relay	OSA20-R00	—	15A incandescent @ 120V, 20A fluorescent @ 120V, 20A fluorescent @ 277V, 15A fluorescent @ 347V; HVAC: 0.5A @ 120VAC, 1A @ 30VDC	5mA, 24VDC	—
Power Pack with Dry Contact Relay and Override Inputs for Occupancy Sensors	OSP20-RDH	120-230-277VAC, 50/60Hz	20A fluorescent/incandescent @ 120V; 20A fluorescent@ 277V; 1HP @ 120V, 2HP @ 240V; HVAC; .05A @ 120VAC, 1A @ 20VDC and 15A fluorescent @ 347V; 1HP @ 120V; 2HP @ 240; HVAC: 0.5A @ 120V, 1A @ 30VDC	5mA, 24VDC	225mA, 24VDC

* Consult factory for 208, 220, and 240V models.

LEVITON SPECIFICATION SUBMITTAL	
JOB NAME:	CATALOG NUMBERS:
JOB NUMBER:	

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Visit our Website at: www.leviton.com/les

LEVITON®

LevNet RF Self-Powered Wireless Passive Infrared Occupancy Sensors

Self-Powered RF Wireless Passive Infrared (PIR) sensors for use with LevNet RF Receivers

BASIC OPERATION

The Wireless Occupancy Sensors (WSCxx-IRW) have built-in solar cells that draw on available ambient light to power themselves and can operate for up to 48 hours in total darkness. Batteries are not required for continuous operation, however batteries can be added as an option for applications without available ambient light.

For improved detection, the sensors use an enhanced PIR element located directly behind a unique multi-zone optical lens. This exclusive Fresnel lens establishes twice as many zones of detection as traditional sensors. The zones can be configured (masked) to block out unwanted traffic zones (i.e. outside hallway traffic). The WSC15-IRW features superior detection for parallel and perpendicular motion. Innovative sensing technology detects motion moving directly towards the sensor.

The self-powered wireless sensor design also overcomes the placement and coverage challenges of traditional sensors. Self-powered wireless sensors enable flexible placement allowing sensors to be mounted wherever needed without the complexity of moving or installing new wiring.

APPLICATIONS

• Retrofits • New construction • Restrooms
• Conference rooms • Classrooms • Private offices
• Executive offices • Daycare facilities

FEATURES

- **Zero Power Consumption:** solar power provides the energy to keep the device on and sensor technology turns the lights off, eliminating additional expenses to the end user's energy bill
- **Zero External Power Required:** with no power wire limitations, this enables the installer to place the sensor in the optimal location of any application to capture minor motion and reduce false OFFs
- **Self-Powered, Self-Charging:** angled solar cells are optimal for light collection enabling the sensor to capture additional ambient light over flat solar cells – 100 LUX vs. 70-80 LUX
- **Quick Charge Time to Operation:** self-powered technology enables the sensor to be operational after a minimum charge time of 1 minute
- **True Wireless:** sensors are self-powered and communicates with all LevNet RF and EnOcean Receivers via radio frequency
- **No Additional Wiring:** self-powered wireless technology eliminates the need to pull additional wire making installation quick and easy and increasing labor savings with little to no impact to business during conversion
- **No Batteries or External Power Required:** exclusive "battery-less" technology significantly reduces callbacks and maintenance for additional savings
- **Up to 48 Hours of Stored Power:** solar panel provides up to 48 hours of power to the sensor when no ambient light is available (for extended "OFF" time, a battery option is available)
- **Advanced Field-of-View:** superior detection for parallel and perpendicular motion; innovative technology detects motion moving directly towards the sensor; 360° rotation to fine tune location of solar cells and field-of-view
- **Improved Aesthetics:** blends seamlessly with ceiling décor and architecture
- **Additional Energy Savings:** wireless technology supports simplified daylight harvesting and manual override options with no additional wiring

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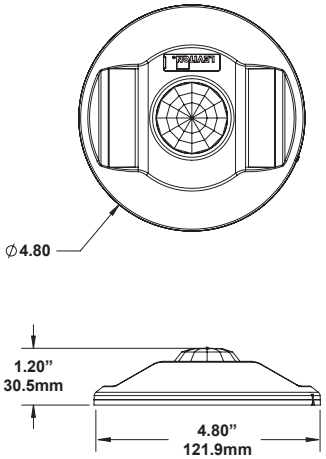
PRODUCT DATA

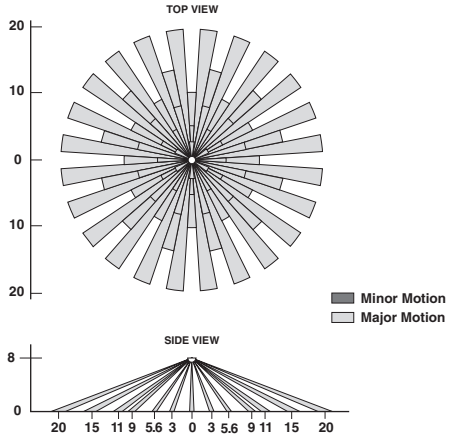
LEVITON®

DIMENSIONS

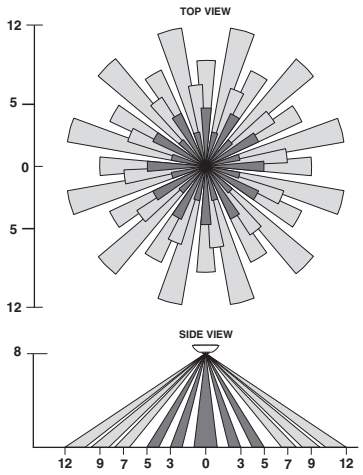


FIELD-OF-VIEW

WSC15 Field of View (in feet)



WSC04 Field of View (in feet)



SPECIFICATIONS

ENVIRONMENTAL	
Frequency	315MHz
Range	up to 100 feet
Transmission Interval	60 seconds
Minimum Light Required	4FC (40 LUX)
Solar Cell Operating Range	4-100FC (40-1000 LUX)
Minimum Charge Time to Begin Operation	1 minute @ 20FC (200 LUX)
Maximum Charge Time	8 hours @ 20FC (200 LUX)
Maintain Charge Time	3 hours per 24 hours @ 20FC (200 LUX)
Operating Life at Full Charge	48 hours
Optional Battery Life	10 years
Operating Temperature Range	32°F to 104°F (0°C to 40°C)
Storage Temperature Range	-4°F to 158°F (-20°C to 70°C)
Relative Humidity	0% to 95%, non-condensing
Usage	Indoors only
Mounting Height	8-12 feet

OTHER	
Listings	CEC Title 24 Compliant, FCC Certified for wireless communication
Warranty	Limited 5-year

ORDERING INFORMATION

CAT. NO.*	DESCRIPTION
WSC04-IRW	LevNet RF Self Powered PIR Occupancy Sensor, 450SF
WSC15-IRW	LevNet RF Self-Powered PIR Occupancy Sensor, 1500SF

*NAFTA compliant and Made in USA models available.

Contact Leviton for a complete list of LevNet RF Self-Powered Wireless Solutions. The line includes Wall Switch Wire In Receivers, Transmitter Switches, Thermostats, Room Controllers and more.

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No Wires. No Batteries. No Limits.

LEVITON SPECIFICATION SUBMITTAL	
JOB NAME:	CATALOG NUMBERS:
JOB NUMBER:	

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LEVITON®

LevNet RF Self-Powered Wireless Solutions

Remote Switches


Single Push ON/OFF Switch


Rocker Switch


Dual Rocker Switch


3 x 3 Rocker Switch


3 x 3 Dual Rocker Switch


Hotel Key Card Holder


Handheld 4-Button Remote

Self-Powered Wireless technology means no wiring is required. Leviton LevNet RF Self-Powered Wireless Solutions are easy to install and maintenance-free, utilizing no batteries and free to operate, saving ongoing labor and material costs while saving energy.

LevNet RF devices offer zero power consumption and zero maintenance for recurring savings for the building owner. EnOcean® technology allows energy harvesting LevNet RF Transmitters to operate indefinitely without the use of batteries. The human motion of a switch actuation, light on a solar cell, or temperature differentials in the environment provide power to LevNet RF Transmitters, eliminating additional expenses to the end user's energy bill and allowing zero maintenance wireless devices. The LevNet RF line includes multiple products that operate in the uncrowded 315MHz band offering greater transmission range (50-150 feet) than other wireless technologies and minimal competitive traffic.

enocean® alliance
No Wires. No Batteries. No Limits.

LevNet RF Remote Switches can control an unlimited number of LevNet RF Receivers that are in range. LevNet RF Remote Switches use no wires or batteries resulting in zero power consumption and no energy used. Pressing the switch or inserting a key card into a holder provides the energy to transmit a wireless signal that controls lights or other devices connected to LevNet RF Receivers. Wireless Switches are primarily used to control lights in businesses or homes, but they can be used to control virtually any on/off device.

Each Self-Powered Wireless Remote Switch can be placed anywhere within range of a Receiver. Traditionally the Remote Switch is surface mounted on a wall with screws or industrial tape, but can also be used in a standard switch box or as a wireless handheld remote. The unique ID of each Switch activates only the intended Receiver(s). Wireless, self-powered technologies make them the ideal solution for retrofits and new construction. Installation is quick and easy with no additional wiring required. It takes only minutes to install and configure.

APPLICATIONS

- Retrofits
- New construction
- Conference rooms
- Classrooms
- Lounges/Lobbies
- Private offices
- Executive offices
- Restrooms
- Daycare facilities
- Multimedia areas
- Multi-location (3-way or 4-way) switching applications

Leviton Mfg. Co., Inc. Lighting Management Systems
201 N. Service Rd. Melville, NY 11747-3138 Tech Line: 1-800-824-3005 Fax: 1-800-832-9538 www.leviton.com/lms

PRODUCT DATA

SINGLE PUSH ON/OFF SWITCH (WSS0S-P)
Leviton Self-Powered Wireless Push ON/OFF Switches (WSSoS-P) work in conjunction with the Wireless RF Occupancy Sensors (WSC) and the RF Wall Switch Receivers to provide an optimal solution for retrofit lighting needs. The Push ON/OFF Switch is optimal for controlling single loads and a convenient multi-location (3-way or 4-way) switching solution, eliminating the need to pull additional wiring.

SINGLE ROCKER DECORA™ SWITCH (WSS0S-D)

DUAL ROCKER DECORA™ SWITCH (WSS0S-D2)

3 X 3 SINGLE ROCKER SWITCH (WSS0S-E0W/WSS0S-E0B)

3 X 3 DUAL ROCKER SWITCH (WSS0S-E2W/WSS0S-E2B)
Control one light or one group of lights with the Wireless Self-Powered Single Rocker Switch. One switch can control an unlimited number of LevNet RF Receivers that are within range.

Control two lights or two groups of lights with the Wireless Self-Powered Dual Rocker Switch. Each rocker can separately control an unlimited number of LevNet RF Receivers that are within range.

HANDHELD 4-BUTTON REMOTE (WSS0S-R)
Control two lights, two groups, or four individual lights with the Handheld Remote. Each button can separately control an unlimited number of LevNet RF Receivers that are within range.

The Remote has four buttons - programmable to control up to four individual Receivers or dependent groups. Small enough to fit in the palm of your hand, you can also keep it in your pocket, on a table, or leave it in your car to turn lights on as you pull up to a building or house.

HOTEL KEY CARD HOLDER (WSS0S-H)
The Self-Powered Wireless Hotel Key Card Holder is designed to create energy saving solutions for the hospitality industry. Energy is saved by ensuring that no devices are left on when the room is not in use. Inserting a Key Card provides the energy to transmit a wireless signal to LevNet RF Receivers that control lights or other devices in the room.

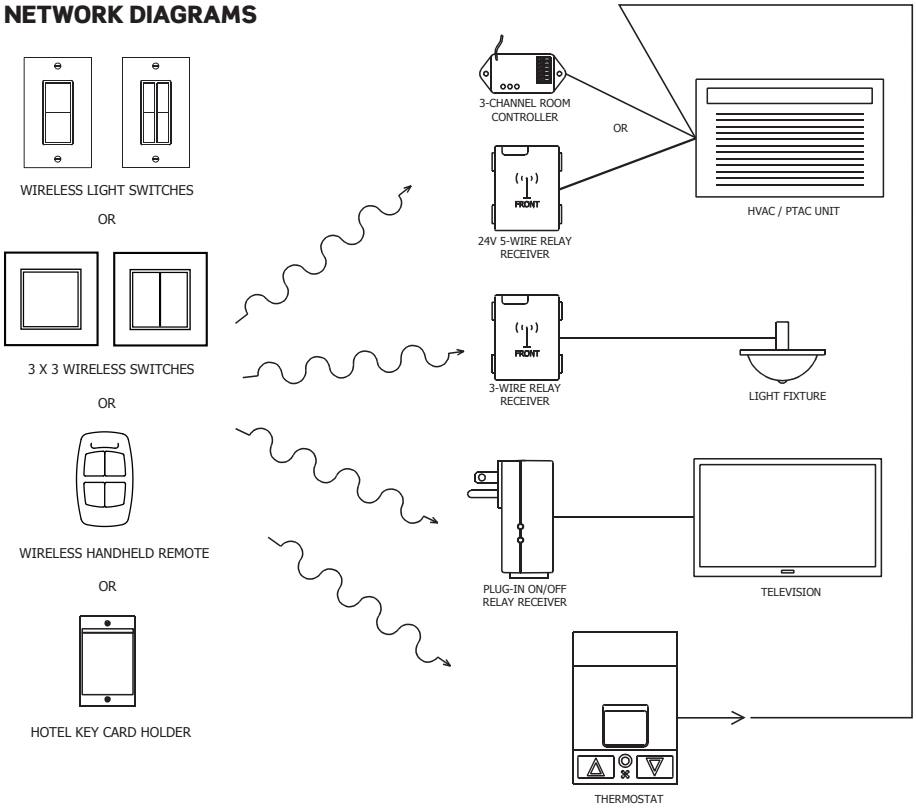
When entering a room, a Key Card is inserted into the holder and a wireless signal is sent to the Receivers that control the loads in the room. The individual Receivers then provide power to the corresponding loads by closing the circuit. When the user exits the room and removes the Key Card from the holder, another wireless signal is sent to the Receivers to open the circuits. Receivers then disconnect power to the devices.

Ideal for energy-saving hotel room controls - occupancy-based control of lights and devices, integrated HVAC and lighting control, and optional master ON/OFF controls.

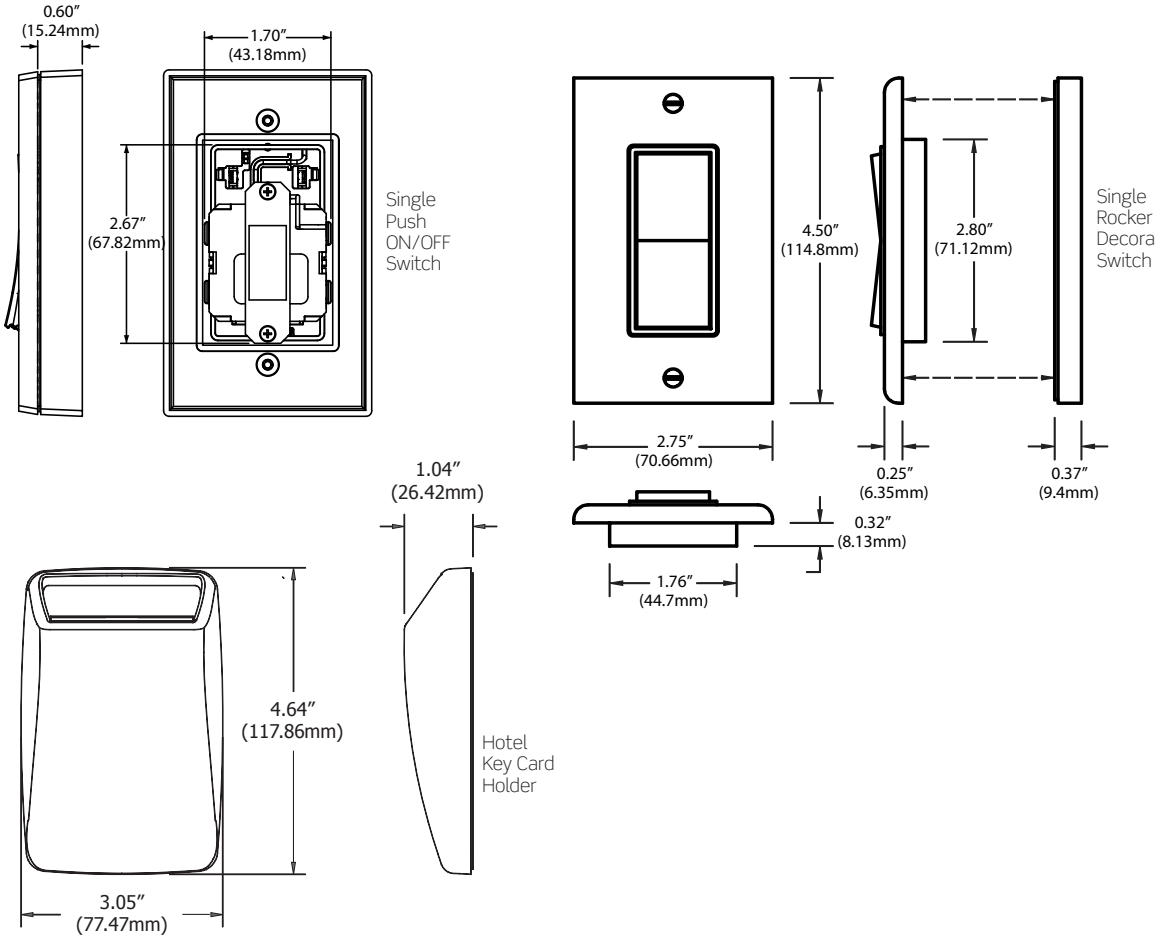
FEATURES

- **Zero Power Consumption:** the motion of a switch actuation provides the energy to power the device, eliminating additional expenses to the end user's energy bill
- **Zero External Power Required:** with no power wire limitations, this offers the installer flexibility to place the RF switch anywhere
- **Quick Charge Time to Operation:** self-powered technology enables the RF device to be operational immediately
- **True Wireless:** RF switches are self-powered and communicates with all LevNet RF and EnOcean Receivers via radio frequency
- **No Additional Wiring:** self-powered wireless technology eliminates the need to pull additional wire making installation quick and easy and increasing labor savings with little to no impact to business during conversion
- **No Batteries or External Power Required:** exclusive "battery-less" technology significantly reduces callbacks and maintenance for additional savings
- **Additional Energy Savings:** wireless technology supports simplified daylight harvesting and manual override options with no additional wiring
- **Toggle style ON/OFF switching:** provides remote control for any pushbutton manual-ON/OFF light switching of a single load at any time
- **Rocker style ON/OFF switching:** provides remote control for manual-ON/OFF light switching of each multiple light load at any time; top button = ON, bottom button = OFF (WSSoS-D, WSSoS-D2, WSSoS-E, and WSSoS-E2)
- **Momentary style ON/OFF Switching:** provides remote control for pushbutton manual-ON/OFF light switching of each multiple light load at any time; hold button=ON, release button = OFF
- **Convenient multi-location (3-way or 4-way) switching:** mount Switches anywhere, create 3-way or 4-way switches, control lights, motors, or other electrical loads, and reconfigure or relocate as needed
- **Save energy:** create manual-ON/auto-OFF controls using LevNet RF Switches and occupancy sensors or by programming all lights to respond to a single master switch
- **Control the way you want it:** use with multiple line voltage or low voltage LevNet RF Receivers, control an unlimited number of LevNet RF Receivers within range for wireless dimming or ON/OFF control

