A Lighting Revolution
An Evolution of Thought

Managing Effective Circadian Lighting Strategies

The Benefits of Human-Centric Circadian Lighting Design

- Increased alertness in the morning.
- Productivity and concentration improvements.
- Improved mood.
- Reduced hyperactivity.
- Reduction in errors and accidents.
- Faster cognitive processing.
- Improved sleep.
- Overall Health Benefits Include:
  - Reduced Incidents of Diabetes
  - Reduced Incidents of Obesity
  - Reduced Cancer Cell Proliferation
  - Improved Cardiovascular Fitness

The Benefits of Distributed Building Intelligence

- Increased Overall Building Efficiency
- Decreased Energy Consumption
- Improved Occupant Health and Productivity
- Decreased Maintenance Costs
- Equipment Failure Predictability
- Increased Equipment Life Span
- Improved Decision-Making with Aggregated Analytics Data
- Networking of Multiple Buildings and Multiple Sites
- Reduced Environmental Impact
- Increased Reliability
- Access to Resiliency Strategies
- Accelerated Recovery from Catastrophic Events

OPIX SYSTEMS

Open Protocol Integrated Exchange

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Low-Voltage Distributed Lighting Intelligence

cX Network Application Server

Complete Integrated Building Automation Solution

From Utility to Building

Renewable Sources

Resiliency

Deployment of localized renewable-source micro-grid provides for rapid recovery from catastrophic events such as hurricanes, floods, seismic events, forest fires, and acts of terrorism or war.

Power Inverter

48VDC Low Voltage Bus

Peripheral Devices

- Wall Switches, Dimmers, Occupancy Sensors
- Temperature, CO2, Humidity Sensors, etc.
- Wired and EnOcean Wireless

Network Interface

Communication Network

SS-1210 Multi-Channel LED Driver

- 12 Independent Output Channels
- Up to 1.5A/Channel Output
- Up to 10 Universal Inputs
- On-Board Watt Meter
- Enocean Wireless Connectivity
- Up to 40 Controllers per Server

Circadian Driver-Less LED Luminaire

- Flat Panel Technology
- Individually Dimmable to <5%
- Individually Tunable or Fixed Color
- Sizes: 2x2, 2x4, 1x4
- Up to 12 LED Engines/Controller

Network Interface

Fully Programmable I/O Devices

- Air Handling Units
- Heat Pumps
- Roof Top Units
- Single Duct VAV Terminal Units
- Fan Powered Terminal Units
- Multi-Zone VVT
- BTU Meter

Plug-n-Play Configurable Devices

- Multi-Zone VVT
- Fan Coil Units
- Unit Ventilators
- Exhaust Fans
- Chiller Plants
- Boiler Plants
- General Monitoring

- On-Demand Load Shedding
- Pumps/Sequencing
- Light Industrial
- Air Compressor Automation
- Custom Applications
- Interior Lighting
- Exterior Lighting

100% Customizable Front-End HMI Solution

- Unlimited Users
- Unlimited Schedules
- Unlimited Alarms
- Unlimited Trends
- 10+ Year Trend Aggregation/ Storage
- Aggregated Analytics/Reporting
- Email/SMS Alarm Notification
- Static + Animated Graphics Library
- Protocol Neutral
- Protocol Translation
- Enterprise Scalability
- Enterprise Integration
- No 'Lite' Versions

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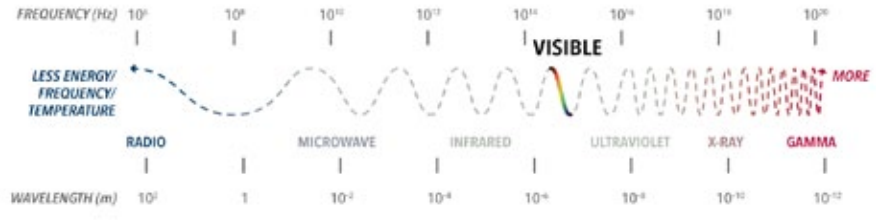
What is the Circadian Rythm, and Why is it Important?

All forms of life on earth operate on a 24-hour internal clock that is always running in the background and cycles between sleepiness and alertness at regular intervals. It's also known as your sleep/wake cycle.
However, over the past century humans have been in a transition from the outdoor workspace to the indoor workspace. The constant exposure to environments that are poorly lit by grossly inferior lighting technologies (flourescent, incandescent, halgen, etc.), have resulted in physiological maladies of epidemic proportions that are only now beginning to be fully understood.

Light

Portion of the electromagnetic spectrum visible to the human eye. Refers to wavelengths between roughly 380 nm and 750 nm. UV is outside of that range.



Responses to Light

1. Image formation and color perception.
2. Calibration of the body's biological clock and circadian rhythms.
3. Direct effects on alertness, mood and cognition.

Properties of Light: Circadian System

- Timing
  - Phase advance: exposure in late night or early in the day
  - Phase delay: exposure in the day or early night
- Intensity
  - Non-linear relationship between intensity and the magnitude of the effect instigated
- Duration
  - Non-linear relationship between duration and magnitude of effect
- Pattern
  - Bright light pulses can be nearly as effective as continuous light exposure
- Light History
  - Recent light exposure moderately desensitizes responses induced by subsequent light stimuli, and vice versa
- Wavelength / Spectrum
  - 480 nm light is very effective at phase shifting, suppressing melatonin, and alerting the brain

Direct Effects of Light

- Light is an acute stimulant that directly affects the brain, during day or night
  - Higher subjective ratings of alertness
  - Changes in EEG brain activity patterns that indicate a more alert state
  - Improvements in cognitive tests
  - fMRI studies show activation of brain areas that mediate alertness (thalamus and brainstem)
  - Some fMRI studies have shown activation the brain area that helps to regulate mood (amygdala)
- Short-wavelength light will improve multiple markers of alertness more than longer wavelength light

"Melanopic Lux" vs. Photopic Lux

Equivalent Melanopic Lux = Photopic Lux x Melanopic Ratio

Melanopic Ratio depends on the light source's specific SPD, which is influenced by lamp type (fluorescent, LED, halogen, etc.) and color temperature (in K).

CCT (K)	Light Source	Ratio
2950	Fluorescent	0.43
2700	LED	0.45
2800	Incandescent	0.54

CCT (K)	Light Source	Ratio
4000	Fluorescent	0.58
4000	LED	0.76
5450	CIE E (Equal Energy)	1.00

CCT (K)	Light Source	Ratio
6500	Fluroscent	1.02
6500	Daylight	1.10
7500	Fluorescent	1.11

OPIXSYSTEMS

8174 S. Las Vegas Blvd. Suite 109
Las Vegas, NV89123

+1 (702) 550-1044
WWW.OPIXSYS.COM