MULTI-ZONE LIGHTING CONTROL SYSTEM
BELEUCHTUNGSSTEUERUNG FÜR MEHRFACHIGE ZONEN
SYSTEME DE COMMANDE D’ECLAIRAGE MULTIZONE

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Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates to improvements in relatively sophisticated lighting control systems of the type used most often in commercial settings for controlling the luminous output of a large number of lighting fixtures which are grouped together in some manner to define various “zones” of light.

Description of Related Prior Art

[0002] In many commercial lighting applications where large numbers of lighting fixtures (say, for example, several hundred) are used to illuminate areas of interest, it is common to group the fixtures in such a manner as to define “zones” of light which can be independently controlled from one or more wall-mounted control units. The wall-mounted control units are typically located in the vicinity of the lights they control. Each control unit usually comprises an array of manually manipulatable zone-intensity or “dimming” actuators, such as sliders or up/down push-buttons, each actuator being specifically assigned or dedicated to a particular lighting zone. Manipulation of any one of these actuators serves to vary a characteristic of a lighting control signal transmitted by the control unit and used to control the output of one (or more) dimming circuits or modules, hereinafter referred to as “dimmers,” which apply power to each of the lighting fixtures defining a particular lighting zone. In addition to providing a means for adjusting the instantaneous light level of several zones of light, each control unit is usually adapted to store preset values for each of the lighting zones controlled by its respective actuators. In response to the actuation of any one of several “scene-select” switches on the control unit, stored preset values can be simultaneously recalled for all of the lighting zones, thereby creating any one of several different lighting scenes in the area illuminated by the preset lighting zones. Such multi-zone, multi-scene lighting control units are commercially available, for example, from Lutron Electronics Co. Inc. under the registered trademark “Grafik Eye”.

[0003] As noted above, it is common to locate the lighting control units in the vicinity of the lighting fixtures they control. The dimmers through which they control power to the fixtures, however, are usually mounted in a centrally located power cabinet which is remote from the control units and lighting fixtures. Communication between the control units and the power cabinet has been achieved by a digital communications link in which the control units sequentially transmit, in a multiplex fashion, zone-intensity information on a low voltage communications bus. The multiplexed information is decoded in the power cabinet by a microprocessor forming part of a dimmer control panel circuit which controls the operation of the dimmers. Upon decoding the multiplexed zone-intensity information and determining, for example, through an appropriately programmed look-up table, which of the dimmers is to receive and act on certain zone-intensity information received by the microprocessor, the dimmer control panel circuit transmits such information to the appropriate dimmers. While it is known to transmit this data to the dimmers on wires connecting each dimmer to the dimmer control panel circuit, it is also known to multiplex such transmission on a digital communications link. In the latter case, each dimmer is assigned a unique binary (or digital) address code, and it responds only to zone-intensity information on the link that is preceded by (or somehow associated with) its respective address code. A microprocessor associated with each dimmer processes the address and zone-intensity information and outputs a dimming control signal which is used to control the firing angle of a triac or the like, thereby adjusting the RMS voltage applied to the associated lighting load and, hence, its luminous output. US-A- 4 924 151 discloses a multi-zone, multi-scene lighting control system, which controls the power supplied to multiple groups of lights. The system comprises a control panel with a number of scene select actuators thereon, said actuators independently controlling the power supplied to zones of lighting fixtures. Any one of a number of pre-set scenes may be selected. Scene identifiers and zone identifiers, which identify the scenes and zones respectively that correspond to the scene select actuators, may be attached to the inside of the control panel cover.

[0004] However, multizone lighting systems of the above type are notoriously difficult to modify (e.g., add dimmers or change the assignment of zone-intensity actuators) once the system is installed and operating. It will be appreciated that, during set-up and checkout, written documentation is always available to correlate each dimmer with the zone-intensity actuators that controls its output. Such documentation is usually in the form of a listing that assigns each dimmer to a particular zone actuator. This listing is desirable when it comes time to program the dimmer control panel circuit’s look-up table that correlates the individual zone-intensity actuators with the dimmers. Should this documentation become unavailable or not readily understood at the time when modifications or additions to the system are required, a great deal of time can be expended in determining what actuator controls what circuit, and what symbology was used to identify the zone actuators so that re-programming of the look-up table can be carried out. Say, for example, a lighting system comprises three wallbox control units U1, U2 and U3, disposed at different locations within a lighting region, and each control unit is capable of controlling six lighting zones through the manipulation of six zone-intensity actuators A1 through A6. Further assume that the system comprises 24 dimmers which control power to the various lighting fixtures of the
system. In programming the dimmer control panel circuit's look-up table, it is necessary to assign each zone-intensity actuator to one or more dimmers. To conserve memory space, this programming is effected by using some abbreviated symbology, such as "U2.A3" and "D19" to identify a particular zone-intensity actuator and its assigned dimmer circuit, respectively. Should one desire to add a new dimmer to the system, one must not only possess the apparatus required to effect re-programming, but also one must have the knowledge of the symbology used in programming the power panel. Even having this information, the system user would then have to know how to program the power panel, a daunting task for all but a few. Ideally, the user should be able to add a new dimmer without need for consultation and/or assistance from the system installer.

SUMMARY OF THE INVENTION

[0005] In view of the foregoing discussion, one object of this invention is to provide a multi-zone lighting control system of the above type in which there is no need for written documentation in assigning a zone-intensity actuator to a selected dimmer.

[0006] According to the invention, there is provided a multi-zone lighting control system for selectively controlling the respective light levels of a plurality of lighting zones, each of such zones comprising a dimmable light source, said lighting control system comprising:

a) a lighting control unit for transmitting zone-intensity information representing a desired light level for each of a plurality of lighting zones on a communications link, said lighting control unit including a plurality of dimming means, each being manually manipulatable to alter said information to reflect a desired change in light level for a different one of the lighting zones; and

b) dimming control means operatively connected to the lighting control unit and responsive to said zone intensity information on the communications link for adjusting the light level of said dimmable light sources to achieve the desired light level in each of said lighting zones, said dimming control means comprising a plurality of dimming circuits, each being adapted to control the luminous output of a light source in one of the lighting zones in response to receiving an input signal from said lighting control unit, the multi-zone lighting control system being characterized by the dimming control means comprising means for assigning each of the dimming circuits to a particular dimming means so that the respective input signal received by an assigned dimming circuit is determined by the zone-intensity information which is adjustable by such dimming means, said assigning means comprising means for selecting a particular dimming circuit from said plurality of dimming circuits, and means responsive to a predetermined sequence of changes in zone-intensity information as produced by a predetermined manipulation of any one of the dimming means to assign said one dimming means to the selected dimming circuit.

[0007] The invention and its various aspects will be better understood from the ensuing detailed description of preferred embodiments, reference being made to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. 1 is a block diagram of a multi-zone lighting control system of the type in which the inventions disclosed herein are useful;

FIG 2 is a more detailed block diagram of the dimmer control panel of the FIG 1 system;

FIG 3 is a front plan view of an interactive display panel useful in programming the programmable dimmer control panel of the FIG 1 system;

FIGS 4A and 4B are flow charts of a computer program adapted for use in the FIG 1 system for assigning a desired zone-intensity actuator to a selected dimmer;

FIG 5 is a block diagram of a digital dimmer embodying various aspects of the invention;

FIG 6 is a perspective view of a portion of a support plate adapted to support a plurality of the dimmers;

FIG 7 is a perspective view of a dimming panel illustrating a preferred layout of dimming circuits and chokes;

FIG 8 is an end view of a portion of the dimmer panel shown in FIG 7;

FIGS 9-11 are flow charts illustrating various programs carried out by the microprocessor component of the dimmer shown in FIG 5; and