NETWORK DIAGRAMS



DIMENSIONS



Leviton Mfg. Co., Inc. Lighting Management Systems
201 N. Service Rd. Melville, NY 11747-3138 Tech Line: 1-800-824-3005 Fax: 1-800-832-9538 www.leviton.com/lms

LEVITON®

LevNet RF Remote Switches

LEVNET RF REMOTE SWITCHES	
Frequency	315MHz
Range	50-150'
Transmission interval	Human touch
Transmission time	Milliseconds
Transmissions	3-5 packets per press or release
Mechanical Cycles	>50,000
Device Address	Unique from factory
Power Supply	Self-generated when Switch is pressed or Key Card is inserted into the switch
Output Channels	Only limited by number of Receivers in range
Usage	Indoors only
Operating Temperature Range	32°F to 104°F (0°C to 40°C)
Radio Certification	FCC Certified for Wireless Communication (U.S.), I.C. Certified (Canada)
Warranty	Limited Five-Year
SINGLE PUSH ON/OFF REMOTE SWITCH (WSSOS-P)	
Pushbutton	1 Single Pushbutton
Dimensions	1.75" W x 4.06" H x 0.48" D (44.45mm x 103.12mm x 12.19mm)
SINGLE ROCKER DECORA™ SWITCH* (WSSOS-D) DUAL ROCKER DECORA™ SWITCH* (WSSOS-D2)	
Rockers	WSSoS-Do: 1 Rocker, 2 pushbuttons WSSoS-D2: 2 Rockers, 4 pushbuttons
Dimensions	2.75" W x 4.5" H x 0.62" D (69.85mm x 114.30mm x 15.75mm)
3 X 3 SINGLE ROCKER SWITCH (WSSOS-E0W | WSSOS-E0B) 3 X 3 DUAL ROCKER SWITCH (WSSOS-E2W | WSSOS-E2B)	
Rockers	WSSoS-Eo: 1 Rocker, 2 pushbuttons WSSoS-E2: 2 Rockers, 4 pushbuttons
Dimensions	3.39" W x 3.29" H x 0.41" D (86.11mm x 83.57mm x 10.41mm)
HANDHELD 4-BUTTON REMOTE (WSSOS-ROW)	
Pushbutton	4 Individual Pushbuttons
Dimensions	1.85" W x 3.15" H x 0.7" D (46.99mm x 80.01mm x 17.78mm)

HOTEL KEY CARD SWITCH (WSSOS-HOW)	
Card Slot	1 (card IN, card OUT) (momentary)
Dimensions	4.52" H x 2.78" W. x 1.38" D (114.8mm x 70.6mm x 35mm)
Recommended Card Size (cards not included)	2.125" W x 3" L (54mm x 76mm) (standard credit card size)
Operating Temperature Range	-13°F to +149°F (- 25°C to + 65°C)

ORDERING INFORMATION

CAT. NO.	DESCRIPTION
WSSOS-P*	Single Push ON/OFF Switch
WSSOS-D*	1-Gang Single Rocker Decora™ Switch
WSSOS-D2*	1-Gang Dual Rocker Decora™ Switch
WSSOS-EOW	3 x 3 Single Rocker Switch, White
WSSOS-EOB	3 x 3 Single Rocker Switch, Black
WSSOS-E2W	3 x 3 Dual Rocker Switch, White
WSSOS-E2B	3 x 3 Dual Rocker Switch, Black
WSSOS-ROW	Handheld 4-Button Remote
WSSOS-HOW	Hotel Key Card Holder

*To indicate color, add suffix to the end of the catalog number.
Available in White (-W), Ivory (-I), Light Almond (-T), Gray (-G), and Ebony (-E).
NAFTA and Made in USA models available.

LEVITON SPECIFICATION SUBMITTAL	
JOB NAME:	CATALOG NUMBERS:
JOB NUMBER:	

Leviton Manufacturing Co., Inc. Lighting Management Systems
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Leviton S. de R.L. de C.V.
Lago Tana 43, Mexico DF, Mexico CP 11290 • Tel. (+52) 55-5082-1040 • FAX: (+52) 5386-1797 • www.leviton.com.mx

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REV JUN 2010

APPENDIX E. CLTC RESULTS

CALIFORNIA LIGHTING TECHNOLOGY CENTER

Cooper Corelite 2x2
Photometric Report

Prepared for
PG&E

Prepared by
Nicole Graeber, Development Engineer
California Lighting Technology Center

July 17, 2012

CALIFORNIA LIGHTING TECHNOLOGY CENTER

Notes

Integrating Sphere

- Power measurements taken on a Yokogawa PZ4000 power analyzer
- Photometric measurements made with a SMS-500 Spectrometer in a 2 meter integrating sphere
- Measurements taken in accordance with LM-79
- Auxiliary correction applied for fixture self absorptions
- Measurements run for Cooper Corelite 2x2

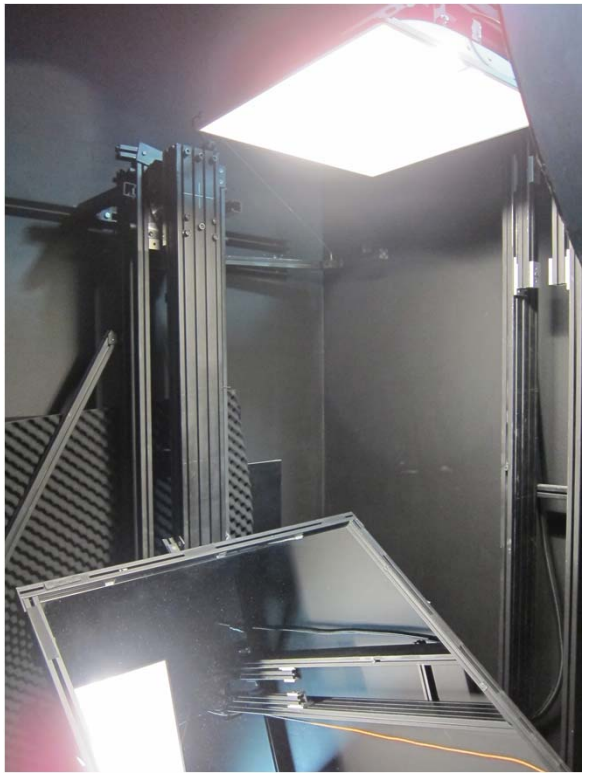
Goniophotometer – Type C

- Power measurements taken on a Xitron 2802 power analyzer
- Photometric measurements made with a T-10 Konica Minolta Illuminance meter
- Measurements presented in accordance with LM-63-2002
- Stray light correction applied
- Measurements run for Cooper Corelite 2x2

Testing Equipment

Integrating Sphere

Goniophotometer



Summary – Cooper Corelite 2x2

			Integrating Sphere			Goniophotometer		
	CCT (K)	**CRI**	**Light Output (lumens)**	**Power (Watts)**	**Efficacy (lumens/watt)**	**Light Output (lumens)**	**Power (Watts)**	**Efficacy (lumens/watt)**
Manufacturer Data – Full Power	**4,000**	**85**	**3,480**	**44**	**79.1**	**3,489**	**44.3**	**78.8**
Full	3,982	87.5	3,410	43.5	78.4	3,513	44.0	80.0
66% Power	3,957	86.9	2,346	28.8	81.5	-	-	-
33% Power	3,949	86.5	1,100	14.6	75.3	-	-	-

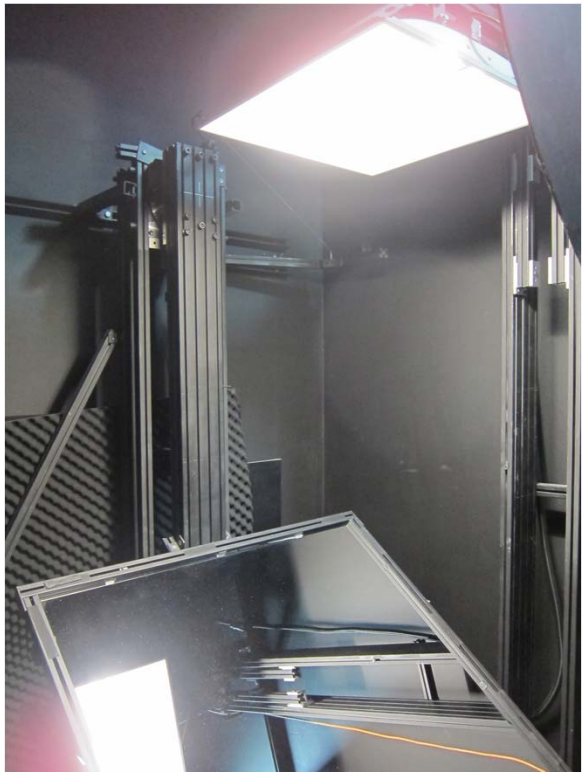
Note: All testing at 277 V

Goniophotometer Lumen Summation

Cooper Corelite 2x2

Zone	Manufacturer Data Lumens	CLTC Test Lumens
0-30	956	1,036
0-40	1,541	1,640
0-60	2,694	2,778
0-90	**3,489**	**3,513**

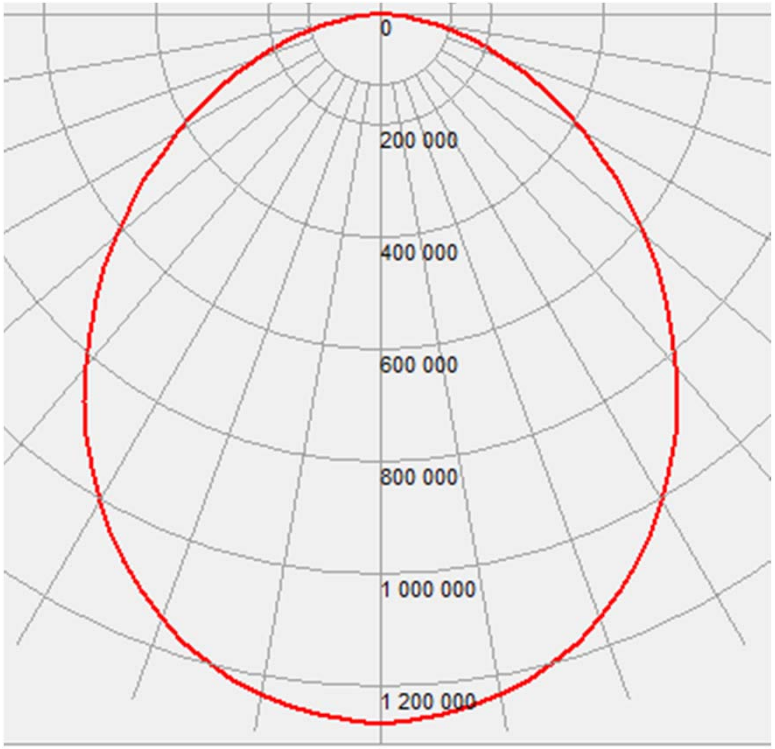
Zone	Manufacturer Data Lumens	Manufacturer Data Zonal Percentage	CLTC Test Lumens	CLTC Test Zonal Percentage	Zonal Lumens Percent Difference
0-10	**119**	3.41%	91	2.60%	0.81%
10-20	**338**	9.69%	314	8.93%	0.76%
20-30	**498**	14.27%	490	13.94%	0.33%
30-40	**585**	16.77%	591	16.83%	-0.06%
40-50	**601**	17.23%	610	17.35%	-0.12%
50-60	**551**	15.79%	558	15.88%	-0.09%
60-70	**437**	12.53%	451	12.84%	-0.31%
70-80	**274**	7.85%	299	8.50%	-0.65%
80-90	**84**	2.41%	109	3.10%	-0.69%
0-90	**3,489**	100%	**3,513**	**100%**	0%



