



LIGHTING PRACTICE: LIGHTING CONTROL SYSTEMS – PROPERTIES, SELECTION, AND SPECIFICATION

AN AMERICAN NATIONAL STANDARD



This is a preview. Click here to purchase the full publication.

www.ies.org

ANSI/IES LP-6 20

**LIGHTING PRACTICE:
LIGHTING CONTROL SYSTEMS –
PROPERTIES, SELECTION, AND SPECIFICATION
AN AMERICAN NATIONAL STANDARD**

Publication of this document
has been approved by IES.
Suggestions for revisions
should be directed to IES.

**Prepared by
The IES Lighting Control Systems Committee**

This is a preview. [Click here to purchase the full publication.](#)



Copyright 2020 by the Illuminating Engineering Society.

Approved by the IES Standards Committee May 27, 2020 as a Transaction of the Illuminating Engineering Society.

Approved May 28, 2020 as an American National Standard.

All rights reserved. No part of this publication may be reproduced in any form, in any electronic retrieval system or otherwise, without prior written permission of the IES.

Published by the Illuminating Engineering Society, 120 Wall Street, New York, New York 10005.

IES Standards are developed through committee consensus and produced by the IES Office in New York. Careful attention is given to style and accuracy. If any errors are noted in this document, please forward them to Brian Liebel, Director of Standards, at standards@ies.org or the above address for verification and correction. The IES welcomes and urges feedback and comments.

Printed in the United States of America.

ISBN# 978-0-87995-393-5

DISCLAIMER

IES publications are developed through the consensus standards development process approved by the American National Standards Institute. This process brings together volunteers representing varied viewpoints and interests to achieve consensus on lighting recommendations. While the IES administers the process and establishes policies and procedures to promote fairness in the development of consensus, it makes no guaranty or warranty as to the accuracy or completeness of any information published herein.

The IES disclaims liability for any injury to persons or property or other damages of any nature whatsoever, whether special, indirect, consequential or compensatory, directly or indirectly resulting from the publication, use of, or reliance on this document.

In issuing and making this document available, the IES is not undertaking to render professional or other services for or on behalf of any person or entity. Nor is the IES undertaking to perform any duty owed by any person or entity to someone else. Anyone using this document should rely on his or her own independent judgment or, as appropriate, seek the advice of a competent professional in determining the exercise of reasonable care in any given circumstances.

The IES has no power, nor does it undertake, to police or enforce compliance with the contents of this document. Nor does the IES list, certify, test or inspect products, designs, or installations for compliance with this document. Any certification or statement of compliance with the requirements of this document shall not be attributable to the IES and is solely the responsibility of the certifier or maker of the statement.

AMERICAN NATIONAL STANDARD

Approval of an American National Standard requires verification by ANSI that the requirements for due process, consensus, and other criteria have been met by the standards developer.

Consensus is established when, in the judgment of the ANSI Board of Standards Review, substantial agreement has been reached by directly and materially affected interests. Substantial agreement means much more than a simple majority, but not necessarily unanimity. Consensus requires that all views and objections be considered, and that a concerted effort be made toward their resolution.

The use of American National Standards is completely voluntary; their existence does not in any respect preclude anyone, whether that person has approved the standards or not, from manufacturing, marketing, purchasing, or using products, processes, or procedures not conforming to the standards.

The American National Standards Institute does not develop standards and will in no circumstances give an interpretation to any American National Standard. Moreover, no person shall have the right or authority to issue an interpretation of an American National Standard in the name of the American National Standards Institute. Requests for interpretations should be addressed to the secretariat or sponsor whose name appears on the title page of this standard.

CAUTION NOTICE: This American National Standard may be revised at any time. The procedures of the American National Standards Institute require that action be taken to reaffirm, revise, or withdraw this standard no later than five years from the date of approval. Purchasers of American National Standards may receive current information on all standards by calling or writing the American National Standards Institute.