FIG. 12 is an electrical schematic showing preferred circuitry for implementing various aspects of this invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0009] Referring now to the drawings, FIG. 1 schematically illustrates a multi-zone lighting control system in which a plurality of lighting control units U1, U2, U3 operate through a plurality of dimmers (dimmer 1 through dimmer N) to control the output intensity of a plurality of lighting loads L1 through LN. While each of the lighting loads is schematically depicted as comprising a single fixture, it will be appreciated that each lighting load usually comprises several, and often many, individual lamps of the same type, e.g., all being either incandescent, fluorescent, neon, etc. As shown, the lighting loads may be grouped together to define a plu-
rality of lighting zones Z1, Z2, Z3, ..., ZN, the light intensity of each zone being controlled by the output of one or more of the dimmers. In the FIG. 1 system, control units U1 - U3 are of conventional design, each comprising a plurality of zone-intensity actuators A1 - A6, shown as sliders, which can be manually manipulated, such as raised or lowered within slots S1-S6, respectively, to vary a characteristic of a lighting control signal produced at the output x of each unit. As explained below, the respective outputs of the control units serve to control the respective outputs Y of the dimming modules and, hence, the light intensity of the lighting zones. Each of the actuators A1 - A6 controls one or more dimmers to control the light intensity in a particular lighting zone to which the dimmers are assigned, e.g. actuator A1 of control unit U1 may control the lighting intensity in zone Z1 by controlling the outputs of dimmers 1 and 2; actuator A1 of control unit U2 may be assigned to control the output of dimmer 3 which controls the lighting intensity in zone Z2; and actuator A4 of control unit U3 may be assigned to dimmers 4 and 5 which control the lighting intensity in zone Z3. In the control units shown, physically moving the slide actuator in the slot acts to raise or lower the light level. In some control units, however, the zone-intensity actuator may take the form of a pair of UP/DOWN push buttons which, through suitable circuitry, have the same effect on the control unit output.

Suitable control units for the FIG. 1 system are the so-called Grafik E Lighting Controls, Models 3000 or 4000, made by Lutron Electronics Co., Inc.

[0010] Lighting control units U1 - U3 are usually wall-mounted devices, each being mounted in a wallbox located in the vicinity of the lighting fixtures they control. The control units communicate with the various dimming modules through a programmable dimmer control panel circuit CP which, together with the dimming modules, is housed in a power cabinet PC located remote from the controls and lighting fixtures, e.g. in a power control room. The dimmer control panel circuit includes a microprocessor 20, such as a Motorola Model 68HC11E9, eight-bit microcontroller, which receives multiplexed zone-intensity information transmitted by the control units over a digital communications link MUX. Upon being sequentially polled in a conventional manner, each control unit transmits, in accordance with an established protocol, a serial message on the link, such message representing digitally encoded zone-intensity information determined by the position of its six zone actuators. Polling of the control units is typically effected at a relatively fast rate, e.g., once every 100 ms., each control unit taking its turn in a predefined time-slot. Upon receiving and de-multiplexing the zone intensity information from the lighting control units, the microprocessor stores this information in a conventional random access memory (RAM) 22, updating the memory with fresh intensity information during every polling cycle. As shown in FIG. 2 which illustrates certain preferred details of the dimming control pane circuit, the zone-intensity information is stored in tabular form, each box (e.g., U1, A1, which identifies actuator A1 of control unit U1) containing eight bits of zone-intensity information for the associated zone actuator for the preceding polling cycle. In the system depicted in FIG. 1, there are a total of eighteen zone actuators; hence, RAM 22 must accommodate eighteen intensity levels, one for each actuator.

[0011] Still referring to FIGS. 1 and 2, the dimming control panel circuit further comprises a look-up table (LUT) 24, preferably a standard electrically erasable read-only memory (EEPROM); a programmable read-only memory (PROM) 26 (described in considerable detail below); and a programming unit 28 including an interactive display 30 through which the look-up table can be programmed to assign each dimming module to a particular zone actuator. While shown separately, it will be appreciated that the look-up table and PROM are often integral portions of the microprocessor and, in fact, are part of the Motorola microcontroller mentioned above. In the example shown in FIG. 1, it is shown that dimmers 1 and 2 control the lamps in lighting zone Z1. Therefore, in setting up the lighting system, it is necessary to assign dimmers 1 and 2 to a single zone actuator, and to store that assignment in the look-up table. As shown in FIG. 2, dimmers 1 and 2 have been assigned to zone actuator U1,A1, i.e. actuator A1 of control unit U1. This assignment is normally achieved by appropriately programming LUT 24 through the programming unit 28. Similarly, FIG. 1 shows that dimming module 3 controls the lamps of zone Z2. In FIG. 2, it is shown that the look-up table has been programmed to assign actuator U1,A2 to this particular lighting zone. Further, it is shown in FIG. 1 that dimmers 4 and 5 control the lamps in zone Z3. Referring to FIG. 2, control of these dimmers has been assigned in the look-up table to zone actuator U1,A3.

[0012] Referring to FIG. 3, the programming unit 28 includes an interactive display 30 which is illustrated as comprising a pair of seven-segment LED (light-emitting diodes) displays 32, 34; a series of push-button switches 35 - 39; and an array of single LEDs 40 - 45. Display 32 is part of the "Select Circuit" portion of the programmer display and is adapted to show a number representing a particular dimming circuit number. A desired dimming circuit number is selected by repeatedly depressing the appropriate UP/DOWN buttons 35, 36 until the display 32 shows the desired circuit number. Assignment of the selected circuit to a particular zone actuator is achieved in the "Select Value" portion of display 30.

[0013] Upon selecting the desired dimmer and entering a program mode (e.g., by depressing buttons 35 and 39 simultaneously for a predetermined time period), button 39 is repeatedly depressed, thereby causing the LED's 40 - 45 to become illuminated, one at a time. These LED's respectively identify various internal programs that are stored in PROM 26, each program enabling the user to adjust certain dimmer parameters and store certain values. When LED 40 is illuminated, for ex-
ample, a program is accessed which allows the user to chose one of four different load types (i.e. incandescent or low voltage, fluorescent, neon or cold cathode, or non-dimmable) by depressing the UP/DOWN buttons 37, 38 until the number (from 01 to 04) is shown on display 34. Based on the load type chosen, the programming unit causes the microprocessor 20 to transmit a load-type signal to the selected dimming module, causing the dimming module to choose an appropriate calibration curve (stored in memory of the dimming module) for dimming the lamps controlled thereby. When LED’s 43 or 44 are illuminated, programs are accessed which allow the user to set either the lowest or highest intensity level available for the selected dimmer. When LED 41 is illuminated, the operator can assign a desired zone actuator to the selected dimmer through the interactive display. At this time, the seven-segment display 34 alternately displays, for one second intervals, a particular control unit number, e.g. Ul, and a particular actuator number, e.g. Al. By depressing the UP/DOWN buttons 37, 38 at the appropriate time, the operator can increment the displayed number by one and thereby select a desired control unit and zone actuator. Having selected both the dimming circuit number and actuator number, the microprocessor assigns (or re-assigns) this particular actuator to the selected dimming circuit after a preset time interval has elapsed, and stores this assignment in the look-up table LUT 24.

[0014] As may be appreciated, assigning a particular zone actuator to a dimmer in the manner described above requires knowledge by the programmer of the actuator symbology. At initial set-up of the system, there is always some documentation, e.g., a work sheet, that correlates these two variables, control unit number and actuator number, in a symbology understood by the microprocessor. With the passage of time, however, such documentation often disappears, and even the smallest change in actuator assignments, or the addition of a new circuit to the system, often requires a service call to the system installer who presumably has retained the necessary documentation to make a change.