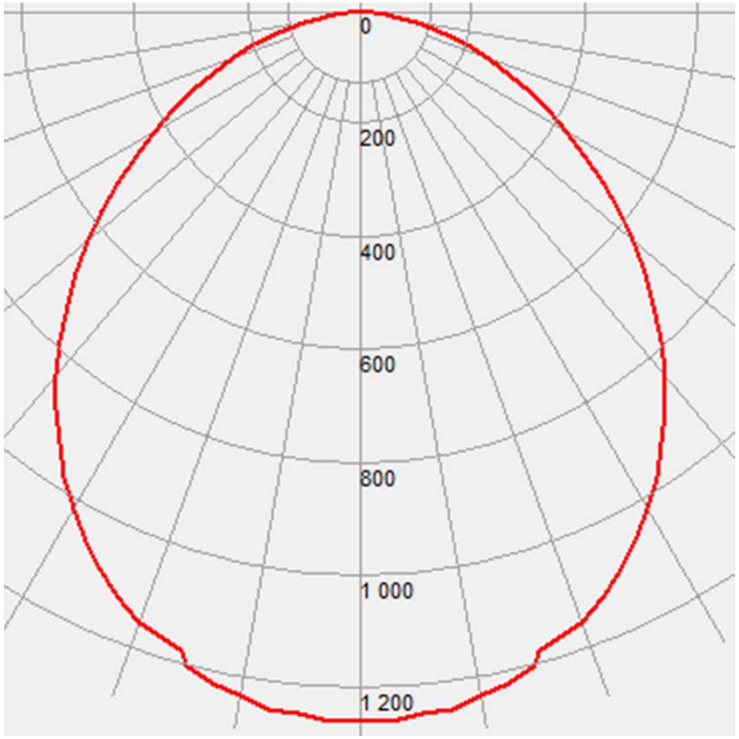
Goniophotometer Candela Distribution

Cooper Corelite 2x2

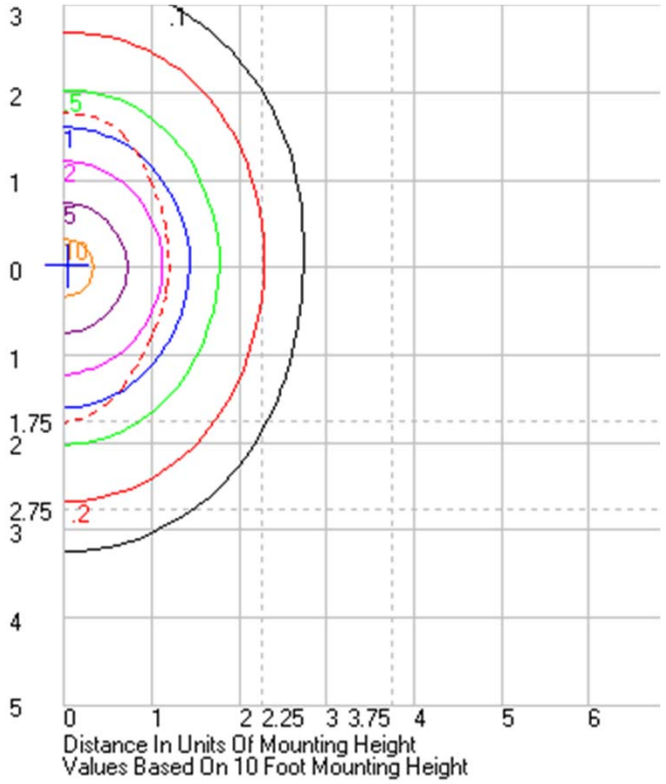
Manufacturer Data



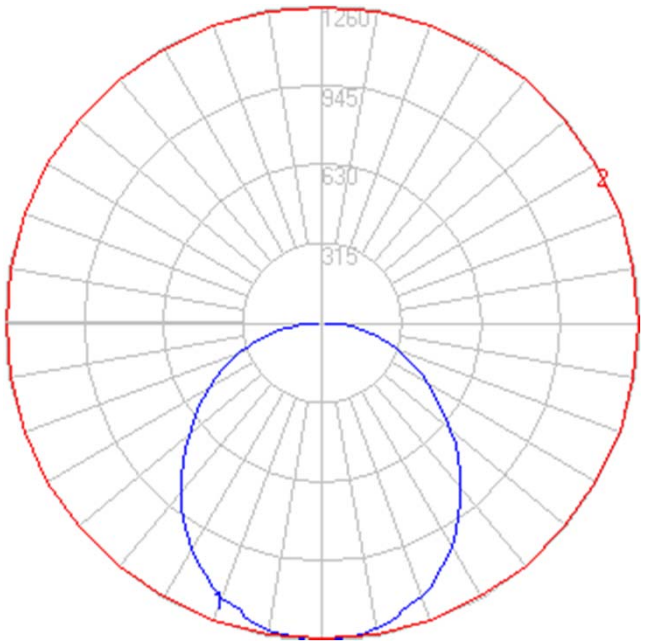
CLTC Test



Goniophotometer Characterization



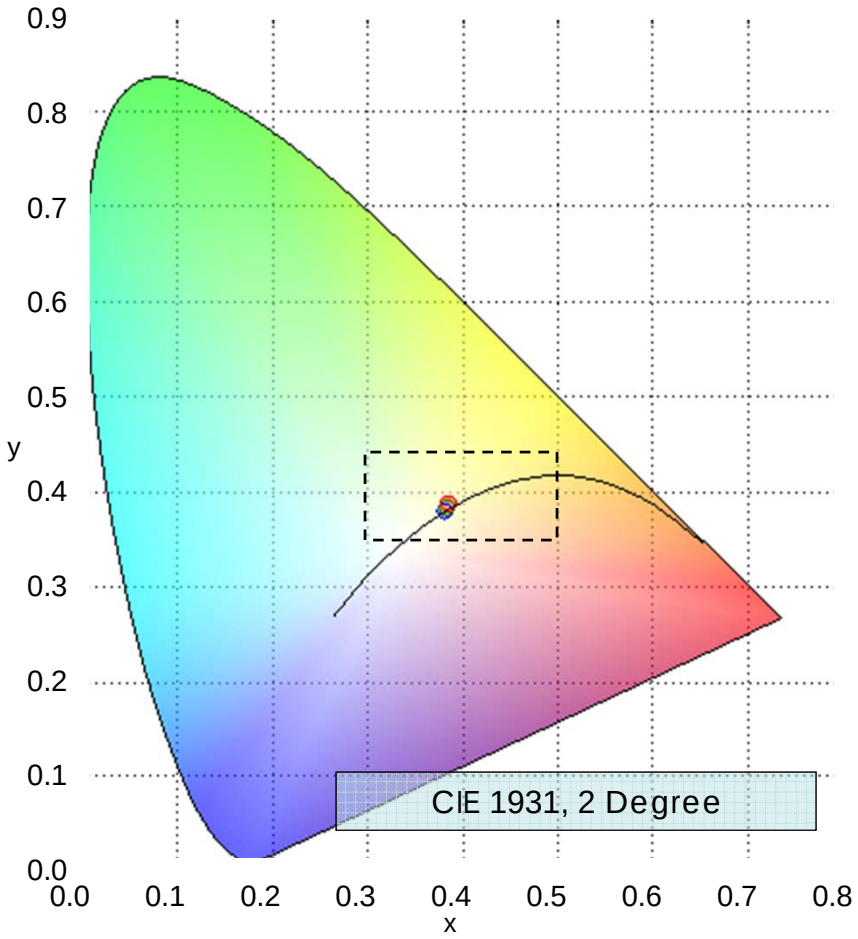
Red Dash: ½ Max Candela
Blue Cross: Max Candela Point



Vertical Plane Through Horizontal Angles:
Blue: 130˚ - 310˚ (Through Max Candela)

Horizontal Cone Through Vertical Angle:
Red: 2.5˚ (Through Max Candela)

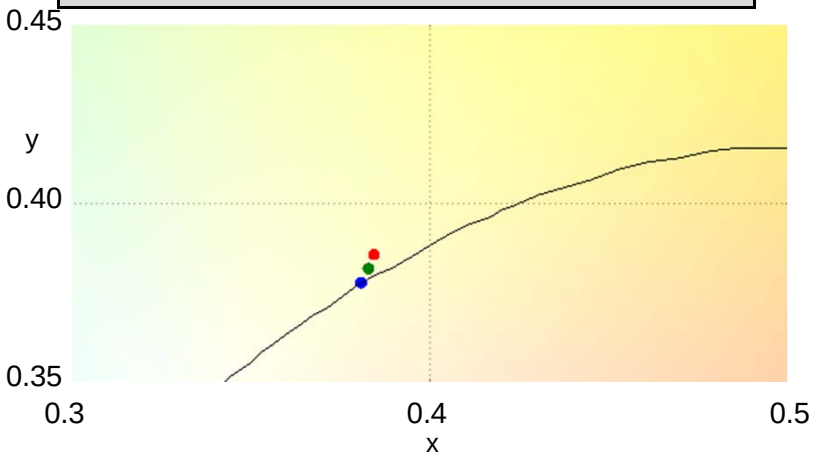
Chromaticity – Cooper Corelite 2x2



Sample	Full Power
CIE x	0.3813
CIE y	0.3779

Sample	66% Power
CIE x	0.3833
CIE y	0.3818

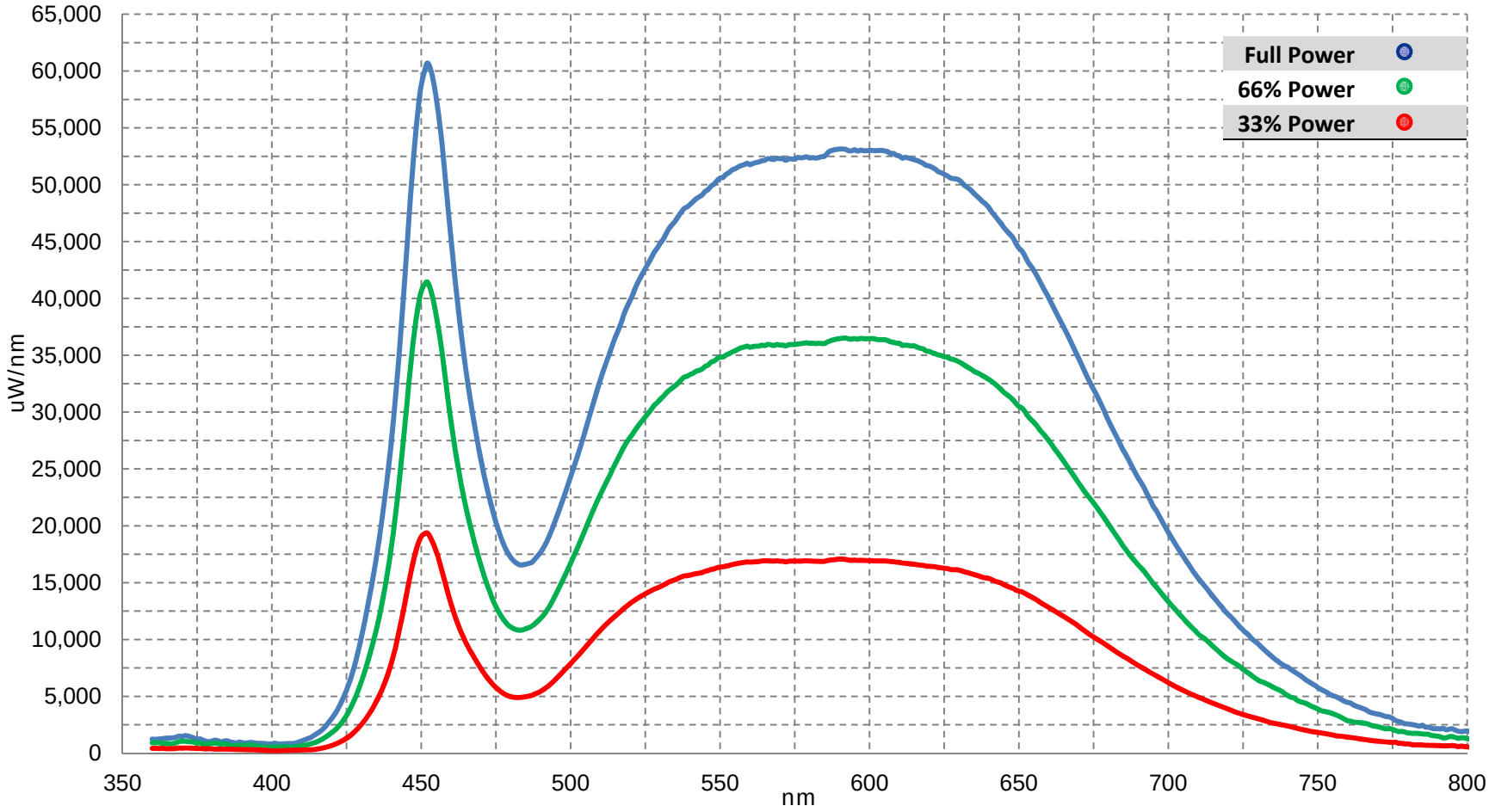
Sample	33% Power
CIE x	0.3848
CIE y	0.3857



CRI Chart – Cooper Corelite 2x2

	Full Power	66% Power	33% Power
R1	87.4	86.6	85.9
R2	90	89.3	88.6
R3	89.8	89.5	89.3
R4	87.3	87	86.6
R5	85.7	84.9	84.1
R6	84.1	83.3	82.6
R7	93	93	93.2
R8	82.7	82	81.5
R9	53.2	50.9	49
R10	74.2	72.8	71.6
R11	84.6	84.4	84
R12	60.6	59	57.2
R13	87.7	86.9	86.1
R14	93.8	93.7	93.6
Ra	**87.5**	**86.9**	**86.5**

Spectral Power Distribution – Cooper Corelite 2x2



Cree CR-22
Photometric Report

Prepared for
PG&E

Prepared by
Nicole Graeber, Development Engineer
California Lighting Technology Center

July 13, 2012

CALIFORNIA LIGHTING TECHNOLOGY CENTER

Notes

Integrating Sphere

- Power measurements taken on a Yokogawa PZ4000 power analyzer
- Photometric measurements made with a SMS-500 Spectrometer in a 2 meter integrating sphere
- Measurements taken in accordance with LM-79
- Auxiliary correction applied for fixture self absorptions
- Measurements run for Cree CR-22

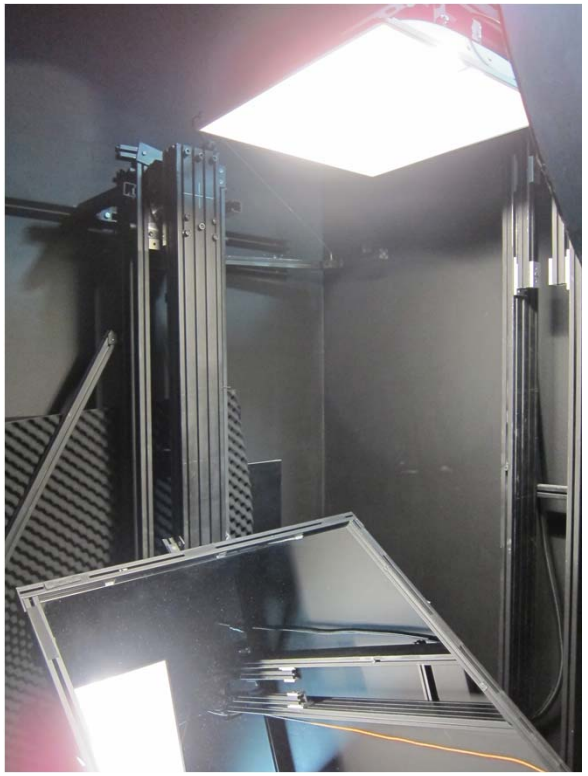
Goniophotometer – Type C

- Power measurements taken on a Xitron 2802 power analyzer
- Photometric measurements made with a T-10 Konica Minolta Illuminance meter
- Measurements presented in accordance with LM-63-2002
- Stray light correction applied
- Measurements run for Cree CR-22

Testing Equipment

Integrating Sphere

Goniophotometer



Summary – Cree CR-22

			Integrating Sphere			Goniophotometer		
	CCT (K)	**CRI**	**Light Output (lumens)**	**Power (Watts)**	**Efficacy (lumens/watt)**	**Light Output (lumens)**	**Power (Watts)**	**Efficacy (lumens/watt)**
Manufacturer Data – Full Power	**4,000**	**90**	**3,200**	**35.0**	**91.4**	**3,280**	**35.52**	**92.3**
Full Power	3,839	93.0	3,134	32.9	95.3	3,127	34.3	91.2
66% Power	3,851	91.8	2,067	21.5	96.1	-	-	-
33% Power	3,882	90.1	1,013	10.9	92.9	-	-	-

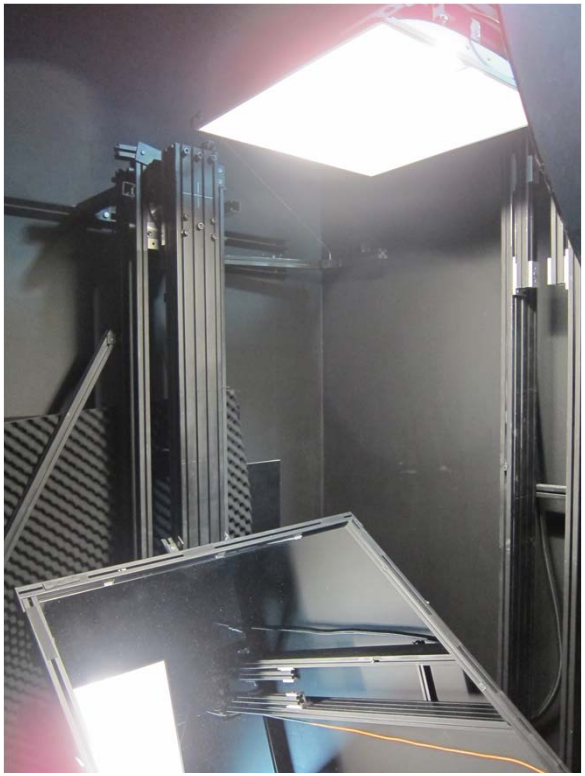
Note: All testing at 277 V

Goniophotometer Lumen Summation

Cree CR-22

Zone	Manufacturer Data Lumens	CLTC Test Lumens
0-30	923	958
0-40	1,527	1,546
0-60	2,704	2,646
0-90	**3,280**	**3,127**

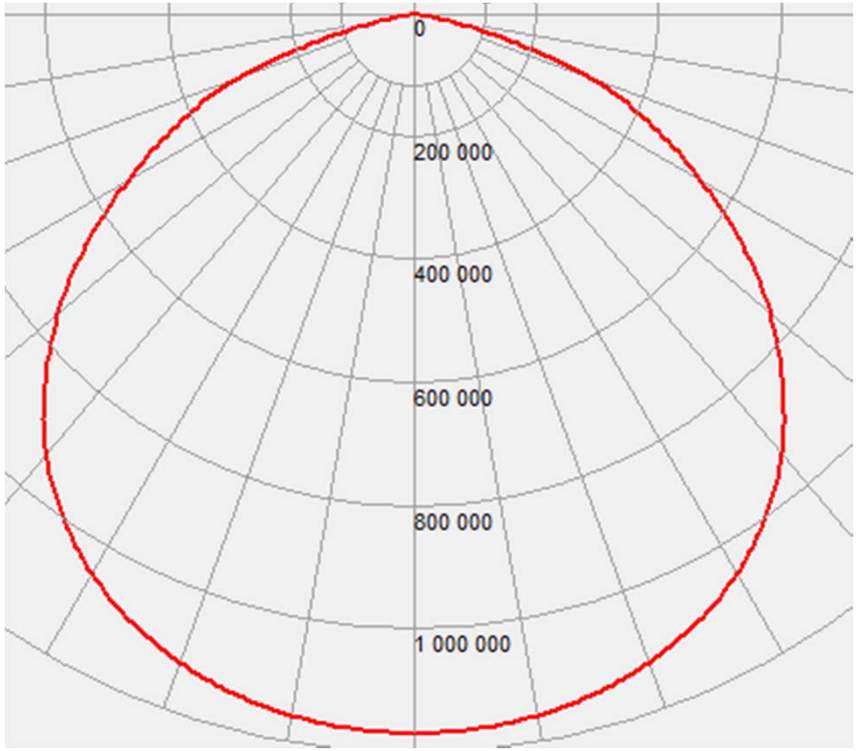
Zone	Manufacturer Data Lumens	Manufacturer Data Zonal Percentage	CLTC Test Lumens	CLTC Test Zonal Percentage	Zonal Lumens Percent Difference
0-10	**111**	3.38%	**81**	2.61%	**0.77%**
10-20	**320**	9.75%	**284**	9.09%	**0.66%**
20-30	**493**	15.03%	**457**	14.62%	**0.41%**
30-40	**604**	18.41%	**572**	18.28%	**0.13%**
40-50	**628**	19.14%	**603**	19.28%	**-0.14%**
50-60	**550**	16.76%	**536**	17.13%	**-0.37%**
60-70	**384**	11.70%	**383**	12.24%	**-0.54%**
70-80	**173**	5.27%	**184**	5.87%	**-0.60%**
80-90	**18**	0.55%	**27**	0.86%	**-0.31%**
0-90	**3,280**	100%	**3,127**	100%	**0**



