SLAVED VARIABLE POWER CONTROL

Inventor: Robert L. Harris, North Scituate, R.I.

Assignee: General Electric Company

Filed: May 18, 1970

Appl. No.: 38,327

U.S. Cl. 323/24, 307/252 T, 321/27 MS
Int. Cl. G05F 1/44

Field of Search 321/5, 27 MS; 323/22 SC, 22 LD, 323/24, 21; 307/252.21, 252.73 T; 317/49

References Cited

UNITED STATES PATENTS

3,358,187 12/1967 Malmin et al. 323/22 SC
3,450,941 6/1969 Butts 323/22 SC

FOREIGN PATENTS OR APPLICATIONS
3,504,266 3/1970 Schlabach et al. 321/5

OTHER PUBLICATIONS
RCA Tech. Notes, Jan 1968; RCA TN No. 740.

Primary Examiner—Gerald Goldberg
Attorney—Paul E. Rochford, Frank L. Neuhauser, Oscar B. Waddell and Joseph B. Forman

ABSTRACT

A dimming circuit is provided which can be included in an essentially unlimited master and slave bank of dimming units controllable from a single master dimmer. The phase control signal on which dimming control of slaves depends is detected from the rapid rise in turn-on current in the master and in each slave coupled to a dependent slave.

4 Claims, 2 Drawing Figures
SLAVED VARIABLE POWER CONTROL

The present invention relates to a solid state dimming circuit which can handle large power loads and which can be used as either a master or a slave in a modular system.

In supplying power controls to control the lighting level of buildings having large areas to be lit, it is desirable to be able to control the lighting in a number of patterns so that various needed and desirable lighting effects can be obtained. For example, in the lighting of a large auditorium or church or gymnasium, it is often desirable to be able to set the level of lighting for the entire enclosed area at one level with a single control. On the other hand, it may be desirable to regulate the lighting level of various portions of the large enclosure from a number of separate controls where the separate controls are located together or at several locations.

One way in which it has been possible to achieve the control of lighting of an entire large structure, and to later modify the lighting arrangement so as to control portions of the lighting from separate controls or separate control points, is by the use of the so called modular system. Using this system, the dimmer modular unit or module is disposed in a single 15 amp branch circuit extending from the circuit breaker in a service entrance box and all of the lights on that single branch circuit are subject to control by the single module connected into the circuit. With one of the modules connected into each of the 15 amp branch circuits which are to be controlled, the individual control of each branch circuit is feasible. That is, control of the lighting powered by each of the branch circuits can be separately controlled either from the dimmer module or from some remote point, where there is an electrical connection between the remote point and the module.

Alternatively, the modules may be interconnected so that control of the lighting on any two or more of the branch circuits is accomplished from a single module or from a remote control point connected to the single module even though there is no interconnection of power lines among the several branch circuits. The master module is that which first receives the direct adjustment signal and the slave modules are those which follow that produced by or from the master module. Also, the entire set of modules may be controlled from a single control point or from a single master module, where all other modules are connected as slaves.

There is a distinct advantage, in the installation of the modules into power circuits of a building, in simplifying the installation procedure and arrangement and rearrangement of wiring which has to be done in order to employ a module as a master or to employ it alternatively as a slave controlled unit.

It is accordingly one object of the present invention to provide a single dimmer module which can be employed alternatively as a master or as a slave unit of a module system.

It is another object of the present invention to provide a module dimmer unit which does not require appreciable modification of the internal wiring or addition or removal of parts to permit use of the module as a master control unit or as a slave controlled unit of a module system for power control.

It is a further object of the present invention to provide a module for power control which can be used as a slave control unit in indefinite numbers without loss or lag of the control operation responsive to a control signal from the first to the last of the modules of a linked system.

Still another object of the present invention is to reduce the level of interference signals which may cause actuations of the master or controlled units of a module system.

Other objects and advantages of the invention will be in part apparent and in part pointed out in the description which follows.

In one of its broader aspects the objects of the present invention are achieved by providing a power control unit, said unit comprising a first and second power terminal to receive alternating current power, and a first and second load terminal for connection of said power control unit to a load, a bidirectional solid state power switch, said switch having two power terminals and a gate terminal, the first power source terminal being connected to a first of said switch power terminals, a pulse coil having a primary and secondary, and a filter coil, the primary of said pulse coil and said filter coil being connected in series between a power terminal of said solid state switch and a first load terminal, the second load terminal being connected to said second power source terminal, a phase shift network including an impedance and capacitance in series connection, said network being connected in parallel with said power switch, the junction of said capacitance and impedance being connected to the gate terminal of said power switch through a solid state trigger switch, a bypass network comprising a resistance and capacitance in parallel connection, said bypass network being connected in parallel to the primary of said pulse coil.