[0015] According to this invention, the above-noted difficulty in making modifications to an existing lighting system of the type described is alleviated by the provision of a computer program that obviates the need for any documentation in order to re-program the look-up table 24 with new zone actuator assignments. According to a preferred embodiment, this program, which is stored in PROM 26, causes the apparatus to carry out the sequence of steps shown in the flow chart of FIG 4. Upon entering a programming mode as described above, pushbutton 39 is repeatedly depressed until LED 42 is illuminated. This LED indicates that the "Zone Capture" program has been accessed. The operator then selects a dimming circuit for zone actuator assignment by depressing UP/DOWN buttons 35, 36. Having made the circuit selection, the microprocessor outputs a signal to the selected dimmer, causing the lamps on the selected circuit to repeatedly flash, full ON and OFF. This flashing is intended to give the operator a visual indication of the lights controlled by the selected dimming circuit. The operator then goes to the specific actuator which is intended to be assigned to the selected dimming circuit and physically moves or manipulates the actuator so as to request a minimum light level. In the control shown in FIG. 1, the operator would move the slider to the bottom of its respective slot. Upon detecting that any of values stored in RAM 22 are at the minimum allowed level, the microprocessor sets a binary bit or flag. Having manipulated an actuator to request minimum light level, the operator is then required to manipulate the actuator towards a position requesting maximum light intensity, e.g. moving the slider towards the top of the slot. At this time, the microprocessor starts an internal timer which sets a time period (e.g. 5 seconds) during which the next sequence of events must be completed in order to assign the manipulated actuator to the selected dimming circuit. The operator then continues adjusting the slider towards a position requesting maximum light level. During this time, the microprocessor monitors the intensity values of the zones for which a flag was set at the beginning of the timing period. As soon as one of the zones, presumably the zone whose actuator is being adjusted, reaches a predetermined value, say, 50% of maximum value, the microprocessor causes the light intensity of the lamps on the selected dimmer circuit to stop flashing and track (in intensity) the adjustment or movement of the actuator. At this point, the selected dimmer has now been "captured" by the actuator. Upon noticing that the lamp(s) on the captured dimmer are tracking the actuator adjustment, the operator begins to adjust the zone actuator in such a manner as to again request minimum (e.g. zero) light intensity. If the actuator has arrived at the minimum light level setting before the internal timer times-out, the selected dimmer will be "locked" to the adjusted actuator, i.e. the microprocessor will re-program the look-up table so as to assign the manipulated actuator to the selected dimmer. If the internal timer times-out before the actuator arrives at the minimum light level setting, the program returns to the dimmer-selection step, and the associated lamps on the selected dimmer begin to flash ON/OFF again.

[0016] By virtue of the above apparatus, it will be appreciated that a user can reconfigure an entire lighting system, i.e., re-assign any or all of the actuators to different dimmers, without ever having any knowledge of the symbology used in initially programming the system. Similarly, dimmers can be added to existing zones, or assigned to previously unassigned actuators without knowledge of the actuator "numbers."

[0017] Referring to FIG. 5, there is shown a functional block diagram of each of the dimmers discussed above. The general purpose of each dimmer is to provide a phase control output to its associated lighting load LL to control the RMS voltage across the load and, hence, its luminous intensity. As discussed below, each dimmer is
adapted to operate on a wide range of input voltages from 80 VAC to 277 VAC, 50 or 60 Hz. A circuit breaker CB functions in a conventional manner to provide AC overcurrent protection. It also functions as a means for removing power to a dimmer, each dimmer having its own breaker. A relay R serves to break power to the load and operates under the control of a microcontroller MP. The switched power of the relay serves to provide power directly to a controllably conductive device, preferably a triac T, and it can also be used to provide a switched hot output necessary for dimming fluorescent loads. The microcontroller controls the turn on sequence of the relay and triac so that the relay contacts are closed with no current through them. The triac responds to a control signal on its gate lead to selectively conduct a portion of the AC line voltage during each half cycle thereof, whereby the RMS voltage across the load can be varied. The triac’s ON time is controlled by the microcontroller and is based on the digital values received on the communications link MUX’ from the control assigned thereto. As discussed below, a plurality of address switches provide each dimmer on the communications link a unique address so that each dimmer can identify zone intensity information intended for it.

[0018] Each dimming circuit also includes a full wave bridge circuit FWB which rectifies the AC line voltage to provide the DC voltage needed to operate the microcontroller and relay coil. A power supply PS uses the rectified AC line voltage to provide 30 volts DC to operate the relay. The power supply also derives a regulated 5 VDC supply to power the microcontroller. A zero-cross detector ZC senses when the line voltage waveform crosses zero and provides an input to the microcontroller for determining the line frequency and phase. A voltage compensation circuit, discussed below, operates to maintain a constant light intensity even when the AC line voltage fluctuates from its nominal value. As also discussed below, the microcontroller is programmed to respond to various inputs, including a triac fault detector FD, to indicate the operating status of the system and various key components. Such status is indicated by a causing status indicator SI, preferably a single LED or other light source, to flash according to a predetermined sequence. A large choke C (e.g. up to 2 or 3 millihenry) is connected in series with the triac output and serves to suppress RFI and reduce lamp buzzing in incandescent lamps.

[0019] In the lighting control system described above, it is noted that the dimming control panel circuit CP controls the respective outputs of the dimmers (Dimmer1-Dimmer N in FIG 1.) Preferably, communication between the control panel circuit and dimmer circuits is carried out on a two-wire serial data link MUX’ to which the dimmers are connected in a daisy-chain fashion. So that each dimmer responds only to intensity information intended for it, each dimmer is commonly assigned a different binary or digital address. In prior art systems, such addressing has been achieved either by an array of bi-stable “DIP” switches, each having an actuator that can be moved between two stable positions, or a rotary, multipositional selector switch, based on the position of a rotatable selector element, determines the dimmer address. In the event a dimmer requires replacement, it will be appreciated that the new unit must have the same address as the defective unit. This requires some attention to detail by the servicing personnel in that an unobserved accidental movement of one of the switch actuators on the DIP switch array, or a rotation of the selector element of the defective unit prior to setting the address of the new unit can be problematic in setting the address of the new unit. Ideally, the replacement dimmer should be self-addressing so as to eliminate human involvement in the addressing process.

[0020] There is provided a digital dimmer that automatically addresses itself as it is mounted on a support plate. The features which enable it to be self-addressing are better shown in FIG. 6. As shown, each dimmer module, designated as reference character 50, comprises a housing 52, e.g., a circuit board, which is mountable in a predetermined location L’ (shown in phantom lines in FIG 6) on a support plate SP. The dimmer circuit board supports the various electronic components (discussed below with reference to FIG. 12) required to vary the intensity of a lighting load in response to receiving a suitable lighting control signal. As noted above, such components include a triac T which is used to selectively interrupt power to the load to dim its output. According to a preferred embodiment, each dimmer module 50 has a unique binary address code determined by an array of normally open address switches 56 - 60, located at the periphery of the circuit board, and means associated with the support plate for selectively changing the conductive state of one or more of the switches as the dimmer module is mounted in a predetermined location L’ on the support plate. Preferably, each of the switches is of the type which includes a movable plunger P which, depending on its extended or retracted position, determines the conductive (open or closed) state of its associated switch. Normally, the plunger of such switches is spring-biased towards its extended position, in which case the switch is normally open. Preferred address switches are the “Detector Switches,” made by Matsushita Electronics Components, Co. When address switches of this type are used, the switch-closing means on the support plate may take the form of an array A of holes H having lands L therebetween and on opposite sides thereof. When the dimmer module is properly positioned on the support plate, the holes act to allow some of the plungers to remain in their normally extended position, thereby allowing their respective switches to remain open, while the lands act to selectively depress the remaining switch plungers, thereby closing their respective switches. Thus, it will be appreciated that the dimmer’s address is determined by the hole/land pattern opposite the position in which it is mounted. By using different hole/land patterns, each dimmer module can re-
receives a unique binary address code. Preferably, a plurality of dimming modules are mounted on the same support plate and, opposite each position on the plate which is to receive a dimmer module, a different hole/land pattern is formed.