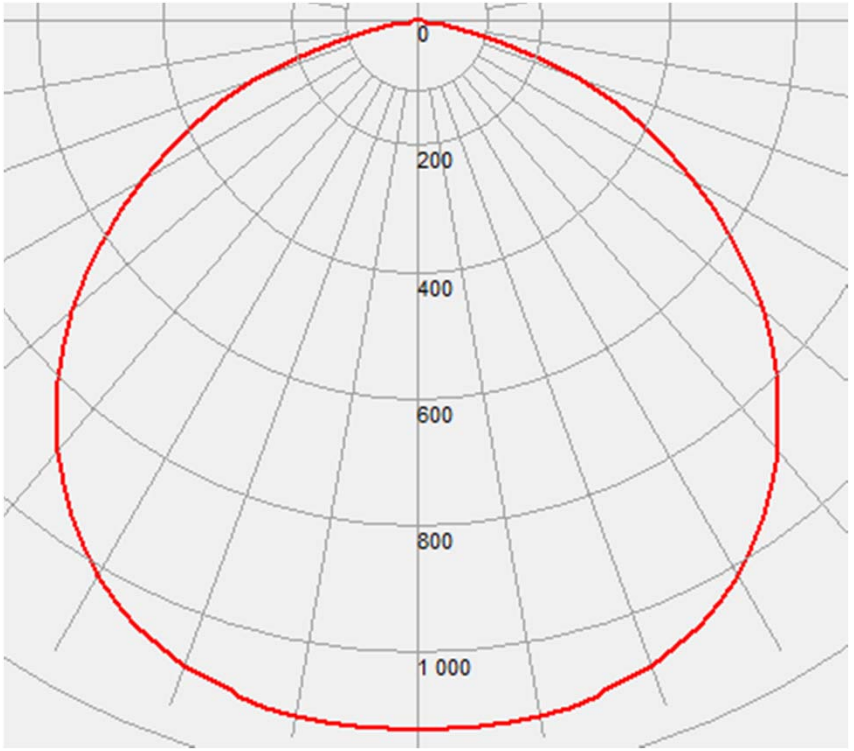
Goniophotometer Candela Distribution

Cree CR-22

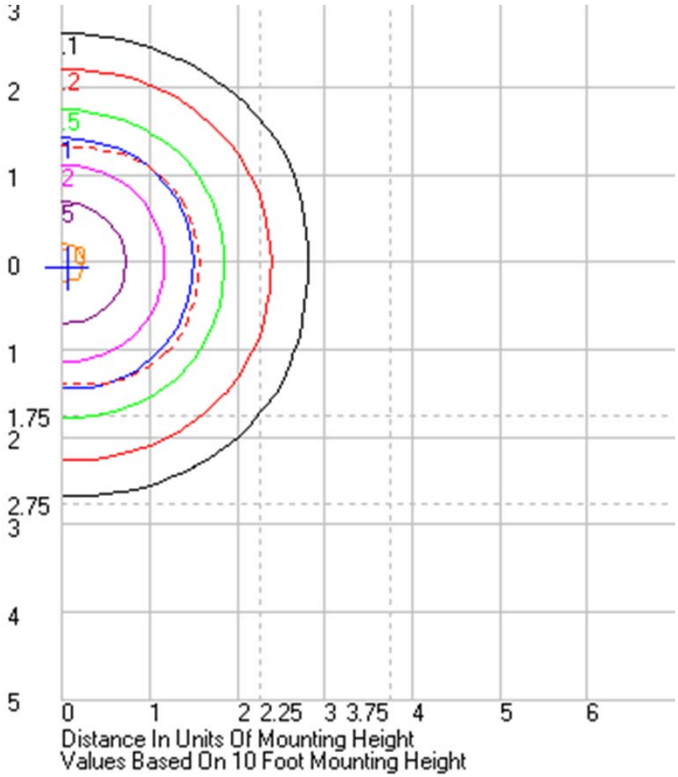
Manufacturer Data



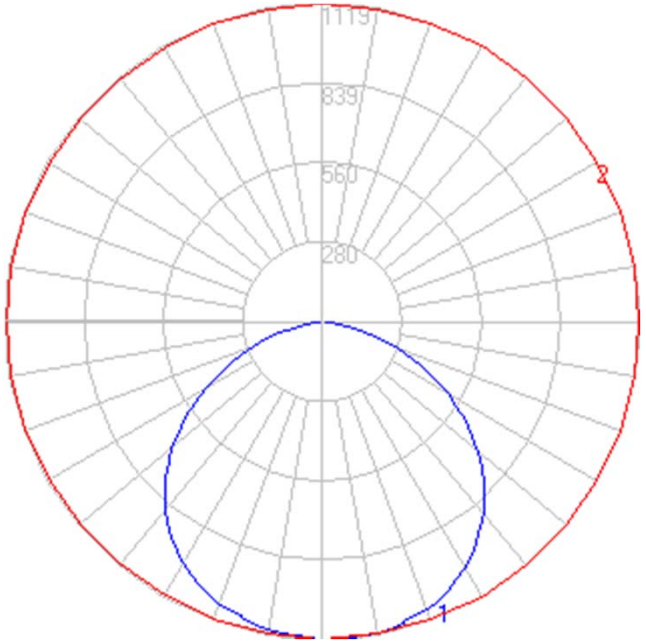
CLTC Test



Goniophotometer Characterization



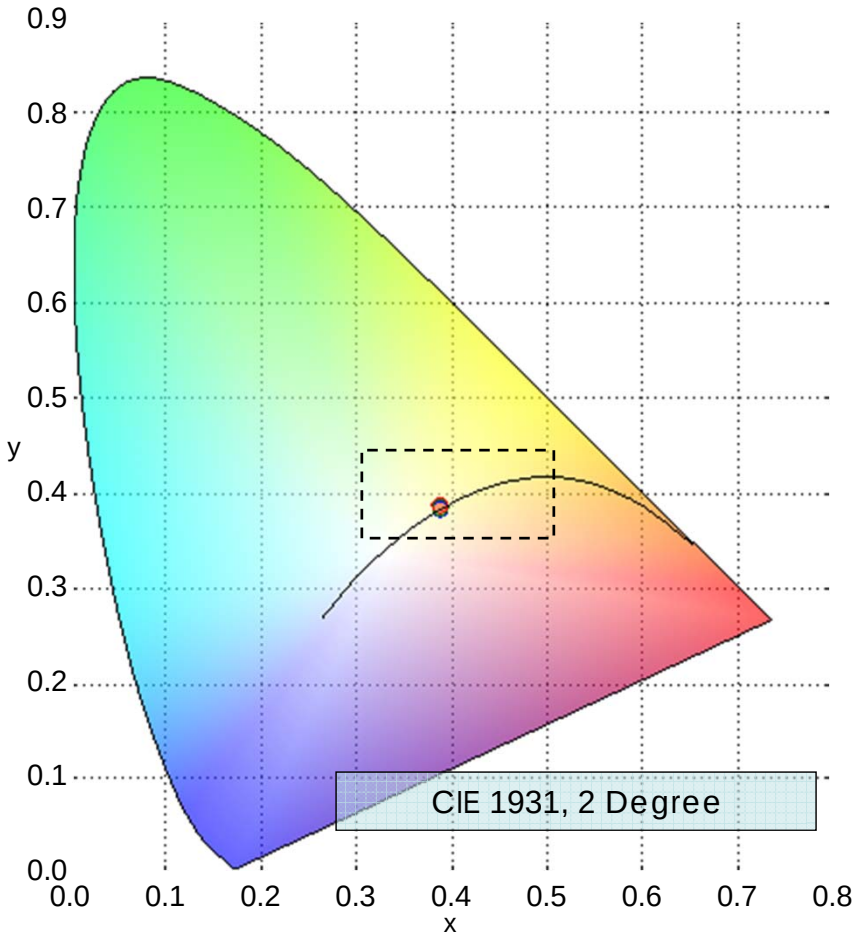
Red Dash: ½ Max Candela
Blue Cross: Max Candela Point



Vertical Plane Through Horizontal Angles:
Blue: 50˚ - 230˚ (Through Max Candela)

Horizontal Cone Through Vertical Angle:
Red: 5˚ (Through Max Candela)

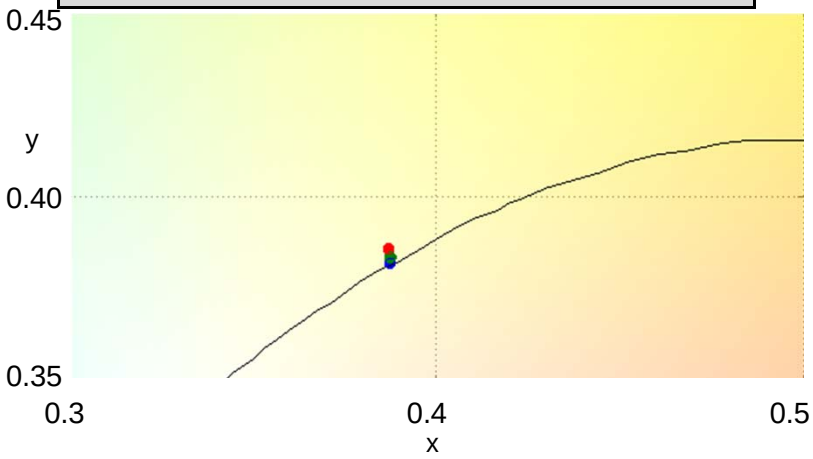
Chromaticity – Cree CR-22



Sample	Full Power
CIE x	0.3878
CIE y	0.3817

Sample	66% Power
CIE x	0.3879
CIE y	0.3833

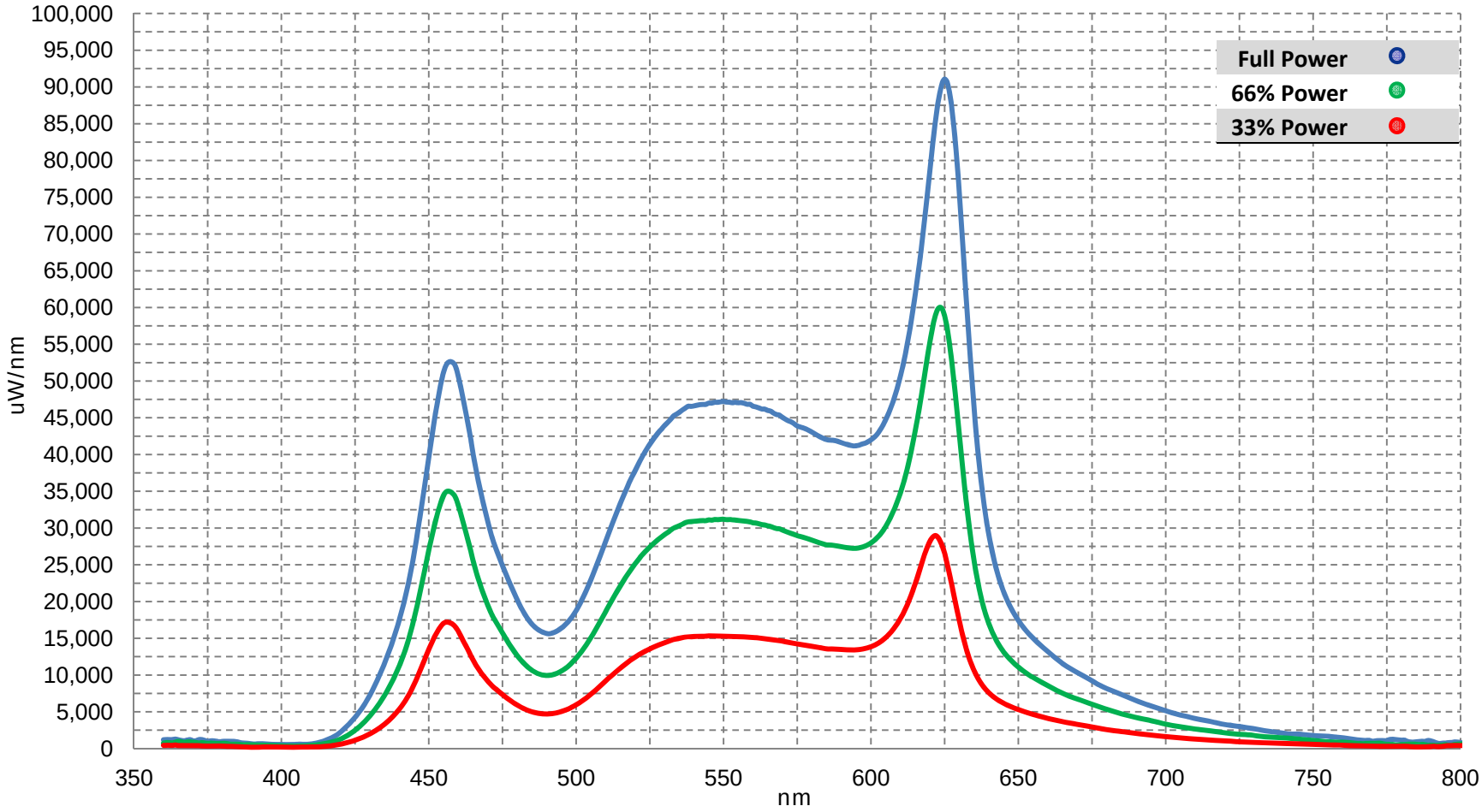
Sample	33% Power
CIE x	0.3874
CIE y	0.3857



CRI Chart – Cree CR-22

	Full Power	66% Power	33% Power
R1	96.5	95.3	93.3
R2	94.9	94	92.8
R3	88.9	88.9	88.9
R4	94.3	93.3	91.8
R5	92.3	91.1	89.1
R6	91.3	90.5	89.2
R7	96.4	95.4	94.3
R8	89.7	86	81.7
R9	69.3	59.6	48
R10	81.2	79.3	76.7
R11	91.3	90.3	88.7
R12	64.6	62.6	59.9
R13	95.8	94.6	92.8
R14	91.8	91.9	92
Ra	93	91.8	90.1

Spectral Power Distribution – Cree CR-22



APPENDIX F. LOAD REDUCTION ANALYSIS

Job No: 1316.57 Date: 11/07/12 By: JBG Check: MAT 11/16/12

Print Date: 12/4/2012

File: GSA 630 Sansome fixture wattage comparison.redacted.xls Sheet: Fixt Wattage Summary

630 Sansome Street 10th floor Rm 1040 - fixture wattage comparison

	T8 base case[4]				LED @ 100%				% change
Area	**Fixture type**	**Fixture Qty**	**Wattage/Area**	**Watts/Fixture**	**Fixture type**	**Fixture Qty**	**Wattage/Area**	**Watts/Fixture**	
Private Office 1	2-Lamp 4' F32T8	3	173.1	57.7	Cree CR-22	3	105.6	35.2	-39.0%
Private Office 2	2-Lamp 2' F17T8	4	135.2	33.8	Cooper Corelite 2X2	4	184.0	46	36.1%
Hallway	2-Lamp 4' F32T8	3	172.7	57.6	Cooper Corelite 2X2	3	137.4	45.8	-20.5%
Hallway [1]	2-Lamp 4' F32T8	1	58.5	58.5	Cooper Corelite 2X2 [1]	1	65.0	65	11.1%
Open Office [2]	2-Lamp 4' F32T8	15	860.2	57.3	Cooper Corelite 2X2 [3]	15	636.3	42.4	-26.0%
		Panel C-10 Linear [5]				**Panel C-10 LED**			
		59	2,833.5	48		53	2,200.8	41.5	-22.3%

Notes:

1 - Emergency fixture (The new emergency fixtures have a significantly higher power draw and a lower power factor. See Hallway[1] monitoring where the emergency fixture is monitored separately.)

2 - Excludes emergency fixture in base case

3 - Includes emergency fixture

4 - T8 base case Wattage/Area values are calculated from the base case monitoring period using only values that are 80% or greater than the area's peak load.

5 - Panel C-10 Linear Wattage/Area value was calculated from the base case monitoring period using only values that are 95% or greater than the peak lighting load.

6 - All LED @ 100% Wattage/Area values were calculated from short term monitored data with all fixtures on collected prior to the LED fixtures being Task Tuned.