As used herein the term bidirectional solid state switch means a solid switch or combination of such switches which are capable of bidirectional phase controlled current switching.

The present invention and the manner in which it can be carried into effect will be better understood in the description which follows by reference to the accompanying drawing in which:

FIG. 1 is a wiring diagram for two modules of the present invention one being illustrated as connected for the master mode of operation and the other being illustrated as connected for the slave mode of operation.

FIG. 2 is an illustration of the circuitry employed in the manual control for remote operation of a dimmer system.

Referring first to FIG. 1, a circuit is shown having an upper module 10 and a lower module 12.

Three wires 14, 16, and 18 connect the upper module to the lower and these connections will be described more fully below.

However, as will be apparent from comparison of the upper with the lower module, the components of each, as illustrated in the wiring diagrams, are essentially duplicates. Yet, as also explained more fully below, the upper module serves as a master and the module below serves as a slave even though either module could serve either function.

Referring now first to the upper module 10, the circuit and its components are described.
Power supply terminals 20 and 22 are adapted to receive line voltage from a branch line of a conventional source of alternating current power not shown. This voltage may be impressed across the terminals 40 and 42 by closing the conventional relay 24. The relay 24 includes two terminals 23 and 25, a conductor bar 26, a magnetic plunger 27 and solenoid coil 28. Coil 28 is connected to receive energizing current from line 31 extending between terminals 30 and 32. Switch terminals 29 a and 29 b are shown as provided in line 31 to permit switching connections to connect the relay across the terminals 30 and 32. The terminals 30 and 32 receive line voltage from power terminals 20 and 22 respectively.

In field installation of the upper module 10 as a master, the master relay switch 29 is located at some remote location at which a manual or other on-off control as well as brightness control are to be exercised. Such a remote on-off and brightness control are shown schematically in FIG. 2. In FIG. 2 the on-off switch 29 has terminals 29d and 29c which corresponds to switch terminals 29a and 29b of the master module 10. The switch 29 is shown in phantom in module 10 for ease of understanding its function in the circuit. In units for field installation as slaves only terminals 29b and 29c are included. Accordingly, the unit for installation as a slave has terminals 29a' and 29b' as seen in module 12 and the connections to a switch such as 29' are omitted as unnecessary for operation of the slave. All units are adapted for ready connection to terminals 29d and 29e of the remote switch control unit of FIG. 2.

When switch 29 of module 10 is closed, current passing through coil 28 causes plunger 27 to descend and close relay 24. With relay 24 closed, line voltage is impressed on the circuit elements between terminals 40 and 42 and accordingly across line 48, terminal 44, and thyrector 46.

The thyrector is employed to protect the triggering network and the SCRs as well. It is incorporated in the circuit to prevent voltage surges from damaging the network. The thyrector may be included in a subcircuit comprising a resistor 52 connected in parallel with the thyrector 46 and a series connection of a capacitor 50, a resistor terminal 51, a terminal 53, a fuse 54, a load (not shown) connected in the circuit through a pair of load or controlled power supply terminals 55 and 56, a resistor terminal 58 and terminal 42. Resistor 52 is connected between terminals 51 and 58. Alternatively thyrector 46 may be included in the power subcircuit in parallel with the reverse parallel SCRs. In this location it may be connected between junctions 83 and 86 as shown in phantom in FIG. 1.

Between terminal 40 and 53 phase controlled switching and auxiliary circuitry is provided as follows:

A primary power path is provided by the series connected terminal 60, conductor 11, terminal 83, bidirectional solid state switch 81, terminals 85 and 86, pulse coil 90, terminal 91, and filter coil 92.

A phase control signal path extends in parallel with bidirectional solid state switch 81 between terminal 60 and 86 and provides a phase control signal through diac 74 as explained more fully below.

With reference first to this phase control signal path, a resistor 62, junction 65, and a capacitor 64 are connected in series between junction 60 on power line 11 and junction 66 on signal line 9. The series connected impedance 62 and capacitor 64 are accordingly connected in parallel to the solid state bidirectional switch 81. A series connected trim resistor 67, junction terminal 70, and capacitor 69 are connected between the junctions 65 and 66.