[0021] In the self-addressing scheme described above, each of the address switches includes a pair of contacts which are shown in the electrical schematic of FIG 12. One contact of each pair is connected to a voltage source. In response to switch closure, a signal appears at the switch output. The respective outputs of the address switches serve as High/Low inputs to a microprocessor forming part of the dimmer. Prior to accepting intensity information from the dimmer control panel over the multiplex link, the binary address produced by the address switches must match the address transmitted on the serial data link.

[0022] In the preferred embodiment shown in FIG 6, there are a total of five address switches 56-60 which define a five-bit binary address code. Obviously, the number of switches is determined by the maximum number of dimmers allowed on the communications link. As noted, the dimmers have predefined mounting locations on the support plate, each of such locations being determined by a pair of spaced guides 62 which engage the lateral edges of a module's circuit board. Each guide is provided with opposing grooves so that adjacent circuit boards can share the same guide. Each guide is provided with a pair of mounting clips 63 which are designed to snap into engagement with apertures 64 formed in the support plate. When the mounting clips are positioned within the apertures 64, a pair of feet 65 on each guide engage the support plate surface at locations 66. When so positioned, guide 62 serve to position the circuit board upright (perpendicular) with respect to the support plate surface.

[0023] While the above embodiment uses an array of electromechanical switches and support plate holes and lands to provide the self-addressing feature, other self-addressing schemes come to mind. For example, magnetic address switches can be used which cooperate with a magnetic/non-magnetic pattern on the support plate. Alternatively, photoelectric switches can be used which cooperate with a reflective/non-reflective pattern on the support plate.

[0024] Referring now to FIGS. 7 and 8, these relate to the dimmer support plate and the arrangement of the heat-generating dimmer components thereon to achieve a relatively high packing density of dimmer modules. Each dimmer includes, in addition to a triac or the like, a relatively large choke or coil for suppressing RFI. When the dimmer is operating, both of these components generate so much heat that it is common to provide some sort of heat sink for conducting heat away from the other circuit elements to avoid damage or, at least, prolong their useful life. Often, a number of dimmers comprising a dimming panel are supported on a common, heat-conducting, support plate with the heat-generating components of each dimmer being thermally coupled to the plate. Usually, the support plate is a casting or extrusion having a plurality of fins or ribs on the opposite side thereof for radiating the heat conducted thereto into the surrounding air. Ideally, the RFI choke, being the larger producer of thermal energy, should be remotely spaced from its associated dimmer components, but since conventional dimmers are packaged with the choke included, the choke is usually positioned relatively close to its associated circuit components.

[0025] As an alternative to using relatively costly castings or extrusion of finned surfaces and the like, and to mounting the choke-containing dimmers side-by-side on a flat, heat-conducting support plate, it is preferred that the support plate take the form of a corrugated metal structure, and that all of the RFI chokes be mounted, side-by-side, in a portion of the plate remote from the other dimming circuit components. Since the chokes are merely copper windings that are relatively insensitive to the high temperature levels that result from grouping the chokes together, there is no disadvantage, other than the necessary re-wiring that results, in locating the chokes remote from the dimmers. The advantage of this arrangement is that the heat generated by the triac can be easily dissipated in the support plate, and the semiconductor circuit elements of the dimming module can operate at a low operating temperature, thereby prolonging their life.

[0026] Referring FIG. 7, the support plate SP is depicted as a corrugated-structure having alternating lands 80 and channels 82. Preferably, the support plate is made of aluminum, about 3 mm in thickness, and the corrugated structure is provided by appropriately bending the plate. Such a corrugated structure has the effect of enlarging the surface area over which heat can be dissipated without enlarging the overall dimensions of the plate. In accordance with a preferred embodiment, the lands and channels are rectilinear, parallel and approximately equal in width, preferably about 40 mm wide, and the depth of the channels is approximately 30 mm. In the dimming panel shown in FIG. 7, sixteen dimmers D1-D16 and their associated chokes C1-C16 are mounted on a common corrugated support. Since the chokes are relatively insensitive to heat, they are mounted as close together as practical, on both the lands 80 and in the channels 82, as better shown in FIG. 8. Since heat rises, it is preferred that the chokes occupy the upper portion of the support plate with the dimmers mounted below. Preferably, the dimmers are mounted on only the land (or the base of the channel) portions of the support plate to provide more thermal isolation from the heat produced by the respective triacs of adjacent dimmers. Since the central region of the support plate will attain a higher temperature than the peripheral portions, it is also preferred that the dimmer modules be arranged in the pattern shown, with gradually fewer modules in the direction of the plate center.

[0027] An advantageous technical effect of the corru-
gated configuration of the support plate is that a chimney effect is created between adjacent lands and channels in which the radiated heat is quickly dispersed in a direction parallel to the longitudinal axes of the lands and channels. This chimney effect is maximized, of course, by arranging the support plate such that the channels extend vertically, whereby the heat generated is free to rise uninhibited. Further, the corrugated configuration of the support plate serves to substantially increase the thermal separation of the dimming circuits. The combination of the corrugated support plate and the remotely located RFI chokes provides a low-cost, yet highly efficient, scheme for reducing the ambient temperature in the vicinity of the heat-sensitive dimmer components, thereby increasing their expected lifetime. Also, as many as twenty-four 16 ampere dimming circuits and their associated 2 millihenry chokes can be housed on a common support plate measuring only about 70 cm. by about 85 cm. in overall dimension.

Temporary lighting may be effected, even in the absence of a dimmer control signal. In the past, a loss or absence of the control signal would necessitate the use of jumper cables or the like to by-pass the dimmer and thereby apply full power to the lighting load. To be provided with temporary lighting of a preset intensity, e.g., full ON, the user need only cycle a circuit breaker (i.e., turn the input power circuit breaker off and on). Referring to FIG. 9, the flow chart illustrates preferred steps carried out by the dimmer's microprocessor in implementing this feature.

Upon powering up the system, the dimmer's microprocessor MP determines whether power has been applied to its associated dimmer module. If it has, the microprocessor then determines whether any valid data has been received from the dimmer control panel circuit CP since power-up. This is determined by monitoring the input data on the communication link MUX'. If no data has been received since the initial power-up, the microprocessor operates the triac to provide full power (or any predefined preset level) to the lighting load. If valid data has been received, the microprocessor continues to monitor the communications link for valid data and operates the lighting load at an intensity determined by such data. When the microprocessor determines that valid data is no longer being received, it determines whether valid data has been received since the last power up. If so, it freezes the lamp intensity at the power level requested prior to loss of data. If not, the lighting load is operated at full intensity, or some other preset value. If power has been removed from the dimmer module after the light intensity has been frozen at some level, such as by switching off the circuit breaker, the program turns to the beginning of the program and, as soon as power is restored, such as by switching on the circuit breaker, the microprocessor will operate the lamps at full intensity, or some preset level. If power to the dimmer has not been interrupted after the light intensity has been frozen at some level, the microprocessor keeps checking for valid data of the multiplex link and, until valid data appears, the light level remains frozen. Should valid data eventually appear, the lights are operated at the intensity requested.

From the foregoing, it will be appreciated that the dimmer can be by-passed in the absence of a control signal by simply turning the circuit breaker CB in FIG. 5 off and on. Power to the load will then be controlled strictly by the circuit breaker as if the dimmer was a short circuit. Normal operation will be immediately restored upon detection of a proper multiplex control signal or valid data.