Prepared by the IES Lighting Control Systems Committee

Joe Bokelman, Co-chair

Kyle J. Hemmi, Co-chair

Mitchell K. Hefter, Vice Chair

Yoelit H. Hiebert, Vice Chair

Harold Jepsen, Secretary

Members

C. Diers	R. Harvey	K. D. Nielsen	H. L. Wolfman
W. Ellis	R. G. Janik	S. L. Pay	J. M. Yorgey
P. K. Ericson	C. C. Jones	T. L. Reemtsma	
L. Gomes	R. N. Miller	L. Schoeneman	
M. L. Goren	M. A. Myer	S. Segal	

Advisory Members

J. Amann	D. Hameed	J. B. Mabray	B. S. Renouf
K. Appleman	G. A. Hauser	D. McLaughlin	M. E. Rosen
L. J. Avanzato	Q. Huang	S. D. Mesh	N. Smirnov
C. Barnes	J. Joffe	A. M. Mor	C. Souders
C. C. Benedict-Uzoruo	M. Jouaneh	L. Mueller	M. J. Stern
R. P. Dagostino	H. M. Kaplan	J. Nekuda	J. M. Sundry
S. S. Ely	E. Lai	D. Noiseux	J. Tan
J. W. Faught	L. O. Lamontagne	B. Palmer	X. Varghese
B. A. Flanary	D. Lenasi	C. Piper	C. K. Wolgamott
J. Frazer	A. R. Levine	E. F. Poland	R. H. Wyton
J. Grandpre	M. A. Lunn	M. E. Poplawski	S. Ziegenfus

CONTENTS

1.0	Introduction and Scope	1
1.1	Introduction	1
1.2	Scope	1
2.0	Core Concepts	1
2.1	User	1
2.2	Controller	1
2.3	Graphical User Interface (GUI)	2
2.4	Program	2
2.5	Interoperability	2
2.6	Protocols	2
2.6.1	Open Protocols	2
2.6.2	Proprietary Protocols	3
2.6.3	Multiple Protocols in One System	3
2.7	Bus	3
2.8	Interchangeability	3
2.9	Conformance vs. Compliance	3
2.10	Network	4
2.11	Platform	4
2.12	Open Systems Interconnection (OSI)	4
2.13	Gateway	4
2.14	Ballast, Drivers, Transformers	4
2.15	Wiring and Communication Methods	4
2.15.1	Line Voltage	4
2.15.2	Low Voltage	5
2.15.3	Ethernet	5
2.15.4	Wireless	5
2.15.5	Light	6
2.16	Architectures	6
2.16.1	Basic Components	7
2.16.2	Networked Control – General	9
2.16.3	Networked Control – Topology	9
2.16.4	Room-Based and Standalone Control	10
3.0	Design Considerations	11
3.1	Owner Project Requirements	11
3.2	Economic Considerations	11

3.3	Building Codes	12
3.3.1	Energy	12
3.3.2	Electrical	12
3.3.3	Fire and Life Safety	12
3.4	Ease of Maintenance	12
3.5	User Expectations	13
3.6	Control Zoning	13
3.6.1	Zoning Strategies	15
3.6.2	Granular Dimming	16
3.6.3	Analog vs. Digital	16
3.6.4	Daylight Zones	16
3.6.5	Flexibility	16
3.7	Energy Codes	16
3.7.1	Exterior Lighting Controls	17
3.7.2	Interior Lighting Controls	17
3.7.3	Demand Response	18
3.8	Integration	18
3.9	Dimming and Perception	18
4.0	Lighting Control Strategies	19
4.1	Basic Strategies	19
4.1.1	Manual Controllers	20
4.1.2	Automatic Controllers	20
4.1.3	Switching	20
4.1.4	Continuous Dimming	20
4.1.5	Step Dimming	20
4.2	Personal Tuning	21
4.3	Institutional Tuning	22
4.4	Adaptation Compensation	22
4.5	Occupancy and Vacancy Sensing	22
4.6	Time Scheduling	23
4.7	Daylight Harvesting	23
4.8	Lumen Maintenance Dimming	24
4.9	Demand Response	25
4.10	Shade Control	26
4.11	Scene Control	26
4.12	Emergency Lighting Control	27
4.13	Color Mixing	29
4.14	Tunable White	29
5.0	Controlling Light Sources	29
5.1	Solid State Lighting (SSL)	30
5.1.1	On-Off Control and Dimming	30
5.1.2	LED Driver-Controlled Dimming Implementation	30
5.1.3	System-Level (Addressable, Two-Way) Protocols	33