The junction 70 between trim resistor 67 and capacitor 69 is connected to a terminal 71a which is one of three terminals 71a, 72a, and 73a to which a remote power controller 90 may be connected. In other words, the remote power controller 90 is not built into each of the module units themselves inasmuch as the remote power control is done from a remote location. The three terminals 71a, 72a, and 73a to which such a controller 90 is connected from a remote location are however built into each of the modules as seen in module 10 and 12.

A second 72a of the three terminals for this remote power control 90 is connected to a diac 74 and the third terminal 73a is connected to power line 11.

As seen in FIG. 2 terminal 71b, 72b, and 73b are provided in remote power controller 90 adapted for connection to the correspondingly numbered a operative terminals of module 10. For clarity of illustration the components of remote power control unit 90 are shown in phantom in module 10. Included in the controller are resistance 95 and variable resistance 94.

Diac 74 is connected to the junction 75 of a series connected pulse coil 76 and a diode 77. The diode 77 is connected to and oriented to permit flow of current to the trigger terminal of a solid state switch such as an SCR 78. The coil 76 is connected at its opposite end through a junction 79 to signal line 9 and to junction 86.

The SCR 78 is connected in reverse parallel with a second SCR 80, to form what is in operational effect a bidirectional solid state switch. A series connected pulse coil 82 and diode 84 supply trigger current to the gate of SCR 80.

The reverse parallel connected SCRs 78 and 80 are connected at their upper end through junction 84 to junction 83 and accordingly to power supply line 11.

Also, the SCRs 78 and 80 are connected at their lower end through a series connection of junctions 85 and 86 of primary 90 of pulse coil, junction 91, and filter coil 92 to junction 53.

Accordingly, it will be evident that the main power path through the apparatus is from power terminal 20 to load terminal 55 and thence to a load not shown and from load terminal 56 to terminal power 22. A portion of the main power path is from terminal 20 to terminal 55 through line 11, the reverse parallel connected SCRs 78 and 80, the two series connected coils 90 and 92, and the fuse 54.

Another portion of the main power path is from terminal 56 to terminal 22 through line 13.

The main path of a trigger signal current to control flow of power through the power path is between junction 60 and junction 79. Referring now specifically to this path, the three terminal 71a, 72a, and 73a are understood to be connected to the three terminal 71b, 72b, and 73b of remote control unit 90, so that variable resistance 94 and resistance 95 are connected between terminals 71 and 73 and terminal 71 is directly connected to terminal 72.
Accordingly, when the reverse parallel SCRs 78 and 80 are in their non-conducting or high impedance state, and with relay 24 closed, as voltage builds up between junction 60 and 53, current will flow through resistances 62 and 95 and variable resistance 94 to charge capacitors 64 and 69.

The rate at which the capacitors are charged is dependent on the values of the resistors. Accordingly, the time during a normal half cycle of alternating current of charging the capacitors is varied by varying the resistance of variable resistance 94. The rate of charging is also in part controlled by the setting of the trim resistor 67, particularly for those settings for variable resistor 93 at the high end of its range of resistances.

The charging of the capacitors results in a build-up of potential on terminal 72a to a voltage level at which diac 74 fires, or in other words, changes from its high impedance state to a low impedance highly conductive state. The firing of diac 74 produces a current flow to diode 77 and through pulse coil 76. Because pulse coil 76 is coupled with pulse coil 82, the flow of current will, depending on its direction, activate the trigger terminal of SCR 78 or SCR 80 and will permit power current to flow through the power current path described above.

Pulse transformer primary 90 is positioned in the power path and between the reverse parallel SCRs and the load terminals 55 and 56. It is the high flow of current through the primary 90 of this pulse transformer at the time at which either of the reverse parallel SCRs are fired (i.e., in either direction) which generates a slave firing signal pulse in the secondary 94 of this pulse transformer. This signal from the secondary 94 of module 10 is supplied through conductors 14 and 16 shown in phantom to the primary 96 of module 12 serving as a slave unit.

The slave unit 12 has essentially all of the same components as master unit 10, the components being shown in solid lines in both modules. Not all of the identifying numbers assigned in module 10 are shown in module 12 but only those needed to explain the operation of the two units. Where shown, they are shown with a prime designation to indicate the corresponding part of module 10 which bears the same identifying numeral without the prime. Where not marked, the functions of components of module 12 will be understood to correspond to those of module 10.

Line 18 supplies power to terminal 29 of module 12 to actuate relay 24' and a similar line 18' is similarly connected to a next lower tier slave module (not shown.) When relay 24 is energized by closing switch 29, all slave relays are similarly energized through lines 18, 18', etc.