The dimmer module of FIG. 5 preferably includes a unique voltage compensation circuit VC which operates to provide a constant lamp output even when the A.C. line voltage fluctuates from a wide variety of nominal values. The voltage compensation circuitry (shown in detail in the electrical schematic of FIG. 12) allows a capacitor to charge up to a reference level during each half-cycle of the A.C. waveform. The microprocessor allows the capacitor to start charging as the A.C. line voltage crosses zero, as determined by the zero-crossing detector ZC, and measures the time it takes to charge to the reference voltage. This charging time is a function of the amplitude of the A.C. line voltage; the higher the line voltage, the faster the charging time. The time measured during each half cycle is compared to a long term (e.g. 15 second) average. An error signal is derived from the comparison, and such signal is used to adjust the triac firing angle in such a manner as to keep the output voltage from changing. The result is that the effects of fast-changing and short lived changes in line voltage, sags and surges, are minimized. While the voltage compensation scheme described above can be used with any conventional line voltage, it will be appreciated that the nominal charging time will vary substantially with the nominal line voltage. That is, if a single charging capacitor is used for all nominal line voltages, it may be relatively easy, based on its value, to detect variations in charging times at low line voltages, e.g., between 80 and 160 volts, and relatively difficult to detect such variations at high line voltages, e.g., between 160 and 277 volts. Thus, to facilitate the charging time measurement for a wide range of line voltages, it is preferred that two different capacitor values be used, a relatively low value for relatively low line voltages, and a relatively high value for relatively high line voltages. Preferably an additional capacitor is switched into a parallel circuit with the normal charging capacitor when the microprocessor detects that the nominal line voltage exceeds a certain level (e.g., 160 volts).

The steps carried out by the microprocessor in compensating for line voltage fluctuations are shown in FIG. 10: Upon initially applying power to the dimmer, the microprocessor delays about 15 seconds before providing voltage compensation. This time period allows the microprocessor to determine a "long term" average for the charging time of the capacitor(s). Referring to the
electrical schematic of FIG. 12, capacitor C8 is the charging capacitor when the line voltage is between 80 and 160 volts, and capacitors C8 and C9 are the charging capacitors when the nominal line voltage exceeds 160 volts. A zero-crossing detector comprising diodes D4, D5, and resistors R6 and R8, provides the reference point from which the charging time is measured. The zero-crossing detector is connected to the output of the diode bridge DB1 which provides full wave rectification of the A.C. line voltage. The output of the zero-crossing detector provides an input to the microprocessor. Until a zero crossing of the line voltage occurs, the microprocessor shorts the capacitor. In response to a zero crossing, the microprocessor allows the capacitor C8 to charge. When a predetermined threshold or reference level is reached, as determined by the values of zener diode D9 and resistor R26, the microprocessor stores the charging time of the capacitor and discharges the capacitor until the next zero crossing. If the measured charging time is shorter than a certain minimum value, the microprocessor then determines whether the charging capacitor selected is adapted for the low nominal voltages. If so, the line voltage is too high for proper operation, and a reset is forced. If the measured charging time is not shorter than the minimum allowed value, then the microprocessor determines whether the charging time is longer than a certain allowed value. If so, the microprocessor determines whether the capacitance adapted for use with high line voltages has been selected. If so, the line voltage is too high for proper operation, and a reset is forced. If not, the lower capacitance is selected, and the program returns to the 15 second delay step. If the measured charging time is neither shorter than an allowed minimum value, nor longer than an allowed maximum value, the microprocessor determines the error between the measured charging time and the long term average. The long term average is then updated by subtracting or adding a fraction of the new charging time, and the firing angle of the triac is adjusted by an amount based on the error, load type and present firing angle.

[0033] In multizone lighting systems of the type described, it is often difficult to identify which dimmer module may have failed in the event of a system malfunction. Usually, test equipment and a skilled technician are required. Also, it is necessary to determine whether the malfunction is indeed due to a dimmer failure, or simply a mis-programmed control scheme. Conventional systems use an indicator lamp to indicate a very basic system status level, e.g. power on/off.

[0034] Each dimmer is equipped with means for monitoring several status states of the dimmer and for providing a visible indication thereof. Preferably, the status indicator takes the form of a single light source which can be selectively energized in different ways to indicate different status conditions, as diagnosed by the dimmer module's microprocessor MP. Preferably, the diagnostic light source is a conventional LED. In response to different inputs indicative, for example, of the status of the communications link, power to the dimmer module, status of the dimmer's power-switching component (triac), control unit status, etc., the microprocessor causes the LED to " blink" according to a readily recognizable pattern, for example, once every second, once every other second, once every third second, several times per second, etc. The status indicated by the blinking LED is recorded in documentation provided the system user.

[0035] Referring to FIG. 11, the flow chart illustrates the various preferred steps carried out by the microprocessor MP in diagnosing the status of its associated dimmer module. First, it is determined whether the dimmer module has power applied to it. This is achieved by monitoring the line source voltage applied to the dimmer. If no power is applied to the dimmer, the LED will be off. If power is applied, the microprocessor determines whether the dimmer module's triac is either shorted or open circuited. This is done by the circuitry described below with reference to FIG. 12. If the triac has failed, the microprocessor causes the status indicator (an LED) to flash several times per second. If the triac is operating properly, the microprocessor determines whether the dimmer is receiving serial data from a control unit over the multiplex link. If no data is received, the LED is blinked on and off slowly, e.g., on for two seconds, and off for four seconds. If data is received, the microprocessor determines whether the dimmer relay is open. If not, thus indicating that the dimmer is operating but the control is telling dimmer to be off, the LED is blinked on for, say 1/4 second, and off for 3/4 second. If the dimmer relay is closed, the LED is blinked on for, say 3/4 second, and off for 1/4 second. This process is continuously repeated to provide a constant update on the dimmer/system status.

[0036] In FIG. 12, a preferred circuit for the dimmer module described above is shown in detail. The various circuit elements of each of the functional blocks shown in FIG. 5 are shown in dashed lines of each block. The AC power circuit includes the circuit breaker S1, relay S2, triac Q5 and RFI choke L1. As mentioned earlier, the circuit breaker provides overcurrent protection and the ability to disconnect AC power to the dimming module. The relay S2 is used to disconnect power to the load being controlled by the dimming module and is controlled by the microprocessor U1. The conduction of triac Q5 is also controlled by the microprocessor in such a manner as to limit conduction to a portion of each AC line cycle; such portion is determined by the zone intensity information provided by one of the wallmounted controls on the multiplex link. Pin 38 of U1 turns on the optically-coupled triac U2 through R14. The current through R16, U2, R17, D7 and D6 triggers the gate of Q5 and forces it to conduct. Once Q5 is conducting, U2 remains on by the current path formed by R18 and R19. This is done to drive high impedance loads with current levels below the holding current of Capacitor C7 is connected across the gate to cathode of Q5 to improve its resistance to
false triggering due to noise. The rate of rise of the load current is limited by the choke L1 to reduce the audible noise (buzzing) in the lamp caused by the abrupt change in current when the Q5 is turned on. The choke also serves, as indicated above, to limit the amount of RFI noise generated by the switching action of Q5. The microprocessor U1 and the relay S1 require DC supply voltages much lower in amplitude than the AC line amplitude. To provide this voltage, the AC line is rectified through the diode bridge DB1 and dropped across a high voltage field-effect transistor FET Q4. Q4 is allowed to turn on whenever Q3 is off. Q3 will be off when the rectified line voltage is less than the sum of the voltages across the zener diode D2 and the drop across the resistor R1 and R1'. The voltage generated across R1 and R1' needed to turn on Q3 is determined by the value of R15. Resistors R1, R1' and R15 form a voltage divider network to bias the base of Q3. The values are selected to limit the peak voltage on Q4 to within its safe operating area. Resistors R2 and R2' provide a means to turn on Q4 when Q3 is off. Resistor R3 serves to slow the charging of the gate capacitor to minimize the RFI noise generated on the AC line when Q4 switches. D11 limits the peak voltage on the gate of Q4. With the values selected, capacitor C1 is allowed to charge to a maximum value of 32Volts. If Q4 is on long enough to try to charge C1 higher, D1 will be biased on, thereby forcing Q3 on and Q4 off.