7 - The base case included a total of (39) 4 foot, 2 lamp, F32T8 fixtures and (20) 2 foot, 2 lamp, F17T8 fixtures

8 - LED: (27) Cooper Corelite 2X2 fixtures and (26) Cree CR-22 fixtures

9 - Comparison: Cooper Corelite 2X2 fixture manufacturer rated wattage - 44, CLTC measured full power wattage - 43.5

10 - Comparison: Cree CR-22 fixture manufacturer rated wattage - 35, CLTC measured full power wattage - 32.9

Fixture Count Summary (Original)

Area	Fluorescent Total
Open Office	16
Printer room	16
Private Office 1	3
Hallway	4
Private Office 2X2 fixtures	20

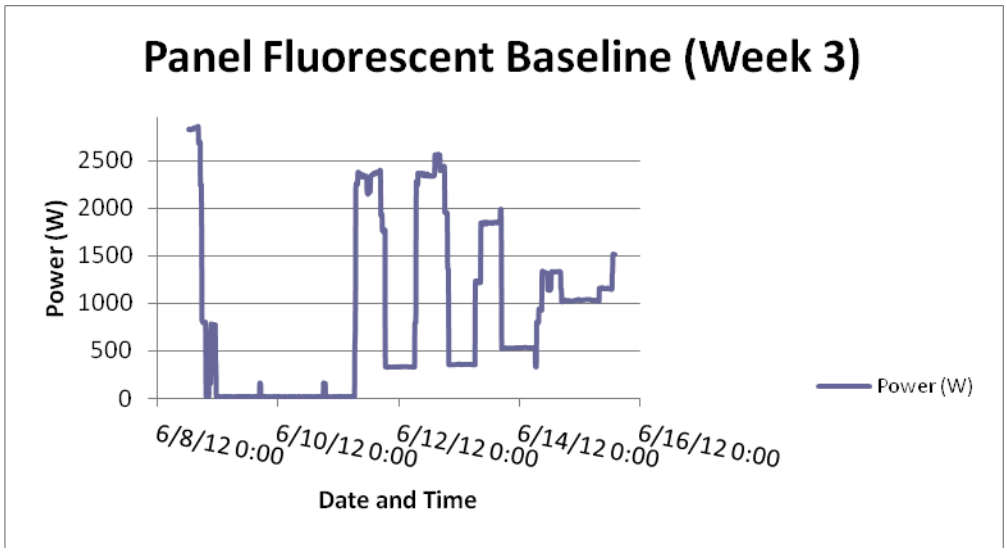
Fixture Count Summary (LED)

LED Type	LED
Corelite	27
Cree	26

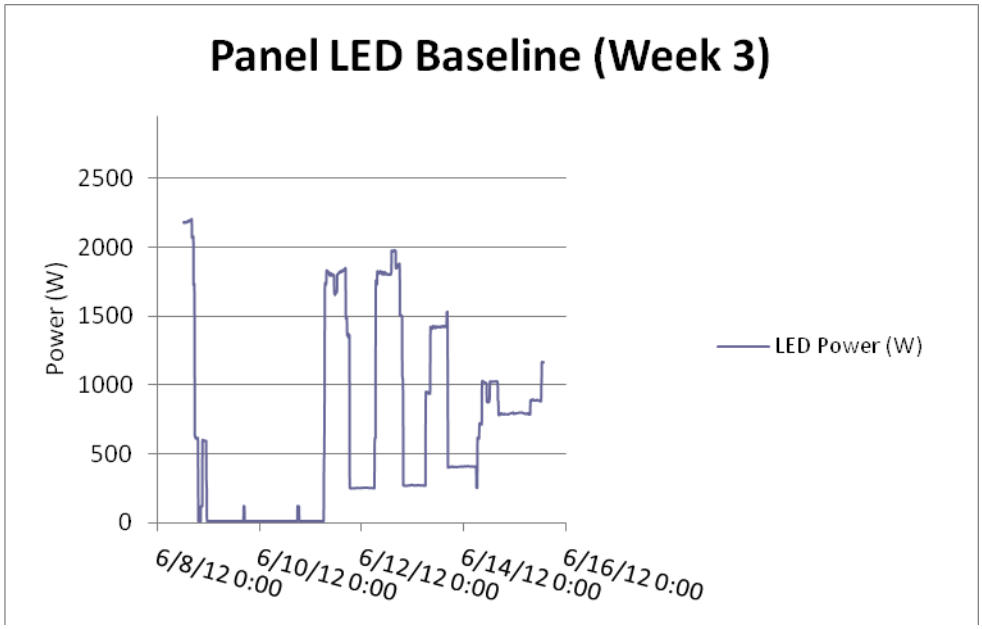
APPENDIX G. DATA AND CHARTS

Power Graph, Typical 15 minute Interval Data as Measured at the Electrical Panel

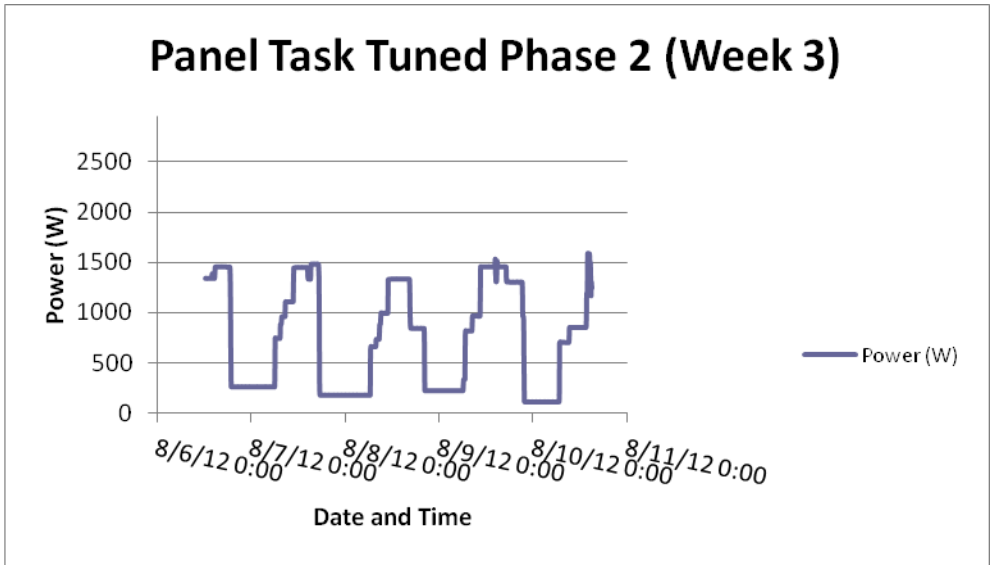
This data is representative for one week (week 3) for each experiment as noted below the graphs. Note that once the LEDs are in place (Phase 1), the phases of control are additive as each experiment includes the effect of the controls which were added in previous phases.



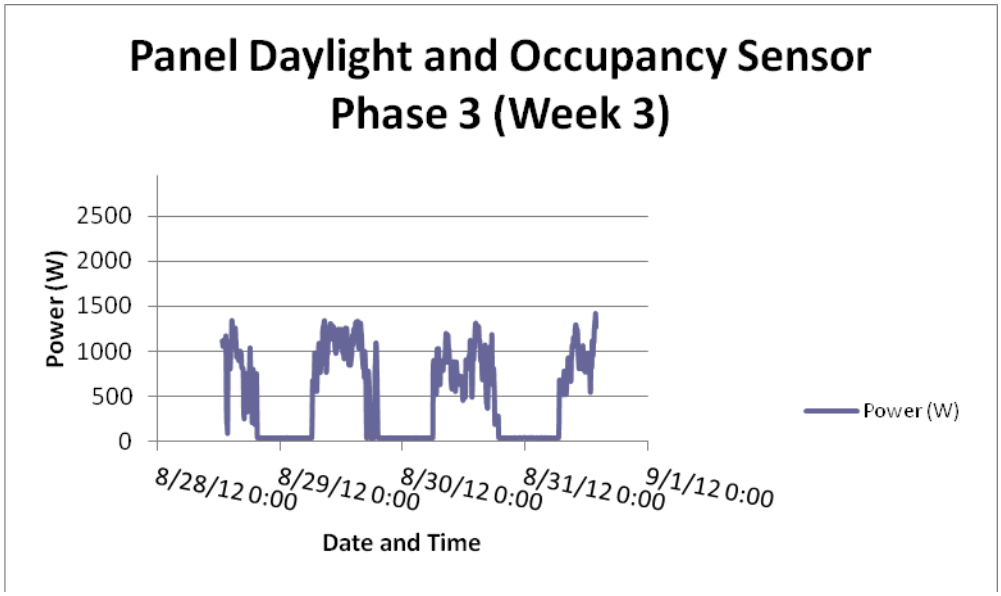
Fluorescent Baseline (Phase 0) is measured data indicating between 2.0 and 2.6 kW power draw at peak, illustrating typical office usage pattern of a 5 day work week.



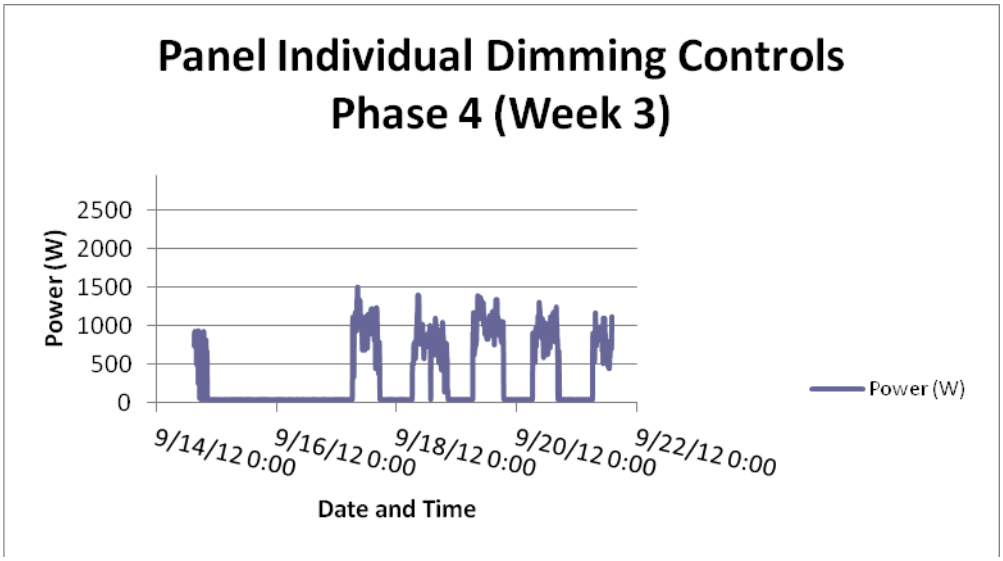
LED Baseline (Phase 1) is based on spot measurement of LED fixtures as applied to the measured usage of the same period. The peak power drawn by the replacement LED fixtures ranges from 1.8 to 2.2 kW, which is a substantial reduction from the original case (Phase 0).



Week 3 of Phase 2 (Task Tuning) provides a stable signature with peak power at 1.5 kW for the entire panel.



Week 3 of Phase 3 (Daylight and Occupancy Sensor Control) indicates peak consumption in the 1.3 kW range. Additionally, the sloping of the power curve suggests that power draw is intermittent throughout the floor. This is to be expected with controls that affect individual areas at different times.



Week 3 of Phase 4 (Individual Dimming Controls) indicates peak consumption in the 1.1 to 1.3 kW range. Here again, the sloping of the power curve suggests that power draw is intermittent throughout the floor. The graph suggests that individual dimming adds to this effect.

APPENDIX H. COST AND SAVINGS ANALYSIS

All values for energy (kWh) consumption in the first table are calculated from the power (W) data collected throughout the project and the elapsed time. The following values were then calculated based on these measured findings and computed values. Note that the “annual” consumption values are not measured, but extrapolated from the measured data.

For 2 Weeks (1st week of each phase is excluded)

Power Consumption (kWh)	Fluor Phase 1	LED Phase 1	Savings	Phase 2	Savings	Phase 3	Savings	Phase 4	Savings	*Savings b/w P1 & P4*
Hall	30	25	16%	9	63%	17	-81%	18	-9%	27%
Private Office 2	13	17	-30%	13	25%	7	46%	7	-4%	58%
Open Offices 1 & 2	112	81	28%	63	22%	53	17%	55	-4%	32%
Private Office 1	21	12	42%	1	96%	0	24%	0	86%	100%
Panel	286	221	23%	187	15%	127	32%	124	2%	44%
Panel (w/o Private Office 1)	265	209	21%	187	11%	127	32%	124	2%	41%

Annualized

Power Consumption (kWh)	Fluor Phase 1	LED Phase 1	Savings	Phase 2	Savings	Phase 3	Savings	Phase 4	Savings	*Savings b/w P1 & P4*
Hall	774	650	16%	240	63%	435	-81%	474	-9%	27%
Private Office 2	344	449	-30%	338	25%	184	46%	191	-4%	58%
Open Offices 1 & 2	2924	2111	28%	1654	22%	1372	17%	1429	-4%	32%
Private Office 1	541	316	42%	14	96%	10	24%	1	86%	100%
Panel	7455	5763	23%	4884	15%	3320	32%	3241	2%	44%
Panel (w/o Private Office 1)	6914	5447	21%	4870	11%	3310	32%	3240	2%	41%

Incremental Energy Savings from Phase 0	Phase 1		Phase 2		Phase 3		Phase 4	
from annual extrapolation	kWh Saved	% Saved	kWh Saved	% Saved	kWh Saved	% Saved	kWh Saved	% Saved
Hall	124	16%	534	69%	339	44%	300	39%
Private Office 2	-105	-30%	6	2%	160	47%	154	45%
Open Offices 1 & 2	812	28%	1269	43%	1552	53%	1495	51%
Private Office 1	226	42%	528	97%	531	98%	540	100%
Panel	1693	23%	2572	34%	4135	55%	4214	57%
Panel (w/o Private Office 1)	1467	21%	2044	30%	3604	52%	3674	53%

Incremental Energy Savings from Phase 1	Phase 2		Phase 3		Phase 4	
from annual extrapolation	kWh Saved	% Saved	kWh Saved	% Saved	kWh Saved	% Saved
Hall	411	63%	215	33%	176	27%
Private Office 2	111	25%	265	59%	259	58%
Open Offices 1 & 2	457	22%	739	35%	682	32%
Private Office 1	302	96%	305	97%	314	100%
Panel	879	15%	2443	42%	2522	44%
Panel (w/o Private Office 1)	578	11%	2138	39%	2208	41%

Energy Savings between Phases	Phases 0 & 1		Phases 1 & 2		Phases 2 & 3		Phases 3 & 4	
from annual extrapolation	kWh Saved	% Saved	kWh Saved	% Saved	kWh Saved	% Saved	kWh Saved	% Saved
Hall	124	16%	411	63%	-195	-81%	-39	-9%
Private Office 2	-105	-30%	111	25%	154	46%	-7	-4%
Open Offices 1 & 2	812	28%	457	22%	283	17%	-57	-4%
Private Office 1	226	42%	302	96%	3	24%	9	86%
Panel	1693	23%	879	15%	1563	32%	79	2%
Panel (w/o Private Office 1)	1467	21%	578	11%	1560	32%	70	2%

Payback Period with Utility Rate of $0.13878/kWh Based on Panel Energy Consumption

(REPORT PAYBACK)

Incremental Energy Savings from Phase 0	kWh Saved/yr	Payback Period (yrs)	Payback Period (yrs)
Phase 1	1693	201	>50
Phase 2	2572	183	>50
Phase 3	4135	132	>50
Phase 4	4214	132	>50
Incremental Energy Savings from Phase 1	kWh Saved/yr	Payback Period (yrs)	Payback Period (yrs)
Phase 2	879	149	>50
Phase 3	2443	84	>50
Phase 4	2522	85	>50
Energy Savings between Phases	kWh Saved/yr	Payback Period (yrs)	Payback Period (yrs)
Phase 0 - Phase 1	1693	201	>50
Phase 1 - Phase 2	879	149	>50
Phase 2 - Phase 3	1563	47	47
Phase 3 - Phase 4	79	123	>50

Cost Data

Phase	**Incremental Cost above Phase 0**	**Incremental Cost above Phase 1**	**Cost between Phases**
0	-	-	-
1	$47,178.00	-	$47,178.00
2	$65,401.00	$18,223.00	$18,223.00
3	$75,657.00	$28,479.00	$10,256.00
4	$77,003.00	$29,825.00	$1,346.00

Cost Effectiveness

Phase	**kWh Saved/$ Spent for Measures from Fluorescents**	**kWh Saved/ $ Spent for Measures from LED Lights**	**kWh Saved/ $ Spent for Measures between Phases**
0	-	-	-
1	0.036	-	0.036
2	0.039	0.048	0.048
3	0.055	0.086	0.152
4	0.055	0.085	0.059

*Note: Used panel consumption including private office 1 because outfitting the space is part of the total cost and cannot be isolated.

Utility Rate
0.13878

Cost of Emerging Technologies Project at 630 Sansome Street

Background

The following is an estimate of the cost for each phase of the lighting retrofit and controls project at 630 Sansome St. The break out of costs are based on invoices and information provided by the vendors and contractor.

COST DATA BY PHASES

Phase	Added Measure	Details	Material Cost (1)	Labor Cost (2)	Engineering Design & License (3)	PG&E Fee	Total	Incremental from Phase 0	Incremental from Phase 1
0	Fluorescents (base)	Incumbent	-	-	-	-		-	-
1	LED	60% of total labor and commissioning	$15,671	$28,860	$400	$2,247	$47,178	$47,178	-
2	LED+task tune	20% of total labor and commissioning	$6,638	$9,620	$1,097	$868	$18,223	$65,401	$18,223
3	LED+task tune+sensors	18% of total labor and commissioning	$710	$8,658	$400	$488	$10,256	$75,657	$28,479
4	LED+task tune+sensors+controls	2% of total labor and commissioning	-	$962	$320	$64	$1,346	$77,003	$29,825
Total			$23,019	$48,100	$2,217	$3,667	$77,003		

Notes

(0) The total cost estimate provided by Enovity for the work was $86,851.25. After pricing neogiation, the project cost was estabished at $77,000 which was used as the basis for this analysis.

(1) Broken out from Enovity invoices - see below

(2) *Labor costs are based on information provided in the Enovity Sep 19, 2011 Proposal for LED Lighting Installation at 630 Sansome St.- see Appendix E. Labor percentages are based on telephone conversations with representatives from Enovity and Adura.*

(3) Engineering and design costs are based on Enovity invoice 0311.032.01A (prorated over Phases 1, 3 and 4) and Enovity Sep 19, 2011 Proposal for LED Lighting Installation at 630 Sansome St.

