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GAS DISCHARGE LAMP DIMMING SYSTEM
EMPLOYING SWITCHING CONTACT INPUTS

BACKGROUND OF THE INVENTION

5 This invention relates to a gas discharge lamp control system which can be dimmed in a smoothly variable manner by the on/off switching signals of contacts operated in accordance with time of day or in accordance with the output of an energy management computer control system.

10 Energy management systems for the control of gas discharge lamps are known and are shown, for example, in U.S. Patent No. 4,350,935, issued September 21, 1982, in the names of Joel S. Spira et al., entitled "Gas Discharge Lamp Control". In such systems, the lamp output is dimmed in accordance with an input signal derived from an environment condition such as exterior light intensity, interior light intensity or by a manual control. The input signal to the
15 dimmer structure is conventionally a continuous analog signal with proportional control being obtained.

20 Other control systems are known in which the system is operated in response to the opening or closure of the switch. For example, switches can be operated in response to time of day and/or the output of an energy management computer system. The operation of the switches will then

switch on and off different load circuits such as air conditioners, furnaces, fans and the like. The control of such loads from input switching signals has been acceptable and even desirable since such loads as air conditioners, furnaces and fans are not easily capable of proportional control. In some cases the use of such control switches has been employed to control interior lighting by appropriate on/off cycling of the lighting, rather than its proportional control.

The control of interior lighting is desirable as an energy saving measure when it is possible to reduce lighting during periods of high ambient light or low activity in certain areas which relate to time of day, such as lunch period, cleanup period and the like. Such control is also desirable as a function of peak loads and the like. It has in the past, however, not been possible to employ the switching signals from time of day, energy management computer, peak demand meters, and other device output contacts to control proportionally controllable gas discharge lamp dimmers.

According to the present invention there is provided a gas discharge lamp control system comprising, in combination: a gas discharge lamp and a ballast therefor; a source of electrical power; dimming control means having a set of analog input proportional control circuit means responsive to predetermined control inputs and an additional single analog input proportional control circuit means for accommodating external stimuli inputs; said dimming control means further having output terminals which are connected between said gas discharge lamp and ballast therefor and said source of electrical power; a plurality of input control switch means each of which is operable between an open and closed position; an isolation circuit associated

with said input control switch means, said isolation
circuit being sufficient at least for reducing
coupling of extraneous noise between various circuits
that are being controlled, and a digital-to-analog
5 convertor having a digital input circuit and an analog
output circuit; said plurality of input control switch
means being coupled to said digital input circuit
through said isolation circuit; the output signal of
said analog output circuit being related to the
10 position of said plurality of input control switch
means; a coupling circuit means for coupling said
analog output circuit to said additional single input
proportional control circuit means of said dimming
control means; and a controller for receiving said
15 external stimuli and for controlling the state of said
plurality of input control switch means.

In accordance with one embodiment of the present
invention, a plurality of contacts which are
associated with time of day measurement and/or with

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the output of such devices as computer energy management systems, peak demand meters and the like, are arranged to provide respective digital inputs into a digital-to-analog converter. Thus, depending upon the position of the plurality of contacts which are controlled, a particular digital number is created in either bit serial or bit parallel format and is used as an input to the digital-to-analog converter. The output of the analog converter is an analog signal having a value of the particular binary number which was input to the converter. This analog signal is then applied through a fader circuit to the proportional input control terminal of a conventional gas discharge lamp dimmer circuit. The dimmer will then accept this information to control the output power applied to the gas discharge lamps in accordance with the digital input number to the digital-to-analog converter. The fader circuit causes a slow change in the analog signal input to the dimmer even though the digital number changes in step fashion. This prevents annoying rapid lighting changes within the interior of the area being controlled. Suitable isolation circuits are provided to isolate the input circuitry of the lamp dimmer controller and the digital system input terminals, so that fault

conditions in either the lamp dimmer system or the energy management computer will not affect the operation of companion-operated devices and to reduce the coupling of extraneous noise between devices within the system.