Once C1 is charged to its maximum value the voltage is used to drive the relay and the microprocessor. The current needed to drive the relay is greater than that required by the microprocessor and the control circuit. To reduce the peak current draw through Q4 and minimize power dissipation when the relay is energized, the current through the relay-coil is used to generate the SVDC supply needed for the microprocessor. When the relay is off, the 32Volts supply is dropped across Q1. The zener D13 allows C2 to charge to 5Volts. Q1 is biased on through R29, and the base voltage is clamped by diodes D15 and D18. When the relay coil is energized, Q8 is turned on by U1, R11, Q2 and R4. The current through the relay coil charges C2 to a value limited by diodes D14 and D13. While D14 is conducting, Q1 is forced off. Hence, C2 can only be charged by the current through the relay coil when the relay is energized.

To control the timing of the gate of Q5, i.e., the triac's firing angle, the AC line zero cross must be known by the microprocessor. This information is provided by the zero-cross detector comprising resistors R6, R6' and the protection diodes D4 and D5. Since the microprocessor is referenced inside the bridge DB1, alternate half cycles of the line voltage force the voltage on pins 41 and 39 of the microprocessor between 5Volts and common. The edges of the transitions define the AC line zero crossing. The microprocessor also requires dimming control information to compute the delay from the zero crossing to turn on the triac during each half cycle. As noted above, this information is received by the dimmer through the serial data link MUX'. A voltage is applied across R7 and pins 1 and 2 of U3 to produce an output through R12, Q7 and R24 into pin 32 of U1. An optically-coupled device is used to provide isolation between the dimmer circuitry referenced to Class I voltage and the Class II circuitry which sends control information to each dimmer.

The input data received on the serial data link is in the form of a string of bits which, in addition to indicating a desired zone intensity, also indicates the load type e.g., incandescent, fluorescent, etc., and maximum and minimum light settings (high and low end trim settings, respectively). The microprocessor uses this information to compute a delay time to turn on the gate of Q5 in each AC half cycle after each AC zero crossing.

Since many dimmer modules may exist on a single serial data link, each dimmer module must have a unique address. The address switches S1, S2, S4, S8, and S16 along with RN1 and RN2 provide inputs to the microprocessor defining a unique combination of up to 32 different addresses.

Light-emitting diode D8 and resistor R20 provide a diagnostic status indicator. The microprocessor causes the LED to "blink" in such a manner as to indicate normal operation or failure modes. One such failure mode is triac Q5 being either open or short circuited. R25, R25', D16 and D17 provide an input into the microprocessor which signifies a fault condition by the presence or absence of voltage at certain points in each half cycle. Another defined failure is the absence of data being received on the serial data link.

The microprocessor also receives an input from the voltage compensation network which it uses to correct the firing angle of the triac during to compensate for variations in the AC line voltage. This correction forces the output voltage of the dimmer to remain relatively constant during these variations. The rectified AC line voltage is taken from the full-wave bridge DB1 through D12. Resistors R5, R5', and capacitor C8 form an integrator to "smooth" the 60Hz ripple of the rectified line voltage. This filtered voltage varies proportionally with the amplitude of the AC line and is used to charge capacitors C9 and C6 through resistor R9. C9 may be switched in and out through R8 and pin 15 of the microprocessor to change the time constant to accommodate different ranges of AC line voltages. C6 is used for 80-160 VAC and C6 plus C9 is used for 160-277 VAC. The capacitors are discharged by R10 and pin 13 of the microprocessor. The microprocessor allows the capacitors to start charging at the AC zero crossing. When the capacitor's voltage reach a threshold level determined by D9, and R26, transistor Q6 turns on and pulls pin 2 of the microprocessor low through R22. The microprocessor measures the charging time of the capacitors and uses it to determine the amount of correction needed. The microprocessor contains the ROM required to store
the program that receives the various inputs and determines the turn-on point of triac Q5 in each AC line cycle. U4 and R13 form an oscillator needed to run the microprocessor.

[0044] The invention has been described with particular reference to preferred embodiments. It will be appreciated the certain variations and modifications can be made without departing from the spirit of the invention. Such variations and modifications are intended fall within the protected scope of the invention, as defined by the appended claims.

Claims

1. A multi-zone lighting control system for selectively controlling the respective light levels of a plurality of lighting zones (Z1, Z2, ...Zn), each of such zones comprising a dimmable light source (L1, L2,.....Ln), said lighting control system comprising:

   a) a lighting control unit (U1, U2,....Un) for transmitting zone-intensity information representing a desired light level for each of a plurality of lighting zones (Z1,Z2,....Zn) on a communications link, said lighting control unit including a plurality of dimming means (A1,A2,....An), each being manually manipulatable to alter said information to reflect a desired change in light level for a different one of the lighting zones (Z1,Z2,....Zn); and

   b) dimming control means (PC) operatively connected to the lighting control unit (U1,U2,....Un) and responsive to said zone intensity information on the communications link for adjusting the light level of said dimmable light sources (L1,L2,....Ln) to achieve the desired light level in each of said lighting zones (Z1,Z2,....Zn), said dimming control means (PC) comprising a plurality of dimming circuits (Dimmer 1, Dimmer 2, .....Dimmer n), each being adapted to control the luminous output of a light source (L1,L2,....Ln) in one of the lighting zones (Z1,Z2,....Zn) in response to receiving an input signal from said lighting control unit(U1,U2,....Un), the multi-zone lighting control system being characterized by the dimming control means (PC) comprising means (CP) for assigning each of the dimming circuits (Dimmer 1, Dimmer 2,.....Dimmer n) to a particular dimming means (A1, A2,......An) so that the respective input signal received by an assigned dimming circuit (Dimmer 1, Dimmer 2,.....Dimmer n) is determined by the zone-intensity information which is adjustable by such dimming means (A1,A2,....An), said assigning means (CP) comprising means for selecting a particular dimming circuit (Dimmer m) from said plurality of dimming circuits (Dimmer 1, Dimmer 2,...Dimmer n), and means responsive to a predetermined sequence of changes in zone-intensity information as produced by a predetermined manipulation of any one of the dimming means (A1, A2,......An) to assign said one dimming means (Am) to the selected dimming circuit (Dimmer m).

2. A multi-zone lighting control system as claimed in claim 1, characterized in that said assigning means (CP) comprises means for storing values representing the instantaneous zone-intensity information produced by said lighting control unit (U1, U2,......Un), and means for monitoring said storing means for changes in said stored values.

3. A multi-zone lighting control system as claimed in claim 1 or 2, characterized in that each of said dimming means comprises an actuator (A1,A2,....An) comprising a moveably mounted member, and wherein said zone intensity information is adjusted by movement of said member.

4. A multi-zone lighting control system as claimed in claim 1 or 2, characterized in that each of said dimming means includes an actuator (A1,A2,....An) comprising a pair of push buttons, one for changing the zone-intensity information so as to increase the luminous output produced by said dimmable light source (L1,L2,.....Ln), and one for changing the zone intensity information so as to decrease the luminous output produced by said dimmable light source (L1,L2,.....Ln).

5. A multi-zone lighting control system as claimed in any one of claims 1 to 4, characterized in that said predetermined sequence of changes in zone intensity information comprises reducing the zone intensity to zero, increasing the zone intensity to a predetermined level, and returning the zone intensity to zero within a predetermined time interval.

6. A multi-zone lighting control system as claimed in claim 1, characterized in that the transmission of the zone-intensity information is by means of multiplexing the zone intensity information on a serial communications link, and wherein each of said dimming means comprises an actuator (A1,A2,....An).

7. A multi-zone lighting control system as claimed in claim 6, characterized in that said assigning means (CP) comprises for storing values representing the instantaneous zone-intensity information produced by said lighting control unit (U1, U2,......Un), and means for monitoring said storing means for changes in said stored values.