Invoiced Costs

Enovity PO 0311.032.01A (a)	Phase 1	Phase 2	Phase 3	Phase 4	Total	Invoiced Costs plus 9% Enovity mark-up Phase 1	Phase 2	Phase 3	Phase 4	9% Total
Materials	0	6,090	651	0	6,741	0	6,638	710	0	7,348
Engineering/Design/License	0	1,006	0	0	1,006	0	1,097	0	0	1,097
Total	0	7,096	651	0	7,747	0	7,735	710	0	8,445

Enovity PO 0311.032.02R	Phase 1	Phase 2	Phase 3	Phase 4	Total	Phase 1	Phase 2	Phase 3	Phase 4	Total
Materials	7,776	0	0	0	7,776	8,476	0	0	0	8,476
Engineering/Design/License	0	0	0	0	0	0	0	0	0	0
Total	7,776	0	0	0	7,776	8,476	0	0	0	8,476

Enovity PO 0311.032.01	Phase 1	Phase 2	Phase 3	Phase 4	Total	Phase 1	Phase 2	Phase 3	Phase 4	Total
Materials	6,601	0	0	0	6,601	7,195	0	0	0	7,195
Engineering/Design/License	0	0	0	0	0	0	0	0	0	0
Total	6,601	0	0	0	6,601	7,195	0	0	0	7,195

Notes

(a) - third party hardware of $1,200 was split between Phase 2 and Phase 3 material

sales tax 8.5%

Purchase Order

Date: May 22, 2012
Purchase Order No.: 0311.032.02R
Quote no.: PB050812EN

Payee: Independent Electric Supply
Address: 1575 Burke Avenue
San Francisco, CA 94124

Contact: Paul Bacigalupi [paul.bacigalupi@iesupply.com]
Phone no.: 415-734-4701
Fax no.: 415-734-4789

Deliver to: US. General Services Administration
Address 630 Sansome Street Room 1040
San Francisco, CA 94111
Attention: Opelia Opelinia
Phone no.: 415-844-5006

Request By	*Approved by*	*Project name*	*Project number*	*Lead Time*
Zinovy Gutman	Jonathan Soper	630 Sansome LED Install	311.032	n/a

Qty	*UOM*	*Description*	*Price per Unit*	*Amount*
27	Unit	Corelite Z3-WL-2L40-1D-UNV-22-T1 LED lighting fixtures	$265.44	$7,166.88

Subtotal	$7,166.88
Shipping	n/a
Taxes 8.5%	$609.18
Total	**$7,776.06**

Please remit confirmation to:
Zinovy Gutman
zgutman@enovity.com
415-974-0390 ext 120
415-279-7002 cell

September 19, 2011

Roger Farzaneh
Senior Product Manager
Pacific Gas & Electric Co.
245 Market St., Mail Code N6G
San Francisco, CA 94105-1702
(415) 973-1097

Re: Proposal for LED lighting installation at 630 Sansome Street, San Francisco

Dear Roger,

This letter provides a proposal to install new LED light fixtures and wireless control systems for the 630 Sansome Street Appraisers office building. The scope of work was provided in the RFP GS-00P-07-BSD-0505 dated September 2nd, 2011.

SCOPE OF WORK

The Scope of work is described under the following Tasks:

1. Provide a professional design for the project work. This must be approved before GSA will give notice to proceed for construction. While design may be simple (e.g., one or two sheets), it must comply with NFPA, NEC and local structural requirements, and be prepared by a professional lighting designer. Photometrics must accompany the lighting design.
2. Install two LED lighting systems, each with an appropriately selected, different, lighting controls system. These systems must be laid out in a way so as to minimize disharmony in the space resulting from use of two different systems. Provide all associated electrical work, controls wiring, seismic cables, etc. needed to create complete systems.
3. Provide all computers and software licensing needed for the systems to be functional.
4. Submit software EULAs for GSA approval, with a vendor point of contract for negotiations. EULA approvals may be required before construction NTP.
5. Repair or replace ceiling tiles as needed. GSA will provide spare tiles.
6. Commission controls and software to assure proper installation and function.

PROPOSED SCHEDULE

Professional design will be completed 60 days from notice to proceed and construction will be complete 60 days from start. Final completion will be no later than Jan 31st, 2012.

COST PROPOSAL

This work can be completed for a cost of ~~**$86,851.25**~~. A cost breakdown is provided below.

Max budget $77k

Cost Summary

Task Description	Enovity Labor Cost	Expenses	Total Cost
Task 1: Design Phase	$1,120.00	$0.00	$1,120.00
Task 2: Construction Phase	$2,800.00	$0.00	$2,800.00
Task 3: Commissioning	$4,880.00	$0.00	$4,880.00
Subcontractors Cost			$70,155.69
PG&E Management Fee (10%)			$7,895.57
Total	**$8,800.00**	**$0.00**	**$86,851.25**

Subcontractor Cost Summary

Subcontractor Name	Description of Work	Price	Mark-Up	Total Cost
			9.00%	
RNM Engineering	Prof. Design	$15,000.00	$1,350.00	$16,350.00
Lighting & Controls Suppliers	LED Fixtures & Controls	$28,913.21	$2,602.19	$31,515.40
Lighting Installer	Electrician, Labor rate is Davis Bacon	$20,449.80	$1,840.48	$22,290.28
Total				**$70,155.69**

Material Cost Summary

Materials Cost						
	Quantity					
CREE	**Core**	**Alternate**	**Price**	**Core Total**	**Alternates**	**Grand Total**
CR22-32L-40K-10V	33	7	$ 264	$ 8,712.00	$ 1,848.00	$ 10,560.00
CR22-20L-40K-10V	4		$ 249	$ 996.00		$ 996.00
TOTAL				**$ 8,712.00**	**$ 1,848.00**	**$ 10,560.00**
ADURA				**Core Total**	**Alternates**	**Grand Total**
Hardware Design/Start-Up	MAIN OFFICE AREA			$ 2,923.60		$ 2,923.60
Annual Software License						
TOTAL				**$ 2,923.60**	**$ -**	**$ 2,923.60**
	Quantity					
COOPER	**Core**	**Alternate**	**Price**	**Core Total**	**Alternates**	**Grand Total**
Z3-WL-2L35-1C-UNV-22-T1	38	4	$ 313	$ 11,899.70	$ 1,252.60	$ 13,152.30
RM-WN-2L35-1C-UNV-11-G1	4		$ 251	$ 1,002.20	$ -	$ 1,002.20
TOTAL				**$ 12,901.90**	**$ 1,252.60**	**$ 14,154.50**
LEVITON	CONFERENCE ROOMS			**Core Total**	**Alternates**	**Grand Total**
LevNet # WSC04				$181.19		$181.19
LevNet# WSD01-001				$657.62		$657.62
Leviton # OSP20-0D0				$131.26		$131.26
LevNet #WSS0S-D2W				$305.04		$305.04
TOTAL				**$ 1,275.11**	**$ -**	**$ 1,275.11**
MATERIALS TOTAL				**$ 25,812.61**	*$ 3,100.60*	*$ 28,913.21*

Sincerely,

Henry Summers P.E., Project Manager
Enovity, Inc.

Cc: *Jonathan Soper, PE, Principal*
Justin Nagy, LEED AP, Marketing

Purchase Order

Date: April 10, 2012
Purchase Order No.: 0311.032.01
Quote no.: via e-mail

Payee: Independent Electric Supply
Address: 1575 Burke Avenue
San Francisco, CA 94124

Contact: Marc Reisfelt
Phone no.: 415-734-4701
Fax no.: 415-734-4789

Deliver to: US. General Services Administration
Address 630 Sansome Street Room 1040
San Francisco, CA 94111
Attention: Opelia Opelinia
Phone no.: 415-844-5006

Request By	*Approved by*	*Project name*	*Project number*	*Lead Time*
Zinovy Gutman	Jonathan Soper	630 Sansome LED Install	311.032	n/a

Qty	*UOM*	*Description*	*Price per Unit*	*Amount*
26	Unit	Cree CR-32L-40K-10V LED lighting Fixtures	$234.00	$6,084.00

Subtotal	$6,084.00
Shipping	n/a
Taxes 8.5%	$517.14
Total	**$6,601.14**

Please remit confirmation to:
Zinovy Gutman
zgutman@enovity.com
415-974-0390 ext 120
415-279-7002 cell

Purchase Order

Date: April 20, 2012
Purchase Order No.: 0311.032.01A
Quote no.: dated 4/19/2012

Payee: Adura Technologies
Address: 22 4th Street, Fl 10
San Francisco, CA 94103

Contact: Alex Do
Phone no.: 415-547-8143
Fax no.: 415-543-8101

Deliver to: US. GSA
Address 630 Sansome Street
Room 1040
San Francisco, CA 94111
Attention: Opelia Opelinia
Phone no.: 415-844-5006

Request By	*Approved by*	*Project name*	*Project number*	*Lead Time*
Zinovy Gutman	Jonathan Soper	630 Sansome LED Install	311.032	n/a

Item	*Qty*	*Description*	*Amount*
Adura Hardware			$5,012.85
	54	Adura Light Controllers - One Relay Dimming Knock-Out - LC1RD-KO (may be substituted with LC-1RD for factory installation)	
	6	Adura Sensor Interface - (SIAC-L2)	
	2	Adura Sensor Interface - (SIAC-EN)	
	1	Adura Gateway	
Third Party Hardware			$1,200.00
	13	Leviton EnOcean Switch - (WSS0S-D)	
	5	Leviton EnOcean PIR - (WSC04-IRW)	
	1	Cellular Router - GradePoint CBR450 w/Verizon USB	
		Subtotal	$6,212.85
		Taxes 8.5%	$528.09
Adura Design and System Startup			$751.29
Adura Annual Software License			$255.00
		Total	**$7,747.23**

Please submit Invoices to:
Enovity Inc.
100 Montgomery Street, Suite 600, San Fransisco CA94104
Zinovy Gutman
zgutman@enovity.com
415-974-0390 ext 120
415-279-7002 cell

APPENDIX I. SURVEYS

The Light Right Survey

Logged in as siobhan_mccabe@emcorgroup.com Log Out Help

«Back to Survey Submissions

Survey Report - PG&E Lighting Controls Project at GSA

INTRODUCTION

The Light Right lighting satisfaction survey tool is a free resource for building owners, operators, or researchers to use to determine building occupants' lighting satisfaction, diagnose existing or potential problems, and improve indoor lighting quality.

The Light Right Survey Tool is intended to help users make more informed decisions about lighting upgrades, including how to combine quality improvements with energy-saving strategies. This report is broken out into 7 sections:

1. **Survey Sample Statistics:** Describe the demographics of the survey sample, determine the validity of the survey, and report errors, if any.
2. **Human Factors Considerations:** Analyze occupant characteristics such as age, gender, primary job, type of workspace, etc. to highlight specific lighting considerations for your building occupants.
3. **Daylight & Views:** Identify your building occupants' accessibility to daylight and views and how they control their immediate daylighting environment, and assess their satisfaction with their daylighting access and controls.
4. **General Lighting:** Assess your building occupants' preference and satisfaction with their general lighting, including the overhead and task lighting systems.
5. **Controls:** Assess your building occupants' preference and satisfaction with the lighting controls being used.
6. **Light Levels:** Analyze your building occupants' ratings of light levels to perform various tasks, general atmosphere and uniformity on work surfaces.
7. **Image & Atmosphere:** Assess how well the lighting contributes to organizational image and the general lighted atmosphere in the workplace.

Section 1: SURVEY SAMPLE STATISTICS

This survey was specifically designed to assist survey managers in identifying problems with their lighting system. Depending on sample size and response rates, you will be able to view the results with varying degrees of confidence. The desired response rate that is referenced in the web application is intended to give you 90% confidence with a 15% margin of error. These calculations are based on the response rate for the question "Overall, is the lighting comfortable?" with the assumption that 70% of respondents would answer "yes." In order to establish statistical significance for any other question or groups of questions in this survey, separate statistical analyses are advised.

Generally, the more people that respond to the survey, the more confident you can be in the results. Keep in mind, however, that all questions are not mandatory and while you might have 100 respondents, that does not mean that every one of them answered each question. Cross-reference the raw data excel document that is available on your account at https://www.lightingsolutions.energy.gov/cls-survey to see how many people answered a specific question.

When drawing conclusions from this data, not only should the number of respondents be considered, but the demographics of the respondents. If the data is weighted heavily due to a non-response bias it will not be representative of the entire sample. Of the respondents, 50% are female and 50% are male. 25% are under the age of 30. Are these statistics representative of your building occupants?

Section 2: HUMAN FACTORS CONSIDERATIONS

People are a company's most valuable resource. There is a large cost associated with hiring and training employees, and while there are many considerations when it comes to achieving high levels of personnel retention, keeping your employees happy and comfortable is of the utmost importance. Research suggests a link between employee job satisfaction and their lighting (Boyce et. al, 2003).

50% of people spend more than six hours at their desk daily. In order to meet their visual needs and ensure that they are comfortable, lighting quality is of the utmost importance. Lighting quality issues are addressed later in this section, *Daylight and Views, and Image and Atmosphere*.

Visual Needs

Occupants that spend a lot of time filing and locating paper documents have more demanding visual needs than those that spend more time on their computer. These areas should be provided with higher ambient

light levels that are more uniform than for computer screen tasks alone. Because the visual tasks in these areas are most often on a vertical plane (such as the tab of a file folder), it also makes sense to provide more diffuse light that delivers vertical footcandles more effectively. Light reflected from light-colored surfaces is an effective means of delivering diffuse light, so adding some indirect lighting or washing a light-colored wall with light can be an excellent solution in printer and copier areas, file storage areas, and similar spaces in the office.

Table 2a: Type of Work and Office Type

	Private Office	Open Office	Other
Accounting/Financial Professional	0%	0%	0%
Administrative Professional	100%	0%	0%
Administrative Support/Clerical	0%	100%	0%
Engineer/Inspector	0%	0%	0%
Technical/Scientist	0%	0%	0%
Project or Program Manager	0%	0%	0%
Supervisor/Team Manager	0%	0%	0%

The visual needs of each of these job descriptions will vary from building to building. In some buildings, accounting professionals may be dealing with small-font numbers on paper, and need higher task lighting levels. Others may have no paper-based printouts at all. Technical/scientific staff may be reading gauges and markings on devices that are aided with specialized, directional lighting. Administrative professionals may be doing more filing work in addition to computer-based work. Managers may need lighting that makes faces readable. In order to appropriately identify and correct issues associated with the lighting system, there should be a familiarity with the type of visual work performed by each job description in order to identify potential lighting issues.

Demographics

To ensure that your building occupants' needs are being met, you will also need to understand who the building occupants are, and what their age groups are.

Lighting needs change as we grow older, and the aging eye needs higher light levels, better uniformity of horizontal light levels, and improved task contrast. Of the respondents, 25% are above the age of 50, which means providing sufficient light for the building's occupants is especially challenging and important.

One or more personal task lights should be provided to the over 50 population as well as any younger employees that have visual difficulties. Providing desktop task lights upon request is an effective way of increasing general occupant satisfaction. It also ensures that worker productivity will not be reduced because they are struggling to see their work clearly.

Visual Comfort and Glare

Glare can be discomfort directly experienced by the employee, usually from excessively bright luminaires or windows, or it can be a bright patch of light reflected from the computer screen and obscuring the screen

image. Glare issues can inhibit productivity and comfort, and corrections should be made to decrease glare.

Window Glare (of those experiencing glare)

Option	Percent
Direct	0
Reflected	0

Overhead Lighting Glare (of those experiencing glare)

Option	Percent
Direct - Local Overhead	0
Direct - Byond Workspace	0
Reflected	0

Task Lighting Glare (of those experiencing glare)

Option	Percent
Direct	100
Reflected	0

If window glare is reported, check to see if each individual employee can reorient their workstation so that they are not facing the bright window and that their computer screen is not facing the bright window (this usually means the direction of the employee's gaze toward the computer screen is parallel to the window). Alternatively, operable shading with horizontal blinds, mesh shades, drapes, etc. can successfully block glare from sun and sky. These should be considered before applying film to darken windows, since the film can make the office interior look gloomy, and even low-transmittance films cannot block glare from direct sun.

Direct glare from task lighting is a problem when the bright light source or lens is visible, but can be alleviated by shielding the source with an opaque vertical shield on the side facing the user. Sometimes the task light is mounted too high and is therefore putting light into the user's eyes rather than just the work surface. A desktop task light can be provided instead. Reflected glare from the task surface is known as a veiling reflection, and is only a serious issue if the occupant uses shiny paper such as glossy photos or magazine pages. Veiling reflections are most effectively remedied by changing the task light to one that is designed to redirect light parallel to the length of the task light, or turning off the fixed undercabinet task light and mounting a movable-head portable task fixture to the desk top instead.

Overhead glare is discomfort caused by overhead light fixtures. If an employee complains of glare and it is alleviated by the brim of a baseball cap, this may be the problem. It is caused by an excessively bright bare lamp or lens or reflective surface that is visible. The solution is to spread the light over a larger area by installing a diffusing lens in front of the bare lamp(s) or by reducing the output of the lamp so that the unit brightness is reduced. This can be done with a low-output fluorescent ballast or a dimming ballast, but do

this only if the Light Level section validates that occupants regard the lighting as being too bright in addition to glaring.

Discomfort glare also produces a painful reaction, but this comes from fixtures that are within the normal field of view (i.e. not looking upward). The cause is light fixtures that emit too much light at high angles, rather than directing most of their light downward (for a recessed fixture, straight down is considered 0°, and the ceiling line is 90°). Discomfort glare is usually caused by excessive light emitted from 60° up to 90°.

- Replace luminaires (ensure that appropriate light levels are being met and verify that the optical characteristics of the replacement luminaire are designed to minimize light emitted above 60°)
- If possible, replace the lens or louver with one that has better shielding. For example, standard prismatic lenses can be replaced with better-quality acrylic lenses designed for computer-screen-intensive areas. These lenses direct more light downward and less at high angles. Some parabolic louvers can be replaced with louvers with more cells, which will improve the shielding angle. It's best to install a few of them and verify that they will work, before committing to a large quantity order.

Section 3: DAYLIGHT AND VIEWS

Access to daylight and a view can play a role in job satisfaction, and therefore employee retention.

Do you like the view from the window? (of those with access to an outdoor view)

Like the view	50%
Do NOT like the view	50%

50% of respondents do not have access to a view. Consider changing the space layout to improve daylighting accessibility. This can be done by locating circulation space along the window walls so that employees have a view out as they go for meetings or coffee breaks. Secondary circulation space can run perpendicular to the windows, allowing employees to look out from their workstations down the aisle toward the windows. Run workstation spines perpendicular to the windows, and reduce non-spine workstation panel heights to 48", allowing staff to see windows even if they are 4 or 5 workstations in from the windows. Locate private offices in the center of the floor plan rather than along the window walls, giving more highly-populated open office areas priority for view. Consider transparent window glass in private offices and meeting rooms, with shades for darkening and privacy.