Note also that this type input can also be used in conjunction with daylight, interior or other photocell controls, and could set the maintained foot-candle level of the photocontrol system.

An important advantage of the arrangement is that any desired number of parallel output circuits (lamp, ballast and dimmer combinations) can be used without adversely affecting input signal level. Thus, when large numbers of output circuits may be controlled from an analog input signal and the actual numbers of output circuits is unknown, the analog signal level may be adversely modified by the connection of a large number of output circuits. When a switch is used for the input circuit, the switch contacts are either open or closed and the control signal is therefore substantially unaffected by the number of output circuits being controlled.

The invention will be described now by way of example only with particular reference to the accompanying drawings which is a block diagram showing

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a system in accordance with the present invention.

Referring to the drawing, there is first shown a conventional gas discharge lamp dimmer system 10 which can

take the form of that shown in U.S. Patent No. 4,350,935,
issued September 21, 1982, in the names of Joel S. Spira,
et al., entitled "Gas Discharge Lamp Control". The a-c
power input schematically illustrated at the terminals 11
5 and 12 is connected through the dimmer structure 10 which
operates to put a variable width notch in the output a-c
power which is applied to the gas discharge lamps and bal-
lasts schematically shown in block 13. The notched waveform
is schematically illustrated under the dimmer output line in
10 the drawing. Conventionally, the notched waveform is con-
trolled in response to input signals which can be applied
from lines 14, 15 or 16 and which correspond to manual con-
trol, the input from an external light sensor and the input
from an interior light sensor, respectively, all of which
15 are conventional.

An additional in-
put 17 is provided for the dimmer structure 10 which operates
like the inputs connected to lines 14, 15 and 16 where, how-
ever, the input control line 17 is operable in response to
20 the opening and closing of one or more switches. Thus, as
further shown in the drawing, a plurality of switches 20, 21
and 22 are provided which are conventional switches operated
from a time of day clock and/or from an energy management
computer system of well known type. The time of day input
25 and the energy management computer system are schematically
illustrated in the block 23. Peak demand devices or other
similar devices with contact closures as an output can also
be used. Note that the inputs to the block 23 are typically
time of day, external temperature, total energy demand in
30 the system which includes the a-c input terminals 11 and 12,
illumination level and manual. Other inputs could also be
applied to the computer system 23.

If desired, it is also possible to manually operate
switches 20, 21 or 22. For example, switch operators can
35 be fixed in a wall box or the like and available for manual
operation.

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The output of the computer system 23 will then open and close the contacts 20, 21 and 22 in predetermined ways which have conventionally controlled such systems as air conditioners, furnaces and fans schematically illustrated in the block 24. For example, the system 23 can consist of a
5 suitable microprocessor, or could consist more simply of a time-driven cam, the lobes of which operate contacts 20, 21 and 22 between opened and closed positions, as will be later described.

10 The three contacts shown are combined to provide a three-bit binary number input through isolation circuits 25, 26 and 27 to the digital input circuits of a conventional digital-to-analog converter 28. The particular three-bit number which is formed will have
15 one of eight values depending upon the open or closed states of contacts 20, 21 and 22.

The output of the digital-to-analog converter 28 will then produce an appropriate output analog signal related to the value of the digital number which was produced. This
20 output signal is preferably connected through a fader circuit 29 to the input line 17 which effects proportional control of the gas discharge lamp control system.

The fader circuit 29 is of well known type and operates to limit the rate of change of the output signal
25 from the fader circuit to a preset rate even though the input signal to the fader circuit from the digital-to-analog converter 28 changes in stepwise fashion from one binary number to another.

Isolation circuits 25, 26 and 27 are desirable to
30 isolate the input circuit 17 of the dimmer 10 from the input circuits from contacts 20, 21 and 22 and from the power devices 24 and computer 23. This isolation greatly reduces the potential coupling of extraneous noise between the various circuits being controlled. It also prevents fault conditions
35 in either of the circuits from affecting the other.

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A tabulation follows, showing the eight digital numbers which can be formed by three contacts 20, 21 and 22 along with the condition causing the closure or opening and the percentage dimming which is desired.