8. A multi-zone lighting control system as claimed in
Mehrzonen-Beleuchtungssteuersystem zur selektiven Steuerung der jeweiligen Helligkeitsgrade einer Vielzahl von Beleuchtungszonen (Z1, Z2, ...Zn), wobei jeder derartige Zone eine helligkeitssteuerbare Lichtquelle (L1, L2, ...Ln) umfasst, wobei das Beleuchtungssteuersystem umfasst:

a) eine Beleuchtungssteuereinheit (U1, U2, ...Un) zum Übertragen von Zonenintensitätsinformation, die einen gewünschten Helligkeitsgrad für jede einer Vielzahl von Beleuchtungszonen (Z1, Z2, ...Zn) darstellt, auf einem Datenübertragungssignal, wobei die Beleuchtungssteuereinheit eine Vielzahl von helligkeitssteuernden Mitteln (A1, A2, ...An) umfasst, wobei jedes zum Verändern der Information handhabbar ist, um eine gewünschte Veränderung im Helligkeitsgrad für eine andere der Beleuchtungszonen (Z1, Z2, ...Zn) widerzuspiegeln; und
b) Helligkeitssteuermittel (PC), die funktionsfähig mit der Beleuchtungssteuereinheit (U1, U2, ...Un) verbunden sind und auf die Zonenintensitätsinformation auf dem Datenübertragungssignal umfassend.
jedes der helligkeitssteuernden Mittel ein Stellglied (A1, A2, ...An) beinhaltet, das ein Paar von Tastschaltern umfasst, einen zur Änderung der Zonenintensitätsinformation, um die durch die helligkeitssteuerbare Lichtquelle (L1, L2, ...Ln) erzeugte Leuchtleistung zu steigern, und einen zur Änderung der Zonenintensitätsinformation, um die durch die helligkeitssteuerbare Lichtquelle (L1, L2, ...Ln) erzeugte Leuchtleistung zu senken.

5. Mehrzonen-Beleuchtungssteuersystem gemäß einem der Ansprüche 1 bis 4, dadurch gekennzeichnet, dass die vorbestimmte Sequenz von Veränderungen der Zonenintensitätsinformation das Reduzieren der Zonenintensität auf Null, das Steigern der Zonenintensität auf einen vorbestimmten Grad und das Zurückführen der Zonenintensität auf Null innerhalb eines vorbestimmten Zeitintervalls umfasst.

6. Mehrzonen-Beleuchtungssteuersystem gemäß Anspruch 1, dadurch gekennzeichnet, dass die Übermittlung der Zonenintensitätsinformation mittels Multiplexen der Zonenintensitätsinformation auf einem seriellen Datenübertragungsglied durchgeführt wird, und wobei jedes der helligkeitssteuernden Mittel ein Stellglied (A1, A2, ...An) umfasst.

7. Mehrzonen-Beleuchtungssteuersystem gemäß Anspruch 6, dadurch gekennzeichnet, dass das zuweisende Mittel (CP) zum Speichern von Werten, die die momentane durch die Beleuchtungssteuerung (U1, U2, ..., Un) erreichte Zonenintensitätsinformation darstellen, und Mittel zum Überprüfen des Speichermittels auf Veränderungen in den gespeicherten Werten umfasst.

8. Mehrzonen-Beleuchtungssteuersystem gemäß Anspruch 6 oder 7, dadurch gekennzeichnet, dass das zuweisende Mittel (CP) einen Mikroprozessor (20) umfasst.

9. Mehrzonen-Beleuchtungssteuersystem gemäß Anspruch 6, 7 oder 8, dadurch gekennzeichnet, dass jedes der helligkeitssteuernden Stellglieder (A1, A2, ...An) ein beweglich angebrachtes Bauelement umfasst, und worin die Zonenintensitätsinformation durch die Bewegung des Bauelementes reguliert wird.

10. Mehrzonen-Beleuchtungssteuersystem gemäß Anspruch 9, dadurch gekennzeichnet, dass das Bauelement verschiebbar angebracht ist.

11. Mehrzonen-Beleuchtungssteuersystem gemäß Anspruch 6, 7 oder 8, dadurch gekennzeichnet, dass jedes der helligkeitssteuernden Stellglieder (A1, A2, ...An) ein Paar von Tastschaltern umfasst, einen zur Änderung der Zonenintensitätsinformation, um die durch die helligkeitssteuerbare Lichtquelle (L1, L2, ...Ln) erzeugte Leuchtleistung zu steigern, und einen zur Änderung der Zonenintensitätsinformation, um die durch die helligkeitssteuerbare Lichtquelle (L1, L2, ...Ln) erzeugte Leuchtleistung zu senken.


Revendications

1. Système de commande d'éclairage à zones multiples destiné à commander de manière sélective les niveaux d'éclairage respectifs d'une pluralité de zones d'éclairage (Z1, Z2, ..., Zn), chacune de ces zones comprenant une source de lumière variable (L1, L2, ..., Ln), ledit système de commande d'éclairage comprenant :

a) une unité de commande d'éclairage (U1, U2, ..., Un) pour transmettre des informations d'intensité de zone représentant un niveau d'éclairage souhaité pour chacune d'une pluralité de zones d'éclairage (Z1, Z2, ..., Zn) sur une liaison de communication, ladite unité de commande d'éclairage comprenant une pluralité de moyens de gradation (A1, A2, ..., An), chacun d'eux pouvant être manipulé manuellement afin de modifier lesdites informations pour refléter une modification souhaitée du niveau d'éclairage pour une zone différente parmi les zones d'éclairage (Z1, Z2, ..., Zn) ; et

b) des moyens de commande de gradation (PC) connectés en fonctionnement à l'unité de commande d'éclairage (U1, U2, ..., Un) et sensibles auxdites informations d'intensité de zone sur la liaison de communication pour ajuster le niveau d'éclairage desdites sources de lumière respectives (L1, L2, ..., Ln) afin d'obtenir le niveau d'éclairage souhaité dans chacune desdites zones d'éclairage (Z1, Z2, ..., Zn), ledits moyens de commande de gradation (PC) comprenant une pluralité de circuits de gradation (Dimmer1, Dimmer2, ..., Dimmer n), chacun d'eux étant adapté pour commander la sortie de lumière d'une source de lumière (L1, L2, ..., Ln) dans l'une des zones d'éclairage (Z1, Z2, ..., Zn) en réponse à la réception d'un signal
d'entrée provenant de ladite unité de commande d'éclairage (U1, U2, ..., Un), le système de commande d'éclairage de zones multiples étant caractérisé par les moyens de commande de gradation (PC) comprenant des moyens (CP) pour attribuer chacun des circuits de gradation (Dimmer1, Dimmer2, ..., Dimmer n) à des moyens de gradation particuliers (A1, A2, ..., An), de sorte que le signal d'entrée respectif reçu par un circuit de gradation attribué (Dimmer1, Dimmer2, ..., Dimmer n) soit déterminé par les informations d'intensité de zone qui peuvent être ajustées par ces moyens de gradation (A1, A2, ..., An), lesdits moyens d'attribution (CP) comprenant des moyens pour sélectionner un circuit de gradation particulier (Dimmer m) parmi ladite pluralité de circuits de gradation (Dimmer1, Dimmer2, ..., Dimmer n) et des moyens sensibles à une séquence prédéterminée de modifications des informations d'intensité de zone telles que produites par une manipulation prédéterminée de l'un quelconque des moyens de gradation (A1, A2, ..., An) afin d'attribuer les susdits moyens de gradation (Am) au circuit de gradation sélectionné (Dimmer m).