Shading and daylighting control

It is important to provide occupants access to daylighting and view when possible, and it is also vital to provide them with an effective means of controlling the daylight to mitigate potential glare. Daylight shading satisfaction will play a role in the occupant's overall satisfaction with the lighting system. The following set of charts will help determine if the daylight control system is well accepted.

Shading Types of Dissatisfied Occupants:

Manual blinds (e.g., Venetian blinds)	0%
Manual window shades (e.g., roller shades)	0%
Automatic blinds or shades	0%
Other (please specify)	0%
No shading control	0%

An appropriate shading system can help to decrease glare associated with daylight (see *Human Factors Considerations* section to determine if glare caused by daylight is a substantial problem). In addition, shading can either provide or inhibit the opportunity for daylight harvesting techniques to control the electric lighting.

If an automatic system is implemented, it should be noted that every building is different and an expert should be involved with commissioning and recommisisoning the system over the course of an entire year. Also, a system needs to be put in place where occupants can register a complaint and have it resolved quickly if there is an glare that they cannot control due to the automated nature of the shades.

Section 4: GENERAL LIGHTING

The chart below represents all of the survey respondents that shared their opinion about their overall comfort regarding the lighting system. If there are different overhead lighting systems in the building, it will be valuable to compare the level of comfort for each system. In addition to overhead lighting, task lighting and wall lighting both play a role in the overall comfort of the lighting system, so be sure to consider these multiple components if your occupants are expressing dissatisfaction.

Table 4a: Overhead Lighting Characterization

Table 4b: Task Lighting

Characterization

Task lighting is an extremely effective way to ensure sufficient light is being provided. There are, however, specific problems that can result from the use of task lighting. Reflected glare from computer screens, veiling reflections, direct glare, and high contrast ratios can all be caused by poor task lighting products or their positioning, so it is important to choose and install task lighting carefully. Ideally, bright lenses or lamps of the task light in use should not be visible to the workstation occupant, or the occupant''s neighbor. The light from the luminaire should be spread evenly across a large area of the desk so that it does not produce a bright pool of light. (High contrast variations in light can cause eye fatigue.) Finally, if the task light (especially an undercabinet light) also illuminates the workstation panel, this helps reduce contrast and softens shadows cast by hands and arms on the desktop.

The illumination of walls in an office environment also plays a role in the occupant's perception of the lighting system. Often, additional wall lighting is incorporated in the lighting system to reduce brightness contrast in the field of view (that is, help even out the lighting in a space in order to improve visual comfort), and produce the cheerful appearance that comes from lighted vertical surfaces. Dim walls or dark walls with sharp-edged light scallops on them may lead to a response that the space feels gloomy. Of the respondents that do not find the overall lighting system comfortable:

Section 5: CONTROLS

Overhead Lighting Controls

Lighting controls are a very important component of the lighting system. They provide great potential to save energy but can also greatly impact the acceptability of the lighting from the user's perspective. First, take a look at the following charts to understand the current lighting controls and the satisfaction associated with them.

Table 5a: Controls by Space Type

	Private Offices	Open Offices / High Partitions	Open Offices / Low Partitions	Other (please specify)
Switch at wall	50%	0%	50%	0%
Handheld remote	0%	0%	0%	0%
Interface at your computer	0%	0%	0%	0%
Automated system / controlled by building management	50%	0%	50%	0%
Other (please specify)	0%	0%	0%	0%

Energy saving controls need to be applied correctly in order to retain occupant satisfaction. Controls that give the occupants more flexibility can increase energy savings and should be incorporated into the system

if possible. Evaluate the capabilities of the current lighting controls and consider the following for the satisfaction of the occupants:

All buildings should have automatic shut-off- The implementation will depend on the specific building. Scheduling the lights to turn off after hours but still providing occupants with override switches allows you to meet this goal, if override switches are conveniently located and the circuiting of the lighting allows for overriding small areas of lights. Occupancy-based controls, especially in smaller enclosed spaces such as conference rooms or private offices can provide additional energy savings when these spaces are used intermittently during business hours. "Occupancy" sensors automatically turn ON and OFF, and "vacancy" sensors require users to turn the lights on but automatically switch lights off after the sensor detects no motion. Vacancy sensors generally save more energy than occupancy sensors. Consider implementing these technologies in private offices, meeting rooms, copy rooms, restrooms, kitchens, and storage spaces, for example. They can even be considered for some open office and corridor areas especially if output can be dimmed to a low level (not fully off).

Consider providing occupants with personal controls- Everybody has a different preference when it comes to light levels, and providing occupants the ability to control the light in their space has been demonstrated to improve job and environmental satisfaction among office workers (Veitch et. al) and to save energy where employees prefer lower light levels. In shared spaces, the implementation can be challenging because the light above one workstation may actually affect the light level at the adjacent workstation, so one person's choice may not suit his or her neighbor.

- Provide Individual Control- In private spaces provide multi-level switching or dimming controls at the wall. In open offices give occupants control over the light(s) immediately above them via handheld remote or control software that resides on their computer.
- Provide Automatic Controls- Spaces with good-quality daylight are opportunities for automatic energy savings in areas along the window walls. Multi-level switching or (preferably) dimming controls on luminaires within 15' of the window allow for dimming luminaires with a minimum of distraction to employees. An experienced professional should recommend the specification, location, and orientation of daylighting controls. Competent commissioning is essential for satisfactory operation.

Task Lighting Control Characterization and Satisfaction:

The different types of task lighting are represented in the bar chart below. Each task lighting type has controls associated with it and that is shown in the table below. For each task lighting type, see the pie charts that illustrate controls satisfaction. If there is a specific issue with lighting controls associated with a task lighting type it will be evident below

Section 6: LIGHT LEVELS

Achieving the appropriate light levels for the multitude of tasks that might be occurring in a space can be challenging. Here is a breakdown of according to the occupants of your building:

When occupants feel that the lighting is too bright for specific tasks, providing them control of the lights is the ideal way to ensure that they are comfortable. If the lighting is too dim for paper tasks or filing/locating files, task lighting might mitigate the issue. If there are complaints that it's difficult to read from a computer screen, then the problem lies in the screen size, resolution, or software graphic display, rather than the lighting. If there is not sufficient light for face-to-face conversations, or typing on a keyboard, it could indicate a need for changes in the general lighting system.

Providing appropriate light levels and uniformity are important to support occupant productivity. Of the occupants that responded to the survey, here is the range of opinions regarding work surface uniformity.

Section 7: IMAGE AND ATMOSPHERE

The lighting in a space can set a certain mood and contribute to occupant comfort or stress. Lighting also plays a major role in portraying an image of the company to both employees and outsiders.

Sometimes occupants will report flicker from fluorescent lamps, when the perception actually stems from overhead glare or a lighting system that is too-uniform and produces little shadowing that can add crispness or clarity to a lighted room. A test for this is to ask occupants to shield their eyes as though they are wearing a baseball cap. If the perception of "flicker" disappears, the culprit may be the overhead, too-uniform lighting system. This problem can be remedied by reducing the amount of overhead ambient lighting by delamping or installing low-output ballasts, adding task lighting to the workstation, and adding accent lighting or wallwashing to highlight surrounding walls.

If occupants do not feel that the general lighting is "nice looking," replacing the luminaires with more attractive, efficient luminaires is an option to improve the appearance of the system (this should involve a lighting professional's guidance). Or, consider reducing the amount of light emitted from overhead luminaires and adding task lighting to the desks, and accent lighting or wallwashing to the walls. This will make the space appear more visually stimulating without replacing the entire overhead lighting system.

"Room surface brightness" is a term which refers to the psychological response to light patterns and light levels on ceilings and walls. If walls and ceilings are dim, the space can feel gloomy and forbidding. If walls have an uneven pattern of light and shadow, especially if the top of the wall is dark, that can also contribute to a perception that the space is unpleasant. Room surface brightness is a combination of the distribution of the light fixture, the proximity of the light fixture to the wall, and the color of the wall. Sometimes repainting a large, dark-colored wall a lighter color can fix the problem. Sometimes washing a wall evenly with light or accenting artwork on the wall is the solution. Sometimes moving the luminaire to

within 2 or 3' of the wall will fix the situation.

A component of indirect lighting on a white ceiling can also increase perceived brightness, making the ceiling feel higher. If considering a new lighting system, a combination of uplight and direct light can be an energy-efficient solution that improves the cheerfulness of the space. There are other options as well, depending on the existing lighting system and its condition. Consult a lighting professional for specific recommendations.

Unnatural skin tone is usually related to the spectrum of the installed lamps. Light sources with a Color Rendering Index (CRI) greater than 80 should be installed at the next opportunity. High-performance fluorescent lamps have a high CRI value but are also more efficient in terms of Lumens-per-Watt, so it may be possible to replace the existing lamps with lower-wattage fluorescent lamps that will improve color quality while reducing energy use.

The color of emitted light (warm, neutral, cool, very cool, for example) can also affect the response to this question. Lamp color is measured in Correlated Color Temperature (CCT). "Warm" is generally around 3000K, neutral is in the range of 3500K to 4000K, cool ranges from 4000K to 5000K, and very cool is usually >5000K. The color temperature preference of the building occupants can be a guide to lamp selection and is represented in the following chart:

Color Appearance of Lighting By Fixture

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References

- Boyce, P. R., Veitch, J.A., Newsham, G. R., Myer, Michael, and Hunter, Claudia (2003). *Lighting Quality and Office Work: A Field Simulation Study.* PNNL-14506
- Farley, K.M.J.; Veitch, J.A. "A Room With A View: A Review of the Effects of Windows on Work and Well-Being", Research Report, Institute for Research in Construction, National Research Council

Canada, IRC-RR-36, 33 pages, 2001.

- Jennings, J, N Colak, and F Rubenstein (2001). *Occupancy and Time-Based Controls in Open Offices.* LBNL-47022
- Newsham, G.; Veitch, J.; Arsenault, C.; Duval, C. 2004. "Lighting for VDT Workstations 2: Effect of Control and Lighting Design on Task Performance, and Chosen Photometric Conditions" Research Report IRC-RR-166, Institute for Research in Construction, National Research Council Canada, Ottawa.
- Veitch, J.A.; Newsham, G.R. 2000. "Preferred luminous conditions in open-plan offices: research and practice recommendations," Lighting Research and Technology, 32, (4), pp. 199-212.
- Veitch, J and G Newsham. 1998. Lighting quality and energy-efficiency effects on task performance, mood, health, satisfaction and comfort. Journal of the Illuminating Engineering Society 27(1):107.
- Wright, Thomas A., and Staw, Barry M. "Affect and Favorable Work Outcomes: Two longitudinal Tests of the happy-productive worker theses." Journal of the Organizational Behavior 20 (1999).

FRANCISCO VEGA, ENOVITY 08/27/12

Installer Survey: 630 Sansome GSA Demonstration Project

1. Have you previously installed new fixtures that incorporate controls similar to the controls used at this installation? X Yes __No

2. Compared to installing new fixtures without dedicated controls, this installation was:
   __ **Simpler** than installing new fixtures without dedicated controls.
   __ **About the same** as installing new fixtures without dedicated controls.
   X **Slightly more difficult** than installing new fixtures without dedicated controls.
   __ **Significantly more difficult** than installing new fixtures without dedicated controls.

3. Did any situational elements **unrelated** to the technology (such as access, wiring, etc.) increase the difficulty of this installation relative to a "normal" installation? __Yes X No
   Please describe. _____

4. Did any situational elements **related** to the technology increase the difficulty of this installation relative to a "normal" installation? X Yes __No
   Please describe. we had to rewire each fixture to acomodate the ADURA controls.

5. Did the fixtures come with accurate installation instructions? X Yes __No

6. Did the controls come with accurate installation and programming instructions? X Yes __No

7. Were the fixtures received in good physical condition/working order? __Yes X No
   Describe any missing/broken/incomplete elements and how the manufacturer responded or reconciled, if applicable.
   one conelite fixture had a broken cover/ lens, but Conelite give us a replacement.

8. Were the controls received in good physical condition/working order? X Yes __No
   Describe any missing/broken/incomplete elements and how the manufacturer responded or reconciled, if applicable.

9. Please provide additional comments as applicable:

Continue on back of sheet.

PG&E Lighting Controls Project at GSA

Questions	Answers	Respondents with Other (3) (LED)	Respondents with Parabolic (1)	Respondents with other (0)
Which of the following most closely defines your job description?				
	Accounting / Financial Professional	0	0	0
	Administrative Professional	1	1	0
	Administrative Support / Clerical	2	0	0
	Engineer / Inspector	0	0	0
	Technical / Scientist	0	0	0
	Project or Program Manager	0	0	0
	Supervisor / Team Manager	0	0	0
What is your age?				
	30 or under	1	0	0
	31 - 40	0	0	0
	41 - 50	1	1	0
	Over 50	1	0	0
What is your gender?				
	Female	3	1	0
	Male	0	0	0
Which of the following best describes your personal workspace?				
	Enclosed private office	1	1	0
	Cubicles with partitions above standing eye level	0	0	0
	Cubicles with partitions below standing eye level	2	0	0
	Other (please specify)	0	0	0
What type of computer screen do you have?				
	Laptop	0	0	0
	Flat Panel Screen	3	1	0
	Traditional Screen (CRT)	0	0	0
	Other (please specify)	0	0	0
On a typical day, how long are you in your personal workspace?				
	More than 6 hours	2	0	0
	4-6 hours	1	1	0
	2-4 hours	0	0	0
	Less than 2 hours	0	0	0
Are you able to see out a window while sitting in your workspace?				
	Yes	3	1	0
	No	0	0	0

Questions	Answers	Respondents with Other (3) (LED)	Respondents with Parabolic (1)	Respondents with other (0)
Do you like the view?				
	Yes	1	1	0
	No	2	0	0
Do you sit adjacent to the window?				
	Yes	3	0	0
	No	0	1	0
Which primary direction does your window face?				
	North	0	0	0
	East	0	0	0
	South	1	0	0
	West	0	0	0
	Do not know	2	1	0
Which of the following most closely resembles the overhead lighting in your immediate work space?				
	Fixture 1	3	0	0
	Fixture 2	0	1	0
	Fixture 3	0	0	0
	I don't see my fixture here.	0	0	0
Overall, is the lighting comfortable?				
	Yes	3	1	0
	No	0	0	0
Do you have task lighting?				
	Yes	1	0	0
	No	2	1	0
Which of the following types of lighting fixtures most closely resembles the task lighting in your personal workspace?				
	Undercabinet task light	0	0	0
	Desktop task light	1	0	0
What type of control do you have for your task lighting?				
	On/Off switch	1	0	0
	Dimmer switch	0	0	0
	Other (please specify)	0	0	0
	Does not apply	0	0	0
Which of the following most closely resembles the lighting on the walls or partitions in your immediate office area.				
	Uniformly bright walls	1	0	0
	Uneven light distribution on walls	0	0	0
	Accent lighting on artwork only	0	0	0
	Walls are dim	1	0	0
	Other	0	0	0
	Do not know	1	1	0

Questions	Answers	Respondents with Other (3) (LED)	Respondents with Parabolic (1)	Respondents with other (0)
Do the overhead lighting fixtures in your workspace turn on automatically (when you enter the space, on a set schedule, or both)?				
	Yes	2	1	0
	No	1	0	0
	Do not know	0	0	0
Do the overhead lighting fixtures in your workspace turn off automatically (when you leave the space, on a set schedule, or both)?				
	Yes	3	1	0
	No	0	0	0
	Do not know	0	0	0
If your lights turn off automatically, can you turn them back on from your immediate work area?				
	Yes	3	0	0
	No	0	1	0
	Do not know	0	0	0
Can you control the overhead lights in your personal workspace without changing the lights in neighboring areas?				
	Yes	1	0	0
	No	1	1	0
	Do not know	1	0	0
How are your overhead lights controlled (check all that apply)?				
	Switch at wall	2	0	0
	Handheld remote	0	0	0
	Interface at your computer	0	0	0
	Automated system / controlled by building management	1	1	0
	Other (please specify)	0	0	0
	Do not know / Does not apply	0	0	0
To what extent can light levels from your overhead lights be adjusted?				
	Lights turn on and off only	0	1	0
	Light level settings are available for high, low, and/or medium	1	0	0
	Continuous dimming available	2	0	0
Do you notice the brightness of the overhead lights changing automatically?				
	Yes	0	0	0
	No	2	1	0
	Do not know	1	0	0

Questions	Answers	Respondents with Other (3) (LED)	Respondents with Parabolic (1)	Respondents with other (0)
Does the change in brightness bother you?				
	Yes	0	0	0
	No	0	0	0
	Do not know	0	0	0
What type of shading system do you have to control the amount of daylight entering your windows?				
	Manual blinds (e.g., Venetian blinds)	2	0	0
	Manual window shades (e.g., roller shades)	0	0	0
	Automatic blinds or shades	0	0	0
	Other (please specify)	0	0	0
	No shading control	1	1	0
	I have no daylight in my workspace	0	0	0
Can you control the amount of daylight entering your windows without affecting other occupants?				
	Yes	2	0	0
	No	0	0	0
I am satisfied with my ability to control my overhead lighting.				
	Strongly Disagree	0	0	0
	Disagree	0	0	0
	Neutral	1	0	0
	Agree	2	1	0
	Strongly Agree	0	0	0
	Does not apply	0	0	0
I am satisfied with my ability to control my task lighting.				
	Strongly Disagree	0	0	0
	Disagree	0	0	0
	Neutral	1	0	0
	Agree	0	0	0
	Strongly Agree	0	0	0
	Does not apply	2	1	0
I am satisfied with my ability to control my window shades or blinds.				
	Strongly Disagree	0	0	0
	Disagree	0	0	0
	Neutral	1	0	0
	Agree	0	0	0
	Strongly Agree	1	0	0
	Does not apply	1	1	0