BINARY NUMBER	CONTACT 20	CONTACT 21	CONTACT 22	DIMMING (% of Full)	TIME OF DAY
000	CLOSED	CLOSED	CLOSED	100%	3 PM-6 PM
001	CLOSED	CLOSED	OPEN	90%	1 PM-3 PM
010	CLOSED	OPEN	CLOSED	80%	11 AM-12 PM
011	CLOSED	OPEN	OPEN	70%	10 AM-11 AM
100	OPEN	CLOSED	CLOSED	60%	9 AM-10 AM
101	OPEN	CLOSED	OPEN	50%	12 PM-1 PM
110	OPEN	OPEN	CLOSED	40%	6 PM-8 PM
111	OPEN	OPEN	OPEN	30%	8 PM-9 AM

The above table shows the switch control responsive only to time of day for an area in which the sun is received in the working area in the morning. Thus, in the morning, interior lighting is dimmed to 80% of its full value. Light intensity is gradually increased as the advantage of sunlight in the building is lost until, between 3 P.M. and 6 P.M., light intensity is at its full value. Note that at lunch time, 12 P.M. to 1 P.M., the lights are dimmed down to 50% of their full value. At the end of the work day and from 6 P.M. to 8 P.M. the light is dimmed to 40% of its value and after 8 P.M. down to 30% of its value.

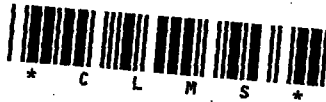
Other inputs (not shown) can cause other switching. For example, if clouds keep the interior room from being sufficiently lighted, an exterior light sensor can override the time-of-day input from contacts 20, 21 and 22. Similarly, if energy demand as determined by the local power

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company is excessive, the time of day closure of the contacts can be modified to reduce the output light to a percentage lower than that which would be called for solely by time of day. External temperature inputs can also operate the switches 20, 21 and 22 appropriately to again modify the percentage dimming of the lamps in accordance with some predetermined schedule.

Additional contacts can be used in the system to permit a larger number of digital numbers in the output which would cause a greater number of possible dimming conditions for the system. Also fewer numbers of contacts can be used where such precision is not necessary.

In the drawing it will be noted that the system is shown using the bit parallel information from contacts 20, 21, 22 into the digital-to-analog converter 28. Clearly, conventional computer techniques can be employed to permit the use of bit serial information, if desired.

Although the present invention has been described in connection with a preferred embodiment thereof, many variations and modifications will now become apparent to those skilled in the art. It is preferred, therefore, that the present invention be limited not by the specific disclosure herein, but only by the appended claims.



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CLAIMS

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- 5 1. A gas discharge lamp control system comprising,
in combination:
- 10 a gas discharge lamp and a ballast therefor; a source
of electrical power; dimming control means having a
set of analog input proportional control circuit means
15 responsive to predetermined control inputs and an
additional single analog input proportional control
circuit means for accommodating external stimuli
inputs; said dimming control means further having
output terminals which are connected between said gas
20 discharge lamp and ballast therefor and said source of
electrical power; a plurality of input control switch
means each of which is operable between an open and
closed position; an isolation circuit associated with
said input control switch means said isolation circuit
25 being sufficient at least for reducing coupling of
extraneous noise between various circuits that are
being controlled, and a digital-to-analog convertor
having a digital input circuit and an analog output
circuit; said plurality of input control switch means
30 being coupled to said digital input circuit through
said isolation circuit; the output signal of said
analog output circuit being related to the position
of said plurality of input control switch means; a
coupling circuit means for coupling said analog
35 output circuit to said additional single input
proportional control circuit means of said dimming
control means; and a controller for receiving said
external stimuli and for controlling the state of said
plurality of input control switch means.
- 35 2. A control system as claimed in claim 1, wherein
said coupling circuit means includes a fader circuit
for controlling the rate of change of the analog



signal on said analog output circuit caused by a change in the input digital signal to said digital-to-analog converter.

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9. A gas discharge lamp control system substantially as hereinbefore described with reference to and as shown in the accompanying drawings.