2. Système de commande d'éclairage à zones multiples selon la revendication 1, caractérisé en ce que lesdits moyens d'attribution (CP) comprennent des moyens pour mémoriser des valeurs représentant les informations d'intensité de zone instantanées produites par ladite unité de commande d'éclairage (U1, U2, ..., Un) et des moyens pour surveiller lesdits moyens de mémorisation quant aux modifications apportées auxdites valeurs mémorisées.

3. Système de commande d'éclairage à zones multiples selon la revendication 1 ou 2, caractérisé en ce que chacun desdits moyens de gradation comprend un actionneur (A1, A2, ..., An) comprenant un élément monté de manière mobile, et dans lequel lesdites informations d'intensité de zone sont ajustées par le déplacement dudit élément.

4. Système de commande d'éclairage à zones multiples selon la revendication 1 ou 2, caractérisé en ce que chacun desdits moyens de gradation comprend un actionneur (A1, A2, ..., An) comprenant deux boutons-poussoirs, l'un pour modifier les informations d'intensité de zone de manière à augmenter la sortie de lumière produite par ladite source de lumière variable (L1, L2, ..., Ln) et l'autre pour modifier les informations d'intensité de zone de manière à diminuer la sortie de lumière produite par ladite source de lumière variable (L1, L2, ..., Ln).

5. Système de commande d'éclairage à zones multiples selon l'une quelconque des revendications 1 à 4, caractérisé en ce que ladite séquence prédéterminée de modifications des informations d'intensité de zone comprend la réduction de l'intensité de zone à 0, l'augmentation de l'intensité de zone à un niveau prédéterminé et le retour de l'intensité de zone à 0 dans un intervalle de temps prédéterminé.

6. Système de commande d'éclairage à zones multiples selon la revendication 1, caractérisé en ce que la transmission des informations d'intensité de zone est réalisée par le multiplexage des informations d'intensité de zone sur une liaison de communication série, et dans lequel chacun desdits moyens de gradation comprend un actionneur (A1, A2, ..., An).

7. Système de commande d'éclairage à zones multiples selon la revendication 6, caractérisé en ce que lesdits moyens d'attribution (CP) comprennent des moyens pour mémoriser des valeurs représentant les informations d'intensité de zone instantanées produites par lesdits moyens de commande d'éclairage (U1 U2, ..., Un) et des moyens pour surveiller lesdits moyens de mémorisation quant aux modifications apportées auxdites valeurs mémorisées.

8. Système de commande d'éclairage à zones multiples selon la revendication 6 ou 7, caractérisé en ce que lesdits moyens d'attribution (CP) comprennent un microprocesseur (20).

9. Système de commande d'éclairage à zones multiples selon la revendication 6, 7 ou 8, caractérisé en ce que chacun desdits actionneurs de gradation (A1, A2, ..., An) comprend un élément monté de manière mobile, et dans lequel lesdites informations d'intensité de zone sont ajustées par le déplacement dudit élément.

10. Système de commande d'éclairage à zones multiples selon la revendication 9, caractérisé en ce que ledit élément est monté de manière coulissante.

11. Système de commande d'éclairage à zones multiples selon la revendication 6, 7 ou 8, caractérisé en ce que chacun desdits actionneurs de gradation (A1, A2, ..., An) comprend deux boutons-poussoirs, l'un pour modifier les informations d'intensité de zone de manière à augmenter la sortie de lumière produite par ladite source de lumière variable (L1, L2, ..., Ln) et l'autre pour modifier les informations d'intensité de zone de manière à diminuer la sortie de lumière produite par ladite source de lumière variable (L1, L2, ..., Ln).

12. Système de commande d'éclairage à zones multiples selon l'une quelconque des revendications 6 à 11, caractérisé en ce que ladite séquence prédéterminée de modifications des informations d'intensité de zone comprend la réduction de l'intensité de zone à 0, l'augmentation de l'intensité de zone à un niveau prédéterminé et le retour de l'intensité de zone à 0 dans un intervalle de temps prédéterminé.
minée de modifications des informations d'intensité de zone comprend la réduction de l'intensité de zone à 0, l'augmentation de l'intensité de zone à un niveau prédéterminé et le retour de l'intensité de zone à 0 dans un intervalle de temps prédéterminé.
ENTER PROGRAMMING MODE.

SELECT ZONE CAPTURE FUNCTION.

SELECT THE DIMMER FOR ZONE ASSIGNMENT.

FLASH LOAD ON SELECTED DIMMER BETWEEN FULL-ON AND OFF.

ADJUST DESIRED ZONE ACTUATOR.

DOES ACTUATOR INDICATE MINIMUM LIGHT LEVEL?

YES

BEGIN ADJUSTING ACTUATOR TOWARDS MAXIMUM LIGHT LEVEL

START TIMEOUT TO LIMIT TIME TO COMPLETE ADJUSTMENT SEQUENCE.

CONTINUE ADJUSTING ACTUATOR TOWARDS THE MAXIMUM LIGHT LEVEL.

NO

ADJUST ACTUATOR TO PRODUCE MINIMUM LIGHT LEVEL.
FIG. 4B

A

DOES LIGHT LOAD TRACK THE ACTUATOR MOVEMENT?

YES

ADJUST ACTUATOR TOWARDS THE MINIMUM LIGHT LEVEL.

NO

B

HAS TIMER TIMED-OUT?

YES

C

DOES ANOTHER DIMMER REQUIRE ZONE ACTUATOR ASSIGNMENT?

NO

HAS THE ACTUATOR PRODUCED THE MINIMUM LIGHT LEVEL?

NO

YES

DOES ANOTHER DIMMER REQUIRE ZONE ACTUATOR ASSIGNMENT?

NO

EXIT PROGRAM MODE!
START POWER-UP SEQUENCE CHECK.

HAS POWER BEEN APPLIED TO THE DIMMING MODULE?

YES

HAS VALID DATA COME IN FROM DIMMER PANEL SINCE POWER-UP?

NO

NO

GO TO FULL INTENSITY.

YES

GO TO THE INTENSITY SPECIFIED BY THE SERIAL DATA.

CONTINUE CHECKING FOR VALID DATA.

FIG. 9A
DISCHARGE VOLTAGE COMPENSATION CAPACITOR UNTIL NEXT AC LINE ZERO CROSSING.

IS THE CHARGE TIME SHORTER THAN THE ALLOWED MINIMUM VALUE?

YES

IS THE CAPACITOR VALUE SELECTED FOR 80–160V AC OPERATION?

YES
LINE VOLTAGE IS TOO LOW FOR PROPER OPERATION, FORCE A RESET.

FIND THE ERROR BETWEEN THE NEW CHARGING TIME AND THE LONG-TERM AVERAGE.

UPDATE THE LONG-TERM AVERAGE BY ADDING OR SUBTRACTING A FRACTION OF NEW CHARGE TIME.

CHANGE TRIAC FIRING TIME BY AN AMOUNT BASED ON THE ERROR VALUE, LOAD TYPE AND CURRENT FIRING ANGLE.

NO

FIG. 10B
FIG. 1A

- IS THE DIMMING MODULE'S TRIAC SHORTED OR OPEN CIRCUITED? [NO → YES]
  - FLASH LED RAPIDLY—APPROXIMATELY 8X A SECOND.
  - LED IS OFF.

- DOES DIMMER MODULE HAVE POWER APPLIED TO IT? [YES → NO]
  - CONTINUE TO MONITOR FOR CHANGES IN ANY OF THE ABOVE STATUS!
IS THE SERIAL DATA LINK FROM THE INTEGRATOR BOARD WORKING? YES NO
BLINK THE LED ON AND OFF SLOWLY--ON FOR 2 SECONDS AND OFF FOR TWO SECONDS.

IS THE DIMMER RELAY ON? YES NO
TURN THE LED ON FOR 3/4 SECOND AND OFF FOR 1/4 SECOND.

FIG. 1B

TURN THE LED ON FOR 1/4 SECOND AND OFF FOR 3/4 SECOND.