5.1.4	Parameters to Consider	33
5.1.5	Gateways for Dimming Controls and LED Sources	35
5.1.6	Other Considerations	36
5.2	Fluorescent	37
5.3	High Intensity Discharge (HID)	38
5.4	Line-Voltage Standard Incandescent and Tungsten-Halogen	39
5.5	Low-Voltage Standard Incandescent and Tungsten-Halogen	40
5.6	Neon and Cold Cathode	41
6.0	Protocols and Methods of Control	41
6.1	Two-Wire Line Voltage Control	41
6.1.1	Constant (Always On) Power (Not Controlled)	41
6.1.2	Switched Control	41
6.1.3	Two-Wire Line-Voltage Phase Control (Phase Cut) for Dimming	41
6.2	Three-Wire Line Voltage (Power or Class 1) for Fluorescent or SSL Dimming	44
6.3	Four-Wire Dimming – Line Voltage Plus Class 1 or Class 2 Low Voltage Communications for Dimming ...	44
6.3.1	DALI, DALI-2	44
6.3.2	10VDC Sinking Protocols	45
6.3.3	10VDC Sourcing Protocol	45
6.4	Line Voltage with Other Wired Digital Protocols	46
6.4.1	DMX512 Digital Control Protocol	46
6.4.2	Ethernet-Based Control Protocols	46
6.5	Pulse-Width Modulation (PWM) for LED Dimming	46
6.6	Power Wiring, Class 1 Wiring, Class 2 Wiring, and Communications Wiring	47
6.7	Transmission Technologies and Hardware	48
6.7.1	RS232 (Currently TIA-232)	48
6.7.2	RS485 (Currently ANSI/TIA/EIA-485)	49
6.7.3	Ethernet and Power over Ethernet (POE)	49
6.7.4	USB (Universal Serial Bus)	50
6.7.5	Wireless	51
7.0	Lighting Control Equipment	59
7.1	User Interfaces	59
7.1.1	Switches	59
7.1.2	Dimmers	59
7.2	Multi-zone Systems: Relay Switching and Programmable Dimming Systems	59
7.2.1	Low-Voltage Relays	60
7.2.2	Scene Controllers	60
7.3	Central Computer-Based and Software-Based Systems	61
7.4	Occupancy Sensors	62
7.4.1	Types of Sensors	63
7.4.2	Design Considerations	64
7.4.3	Powering Occupancy Sensors	66
7.4.4	Coverage Patterns	67
7.4.5	Energy Savings Potential	68
7.4.6	Occupancy Sensor Adjustments	68

7.5	Vacancy Sensors	68
7.6	Photosensors	68
7.6.1	General Operation	69
7.6.2	Switching versus Dimming	70
7.6.3	Exterior Applications	71
7.6.4	Interior Applications	71
7.6.5	Open-Loop Systems	72
7.6.6	Closed-Loop Systems	73
7.6.7	Dual-Loop Control	75
7.6.8	Photosensor Placement	75
7.6.9	Photosensor System Design and Layout	75
7.6.10	Location of the Critical Task	77
7.6.11	Energy Modeling of Photosensor Control Systems	78
7.6.12	Setup and Programming of Photosensor Control Systems	78
7.7	Shade Control	79
7.8	Emergency Lighting Control Strategies	80
8.0	Design Deliverables	80
8.1	Control Narrative	80
8.2	Control Zone (Channel) Plan	81
8.3	Equipment Specifications	82
8.4	One-Line (Single-Line) Diagrams	82
8.5	Lighting and Relay Panel Schedules	84
8.6	Startup and Configuration	86
8.7	Retrofits	86
9.0	Commissioning	86
Annex A – Additional Reading		87
Annex B – Applications Standards and Codes		87
B.1	Equipment Regulations	88
B.2	Non-regulatory Government Programs	88
B.3	Green Building Codes and Rating Systems	88
Annex C – Lighting Control Protocols		88
C.1	Common Name: 1-10VDC Current Sinking (Non-standby Mode)	89
C.2	Common Name: 0-10VDC Current Sinking (Standby Mode)	90
C.3	Common Name: 0-10 VDC Front End (Current Source)	90
C.4	Common Name: ASCII	91
C.5	Common Name: ACN	91
C.6	Common Name: BACnet	92

C.7	Common Name: DALI	93
C.8	Common Name: DMX512.....	95
C.9	Common Name: EnOcean	96
C.10	Common Name: Konnex (KNX)	96
C.11	Common Name: LonWorks	97
C.12	Common Names: MIDI and MIDI Show Control.....	98
C.13	Common Name: Modbus	98
C.14	Common Name: RDM	99
C.15	Common Name: SMPTE	100
C.16	Common Name: TCP/IP (IP-Based Protocols)	100
C.17	XML (Extensible Markup Language).....	101
C.18	Common Name: WPAN	102
C.19	Common Name: Z-Wave.....	102
C.20	Automated Demand Response (ADR)	103
C.21	Common Name: Wi-Fi	103
C.22	Bluetooth	104
C.23	Interoperability and Visible Light Communication (VLC)	105
C.24	Common Name: ELMS.....	105
C.25	Other Protocols	106
 Annex D – Interoperability: The OSI Seven-Layer Model		106
 References		108