In master module 10, both secondaries 76 and 82 of the trigger pulse coil 96, 76, and 82 are included in the trigger circuit. Turn on pulses are supplied to SCRs 78 and 80 when diac 74 fires. Accordingly, as explained above when diac 74 fires, a turn-on pulse is delivered to SCR 78 or to SCR 80 through its respective diode 77 or 84. Depending on the direction of current flow, coil 76 or coil 82 receives or imparts a pulse to its respective SCR through its respective diode 77 or 84. Although pulse coil 96 is part of the trigger pulse coil 76, 82, and 96, it takes no part in initiating conduction of the SCRs of module 10.

In slave unit 12, however, initiation of conduction of SCRs does not result from firing of a diac 74'. Rather, the primary 96' receives a pulse signal through conductors 14 and 16 from pulse coil secondary 94 of pulse coil 90 and 94. The pulse received by primary 96' causes triggering pulses to be generated in secondaries 76' and 82'. These triggering pulses are transmitted in turn to diodes 77' or 84' of the SCRs 78' or 80' of slave unit 12 depending on the direction of the pulse received in primary 96'.

It will be seen that the primary 96' of a trigger pulse coil of the slave 12 is connected to receive the signal from pulse coil secondary 94 of the master 10.

It is important to note that both the slave 12 and the master 10 have essentially the same pulse coils and pulse coil components. This permits either unit 10 or 12 to be connected as a master or a slave.

One difference in the mode of connection is that pointed out above namely that the primary 96 of the trigger pulse coil of master 10 is not connected to play a part in firing of SCRs 78 or 80. In the slave mode of operation the electrodes 71a', 72a', and 73a' of module 12 have no connections made to them and no trigger pulse is generated in the phase shift circuitry associated with these terminal of module 10.

A signal is generated in primary 90 due to the rapid rise in current when the SCRs are turned on and it is this signal which is transmitted to the slave module 12, as indicated above to turn on the slave. Accordingly, any such pulse generated in primary 90 will also cause slave module 12 to turn on.

The pulse transformer 90, 94 has in parallel with its primary 90 a resistance 100 of relatively low value which may suitably be of the order of 5 ohms. Pulse coil primary 90 also has in parallel therewith a capacitor 102 which may also suitably be of the order of 0.47 microfarads.

The functions of the parallel resistor 100 and capacitor 102 are as follows:

The capacitor is needed to permit line noises to bypass the primary 90 of the sensing pulse transformer 90, 94.

The line noises can enter the power line from the power supply and, in the absence of the rate network 106, 108 described below, can turn on either of the SCRs depending on the direction in which the noise spike proceeds through the line. A momentary flash or winking occurs in the master light load and will also occur as well in all slave light loads as a result of a spike producing a momentary pulse in master pulse primary 90. The flash production in all slaves is due to the arrangement by which the slaving is cascaded. This is illustrated in FIG. 1 in which the lines 14' and 16' are seen to be connected from secondary 94' of pulse transformer 90', 94' of slave module 12. These lines conduct a pulse to a primary of a lower tier slave (not shown) in the same manner in which lines 14 and 16 carry a pulse from secondary 94 of module 10 to primary 96 of module 12.

A second function of the capacitor 102 relates to a rate network. The rate network comprises the resistor 106 and capacitor 108 in line 110, the line 110 extending between terminals 83 and 91 in the power path. The capacitor 102 also permits signals passing through the rate network to act in effect as if the rate
network were connected directly across the SCRs. This effect is achieved because the rate network is connected in parallel with both the SCRs and the primary 90 of the signal generating pulse transformer. If the capacitor 102 were omitted and the rate network were connected in parallel only with the SCRs, a spike or noise which had gone around the master SCRs would generate a pulse in the signal pulse coil 90 and cause a winking of the slave SCRs such as 78', 84' controlled by the pulse coil 90.

Accordingly, the capacitor 102 permits noise pulses which arrive at junction 86 or 91 to bypass the pulse coil primary 90.

The capacitor 102 is also effective in preventing flashing or winking of the master light load due to a particularly large spike pulse because it provides a connection between the SCRs and the rate network which has a low impedance path for the type of large spike pulse which could turn the SCRs on in the presence of a rate network alone connected between junctions 83 and 91.