Questions	Answers	Respondents with Other (3) (LED)	Respondents with Parabolic (1)	Respondents with other (0)
My work surface is evenly lighted without very bright or dim spots.				
	Strongly Disagree	0	0	0
	Disagree	1	0	0
	Neutral	0	1	0
	Agree	2	0	0
	Strongly Agree	0	0	0
	Does not apply	0	0	0
The lights flicker throughout the day.				
	Strongly Disagree	2	0	0
	Disagree	1	0	0
	Neutral	0	0	0
	Agree	0	1	0
	Strongly Agree	0	0	0
	Does not apply	0	0	0
My skin is an unnatural tone under the lighting.				
	Strongly Disagree	1	0	0
	Disagree	1	0	0
	Neutral	1	0	0
	Agree	0	0	0
	Strongly Agree	0	0	0
	Does not apply	0	1	0
The lighting fixtures in the general office area around my workspace are nice-looking.				
	Strongly Disagree	0	0	0
	Disagree	0	0	0
	Neutral	0	0	0
	Agree	2	1	0
	Strongly Agree	1	0	0
	Does not apply	0	0	0
The lighting helps create a good image for the organization.				
	Strongly Disagree	0	0	0
	Disagree	0	0	0
	Neutral	0	0	0
	Agree	2	1	0
	Strongly Agree	1	0	0
	Does not apply	0	0	0

Questions	Answers	Respondents with Other (3) (LED)	Respondents with Parabolic (1)	Respondents with other (0)
The room surfaces (walls, ceilings) have a pleasant brightness.				
	Strongly Disagree	0	0	0
	Disagree	0	0	0
	Neutral	0	0	0
	Agree	2	1	0
	Strongly Agree	1	0	0
	Does not apply	0	0	0
Paper Tasks (reading and writing)				
	Much Too Bright	0	0	0
	Too Bright	0	0	0
	Just Right	3	1	0
	Too Dim	0	0	0
	Much Too Dim	0	0	0
	Does not apply	0	0	0
Reading from a computer screen				
	Much Too Bright	0	0	0
	Too Bright	0	0	0
	Just Right	3	1	0
	Too Dim	0	0	0
	Much Too Dim	0	0	0
	Does not apply	0	0	0
Typing on keyboard				
	Much Too Bright	0	0	0
	Too Bright	0	0	0
	Just Right	3	1	0
	Too Dim	0	0	0
	Much Too Dim	0	0	0
	Does not apply	0	0	0
Filing or locating papers				
	Much Too Bright	0	0	0
	Too Bright	0	0	0
	Just Right	3	1	0
	Too Dim	0	0	0
	Much Too Dim	0	0	0
	Does not apply	0	0	0
Face to face conversations				
	Much Too Bright	0	0	0
	Too Bright	0	0	0
	Just Right	3	1	0
	Too Dim	0	0	0
	Much Too Dim	0	0	0
	Does not apply	0	0	0

Questions	Answers	Respondents with Other (3) (LED)	Respondents with Parabolic (1)	Respondents with other (0)
Glare reflected from your work surface				
	Never	1	0	0
	Rarely	2	1	0
	Sometimes	0	0	0
	Often	0	0	0
	Always	0	0	0
Glare from the light fixtures reflected on your computer screen				
	Never	1	0	0
	Rarely	2	1	0
	Sometimes	0	0	0
	Often	0	0	0
	Always	0	0	0
Glare from the window reflected on your computer screen				
	Never	1	0	0
	Rarely	2	1	0
	Sometimes	0	0	0
	Often	0	0	0
	Always	0	0	0
Glare from the overhead lighting in your immediate workspace (usually experienced as discomfort)				
	Never	1	1	0
	Rarely	2	0	0
	Sometimes	0	0	0
	Often	0	0	0
	Always	0	0	0
Direct glare from the light fixtures beyond your immediate workspace (the light fixtures appear too bright)				
	Never	1	0	0
	Rarely	2	1	0
	Sometimes	0	0	0
	Often	0	0	0
	Always	0	0	0
Glare from your task lighting				
	Never	0	1	0
	Rarely	1	0	0
	Sometimes	0	0	0
	Often	0	0	0
	Always	2	0	0
Direct glare from a window				
	Never	1	0	0
	Rarely	2	1	0
	Sometimes	0	0	0
	Often	0	0	0
	Always	0	0	0

Questions	Answers	Respondents with Other (3) (LED)	Respondents with Parabolic (1)	Respondents with other (0)
What is the color appearance of the lighting in your personal workspace?				
	Very Warm	0	0	0
	Somewhat Warm	1	0	0
	Neutral	1	1	0
	Somewhat Cool	1	0	0
	Very Cool	0	0	0
	Do not know	0	0	0
What would you prefer for the color appearance of the lighting in your personal workspace?				
	Very Warm	0	0	0
	Somewhat Warm	1	0	0
	Neutral	2	0	0
	Somewhat Cool	0	1	0
	Very Cool	0	0	0
	Do not know	0	0	0
Please feel free to submit any other comments about your lighting below:				
		In the beginning of the lighting installation, the lights were extremely bright. Yet, it never bothered me either way whether or not there was light or not since I had a window that projected light from outside into my office. Also, we were told that the lights would automatically shutoff when you left your office for a long period of time, but it never came back on due to Title 24. However, if we adjusted the lights to a certain level and clicked the switch, the lights would not revert back to the level we changed it to. That has since been corrected.		

Questions	Answers	Respondents with Other (3) (LED)	Respondents with Parabolic (1)	Respondents with other (0)
Please feel free to submit any other comments about this survey below:				
		I love this type of lighting for our offices and I would like to hope that we could eventually retrofit the entire building a phase at a time for energy sustainability, the convenience in purchasing light bulbs that were uniform throughout and were less-expensive. I know there are many tenants at 630 Sansome and 555 Battery who constantly request that we de-lamp their light fixtures since they're sensitive to the brightness. This type of lighting would alleviate that problem in the future for people without affecting other adjacent employees.		

The Light Right Survey

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Survey Report - PG&E Lighting Controls Project at GSA

All questions are optional, so group responses may not add up to 100%.

	Other (LED)	Parabolic
	3 responses	1 responses
Lighting is comfortable	100%	100%
Lighting is not comfortable	0%	0%
DEMOGRAPHICS		
Accounting/Financial Professional	0%	0%
Administrative Professional	33%	100%
Administrative Support/Clerical	66%	0%
Engineer/Inspector	0%	0%
Technical/Scientist	0%	0%
Project or Program Manager	0%	0%
Supervisor/Team Manager	0%	0%
Age: 30 or under	33%	0%
Age: 31 - 40	0%	0%
Age: 41 - 50	33%	100%
Age: Over 50	33%	0%
Female	100%	100%
Male	0%	0%
GENERAL LIGHTING		
Control overhead lights using switch at wall	66%	0%
Control overhead lights using handheld remote	0%	0%
Control overhead lights using interface at your computer	0%	0%
Control overhead lights using automated system/controlled by building management	33%	100%
Control overhead lights using other methods	0%	0%
Overhead lights turn on and off only	0%	100%
Overhead light levels settings are available for high, low and/or medium	33%	0%
Continuous dimming is available for overhead lights	66%	0%
Satisfied with my ability to control my overhead lighting	66%	100%
Neutral with my ability to control my overhead lighting	33%	0%
Dissatisfied with my ability to control my overhead lighting	0%	0%
TASK LIGHTING		

Has task lighting	33%	0%
Has undercabinet task lighting	0%	0%
Has desktop task lighting	33%	0%
No task lighting	66%	100%
Control task lighting using On/Off switch	33%	0%
Control task lighting using Dimmer switch	0%	0%
Control task lighting using other	0%	0%
Satisfied with my ability to control my task lighting	0%	0%
Neutral with my ability to control my task lighting	33%	0%
Dissatisfied with my ability to control my task lighting	0%	0%
DAYLIGHTING AND VIEWS		
See out a window while sitting in your workspace	100%	100%
Sit adjacent to a window	100%	0%
North is the primary direction my window faces	0%	0%
East is the primary direction my window faces	0%	0%
South is the primary direction my window faces	33%	0%
West is the primary direction my window faces	0%	0%
I do not know the primary direction my window faces	66%	100%
Satisfied with the view	33%	100%
Dissatisfied with the view	66%	0%
Control daylight using manual blinds	66%	0%
Control daylight using manual window shades	0%	0%
Daylight is controlled by automated blinds or shades	0%	0%
Daylight is controlled by some other method	0%	0%
Daylight entering workspace is not controlled	33%	100%
Satisfied with ability to control window shades or blinds	33%	0%
Neutral with ability to control window shades or blinds	33%	0%
Dissatisfied with ability to control window shades or blinds	0%	0%

The Light Right Survey Example

PRIVACY STATEMENT

This survey is being conducted to determine occupant preferences about office lighting. The information gathered may be used by employers or facility managers to make informed choices about lighting, and to improve the state of knowledge about lighting and worker satisfaction.

ABOUT THIS SURVEY

Responses are anonymous — Your responses to this on-line survey will be sent directly to the survey administration company server which is not associated with and cannot be accessed by your employer. This ensures that your specific responses will never be available to the organization or individuals that you work for. Your responses will only be available as aggregated group information. Participation is Voluntary — This survey is entirely voluntary, and you are free to choose at any time whether or not to provide responses to the survey or individual questions. Your Rights — If you have questions about your rights as a participant of this research survey or this website, please email the Institutional Review Board at Pacific Northwest National Laboratory. A research specialist will respond to your question promptly.

Start Survey

The Light Right Survey Example

Overall Survey Progress:

Introduction

Which of the following best describes the type of work that you do?

- ○ People management, leadership, and/or training
- ○ Computer aided design, engineering, or software development
- ○ Combination of computer work, paper tasks, phone calls and meetings
- ○ Facility management
- ○ Other

What is your age?

- ○ 30 or under
- ○ 31 - 40
- ○ 41 - 50
- ○ Over 50

What is your gender?

- ○ Female
- ○ Male

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The Light Right Survey Example

Overall Survey Progress:

Personal Workspace Information

Which of the following best describes your personal workspace?

- ○ Enclosed private office
- ○ Cubicles with partitions above standing eye level
- ○ Cubicles with partitions below standing eye level
- ○ Other (please specify)

What type of computer screen do you have?

- ○ Laptop
- ○ Flat Panel Screen
- ○ Traditional Screen (CRT)
- ○ Other (please specify)

On a typical day, how long are you in your personal workspace?

- ○ More than 6 hours
- ○ 4-6 hours
- ○ 2-4 hours
- ○ Less than 2 hours

Are you able to see out a window while sitting in your workspace?

- ○ Yes
- ○ No

Do you like the view?

- ○ Yes
- ○ No

Do you sit adjacent to the window?

- ○ Yes
- ○ No

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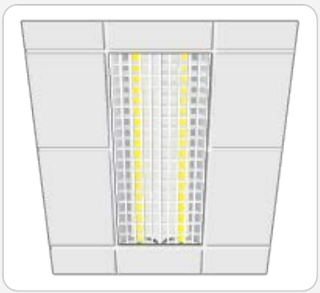
The Light Right Survey Example

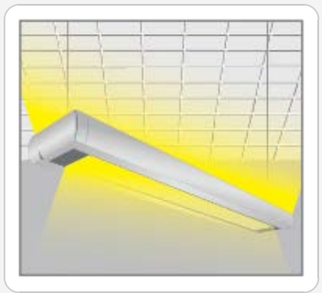
Overall Survey Progress:

Overhead Lighting

Which of the following most closely resembles the overhead lighting in your immediate work space?

(Click on the image to make your selection)





- ○ I don't see my fixture here.

Overall, is the lighting comfortable?

- ○ Yes
- ○ No

Task Lighting

Do you have task lighting?

- ○ Yes
- ○ No

Which of the following types of lighting fixtures most closely resembles the task lighting in your personal workspace?

- ☐ Undercabinet task light
- ☐ Desktop task light

What type of control do you have for your task lighting?

- ○ On/Off switch
- ○ Dimmer switch
- ○ Other (please specify)
- ○ Does not apply

Wall Lighting

Which of the following most closely resembles the lighting on the walls in your general office area?

- ○ Uniformly bright walls
- ○ Uneven light distribution on walls
- ○ Accent lighting on artwork only
- ○ Walls are dim
- ○ Other
- ○ Do not know

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The Light Right Survey Example

Overall Survey Progress:

Overhead Lighting Controls

Do the overhead lighting fixtures in your workspace turn on automatically (when you enter the space, on a set schedule, or both)?

- ○ Yes
- ○ No
- ○ Do not know

Do the overhead lighting fixtures in your workspace turn off automatically (when you leave the space, on a set schedule, or both)?

- ○ Yes
- ○ No
- ○ Do not know

If your lights turn off automatically, can you turn them back on from your immediate work area?

- ○ Yes
- ○ No
- ○ Do not know

Can you control the overhead lights in your personal workspace without changing the lights in neighboring areas?

- ○ Yes
- ○ No
- ○ Do not know

How are your overhead lights controlled (check all that apply)?

- ☐ Switch at wall
- ☐ Handheld remote
- ☐ Interface at your computer
- ☐ Automated system / controlled by building management
- ☐ Other (please specify)
- ☐ Do not know / Does not apply

To what extent can light levels from your overhead lights be adjusted?

- ○ Lights turn on and off only
- ○ Light level settings are available for high, low, and/or medium
- ○ Continuous dimming available

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The Light Right Survey Example

Overall Survey Progress:

Window Shade Controls

What type of shading system do you have to control the amount of daylight entering your windows?

- ○ Manual blinds (e.g., Venetian blinds)
- ○ Manual window shades (e.g., roller shades)
- ○ Automatic blinds or shades
- ○ Other (please specify)
- ○ No shading control
- ○ I have no daylight in my workspace

Can you control the amount of daylight entering your windows without affecting other occupants?

- ○ Yes
- ○ No

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The Light Right Survey Example

Overall Survey Progress:

To what extent do you agree or disagree with the following statements about the lighting in your personal workspace?

	STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE	DOES NOT APPLY
I am satisfied with my ability to control my overhead lighting.	○	○	○	○	○	○
I am satisfied with my ability to control my task lighting.	○	○	○	○	○	○
I am satisfied with my ability to control my window shades or blinds.	○	○	○	○	○	○

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The Light Right Survey Example

Overall Survey Progress:

To what extent do you agree or disagree with the following statements about the lighting in your personal workspace?

	STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE	DOES NOT APPLY
My work surface is evenly lighted without very bright or dim spots.	○	○	○	○	○	○
The lights flicker throughout the day.	○	○	○	○	○	○
My skin is an unnatural tone under the lighting.	○	○	○	○	○	○

To what extent do you agree or disagree with the following statements about the lighting in your general office area?

	STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE	DOES NOT APPLY
The lighting fixtures in the general office area around my workspace are nice-looking.	○	○	○	○	○	○
The lighting helps create a good image for the organization.	○	○	○	○	○	○
The room surfaces (walls, ceilings) have a pleasant brightness.	○	○	○	○	○	○

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The Light Right Survey Example

Overall Survey Progress:

How would you rate the lighting in your workspace for each of the following tasks?

	MUCH TOO BRIGHT	TOO BRIGHT	JUST RIGHT	TOO DIM	MUCH TOO DIM	DOES NOT APPLY
Paper Tasks (reading and writing)	○	○	○	○	○	○
Reading from a computer screen	○	○	○	○	○	○
Typing on keyboard	○	○	○	○	○	○
Filing or locating papers	○	○	○	○	○	○
Face to face conversations	○	○	○	○	○	○

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The Light Right Survey Example

Overall Survey Progress:

How often do you experience any of the following conditions when in your personal workspace during an average day? For the purpose of answering these questions, consider the definition of glare to be unwanted light, i.e., loud noise is to sound, as glare is to light.

	NEVER	RARELY	SOMETIMES	OFTEN	ALWAYS
Glare reflected from your work surface	○	○	○	○	○
Glare from the light fixtures reflected on your computer screen	○	○	○	○	○
Glare from the window reflected on your computer screen	○	○	○	○	○
Glare from the overhead lighting in your immediate workspace (usually experienced as discomfort)	○	○	○	○	○
Direct glare from the light fixtures beyond your immediate workspace (the light fixtures appear too bright)	○	○	○	○	○
Glare from your task lighting	○	○	○	○	○
Direct glare from a window	○	○	○	○	○

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The Light Right Survey Example

Overall Survey Progress:

Lighting comes in a range of colors, from a "warm" white to "cool" white. "Warm" light is often described as slightly yellow in appearance, and "cool" light is often described as slightly blue in appearance. Using the indicated color range, please indicate:

	VERY WARM	SOMEWHAT WARM	NEUTRAL	SOMEWHAT COOL	VERY COOL	DO NOT KNOW
What is the color appearance of the lighting in your personal workspace?	○	○	○	○	○	○
What would you prefer for the color appearance of the lighting in your personal workspace?	○	○	○	○	○	○

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The Light Right Survey Example

Overall Survey Progress:

If you could change the lighting in your office, what would you do? Please check all that apply.

- ☐ Change the location of the overhead lighting fixtures relative to your workstation
- ☐ Make the overhead lighting fixtures produce more light
- ☐ Make the overhead lighting fixtures produce less light
- ☐ Make the overhead lighting fixtures less glary
- ☐ Change the aesthetic appearance of the lighting fixtures
- ☐ Change the color appearance of the light produced by the lighting fixtures
- ☐ Add a task light
- ☐ Be able to control the brightness/light output of the overhead lighting fixtures with a dimmer or high/low switch
- ☐ Get better access to a window view
- ☐ Get better access to daylight
- ☐ Have light bulbs replaced faster when they burn out and fixtures repaired faster when they break
- ☐ I would not change anything

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The Light Right Survey Example

Overall Survey Progress:

Comments

Please feel free to submit any other comments about your lighting below:

Please feel free to submit any other comments about this survey below:

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Submit Survey