Resistor 100 is included in parallel with capacitor 102 to prevent flashing in the slaves from a pulse generated in pulse primary 90 as capacitor 102 discharges at the time the SCRs stop conducting. In fact, the coil 90 and capacitor 102 can function as a tank circuit and cause repeated pulses to be generated in pulse primary 90. However, resistor 100, which may have a low resistance value of the order of 5 ohms, dissipates the energy stored in the capacitor so that current pulses do not flow through the pulse coil primary 90 when the capacitor discharges.

With the rate network 106, 108 in place, the line noises are transmitted around the SCRs and the primary 90 of the pulse transformer.

However, because of the relatively high impedance of the primary 90 compared to the SCRs in the absence of the capacitor 102, there would be occasional flashing or winking of the master light load when a particularly steep wave front is impressed across the master SCRs resulting in the SCRs turning on. This flash in the master would not be transmitted to the slaves because of the spike, but would be because the SCRs had been turned on. As in every instance when the SCRs are turned on, there is a signal pulse generated in primary 90 due to the rapid increase in current as the SCRs start to conduct.

In closing relay 24, a winking can result because a line voltage is at that time applied to the SCRs and the voltage across the SCRs in the absence of the rate network, will go from zero to whatever instantaneous value of the half cycle the line voltage happens to be at.

If a rate network were connected only across the SCRs, the slaves would wink although the rate network would be effective in preventing winking of the master. Accordingly, a particular array of circuit elements as shown in FIG. 1 protects the circuit from flashing or winking due to spikes of various sources and performs this function effectively without reference to the size or strength of the spike within the limits of spikes normally encountered on power lines.

A further desirable feature of the present invention is that it permits independent master control of a group of subservient modules. Thus while module 12 serves as a slave module as shown hooked up with wires 14, 16 and 18 from module 10, it can also be used as a master by incorporating remote switch 29' and remote controls 90', 93', 95' into the circuit by connecting leads 71b', 72b' and 73b' to module 12 leads 71d', 72d' and 73d'. Thus if master 10 is shut off, module 12 functions as a master and controls all subservient slaves. Also if module 12 and all its slaves are set at a low lighting level, they remain subservient to master 10 for all lighting levels above the low level for which module 12 is set.

From the foregoing it is apparent that unique control of dimming operations is feasible using the module of the present invention.

What is claimed is:

1. A power control unit, said unit comprising a first and second power terminal to receive alternating current power, and a first and second load terminal for connection of said power control unit to a load, a bidirectional solid state switch having two power terminals, said bidirectional switch including two unidirectional solid state switches connected in reverse parallel, each of said unidirectional solid state switches having a gate terminal, a first pulse transformer having a primary and two secondaries, each secondary of said first pulse transformer being connected respectively to a separate gate terminal of said unidirectional solid state switches, the first power source terminal being connected to a first of said bidirectional switch power terminals, a second pulse transformer having a primary and secondary, the primary of said second pulse transformer being connected in series with a filter coil between the second of said bidirectional switch power terminals and a first load terminal, the second load terminal being connected to said second power source terminal a phase shift network including a variable impedance and capacitance in series connection, said network being connected in parallel with said power switch, the junction of said capacitance and impedance being connected through a solid state trigger switch to a secondary of said first pulse transformer, a by-pass network comprising a resistance and a capacitance in parallel connection, said by-pass network being connected in parallel to the primary of said second pulse transformer.

2. A power control unit, said unit comprising a first and second power terminal to receive alternating current power, and a first and second load terminal for connection of said power control unit to a load, a bidirectional solid state switch, said switch having two power terminals and a gate terminal, the first power source terminal being connected to a first of said switch power terminals, a pulse transformer having a primary and secondary, the primary of said pulse transformer being connected in series with a filter coil between the second of said switch power terminals and a first load terminal,
the second load terminal being connected to said second power source terminal, a phase shift network including a variable impedance and capacitance in series connection, said network being connected in parallel with said power switch, the junction of said capacitance and impedance being connected to the gate electrode of said power switch through a solid state trigger switch, a by-pass network comprising a resistance and a capacitance in parallel connection, said by-pass network being connected in parallel to the primary of said pulse transformer, and a rate network comprising a series connected resistance and capacitance connected in parallel with the series connected power switch and pulse transformer primary.

3. The unit of claim 1 in which the solid state bidirectional switch has said first pulse transformer secondaries connected in series with diodes to supply trigger voltage to said reverse parallel switches and said first pulse transformer secondaries are magnetically coupled to each other and to said second pulse transformer primary winding having two terminals.

4. The unit of claim 1 in which the impedance of said phase shift network is remote from said unit and said impedance is variable from a remote location.

* * * * *