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(54) **METHOD AND APPARATUS FOR ELECTRICAL LOAD CONTROL NETWORK**

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H02J 3/14 (2006.01)
H02J 13/00 (2006.01)
H02J 3/00 (2006.01)

(52) **U.S. Cl.**
CPC **H02J 3/14** (2013.01); **H02J 13/0062** (2013.01); **Y02B 70/3225** (2013.01); **Y02B 90/2638** (2013.01); **Y04S 20/222** (2013.01); **Y04S 40/124** (2013.01); **Y10T 307/461** (2015.04); **Y10T 307/469** (2015.04); **Y10T 307/477** (2015.04)

(58) **Field of Classification Search**

CPC H02J 3/00
USPC 307/38
See application file for complete search history.

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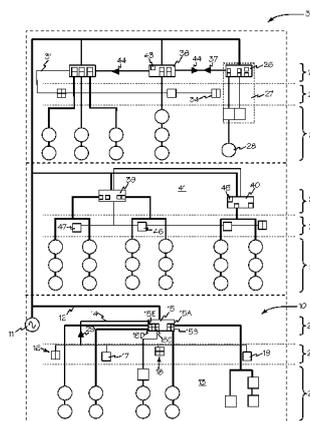
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(57) **ABSTRACT**

The methods and apparatus described enable automatic configuration, or commissioning, of controller devices and load control devices through a low voltage communication network controlled by one or more controller devices. These methods and apparatus further enable expansion of the load control system by connection of additional loads and or load control devices and or controller devices which will reinitialize the low voltage communication network and automatically reconfigure the controller devices and load control devices connected to the network.

5 Claims, 3 Drawing Sheets



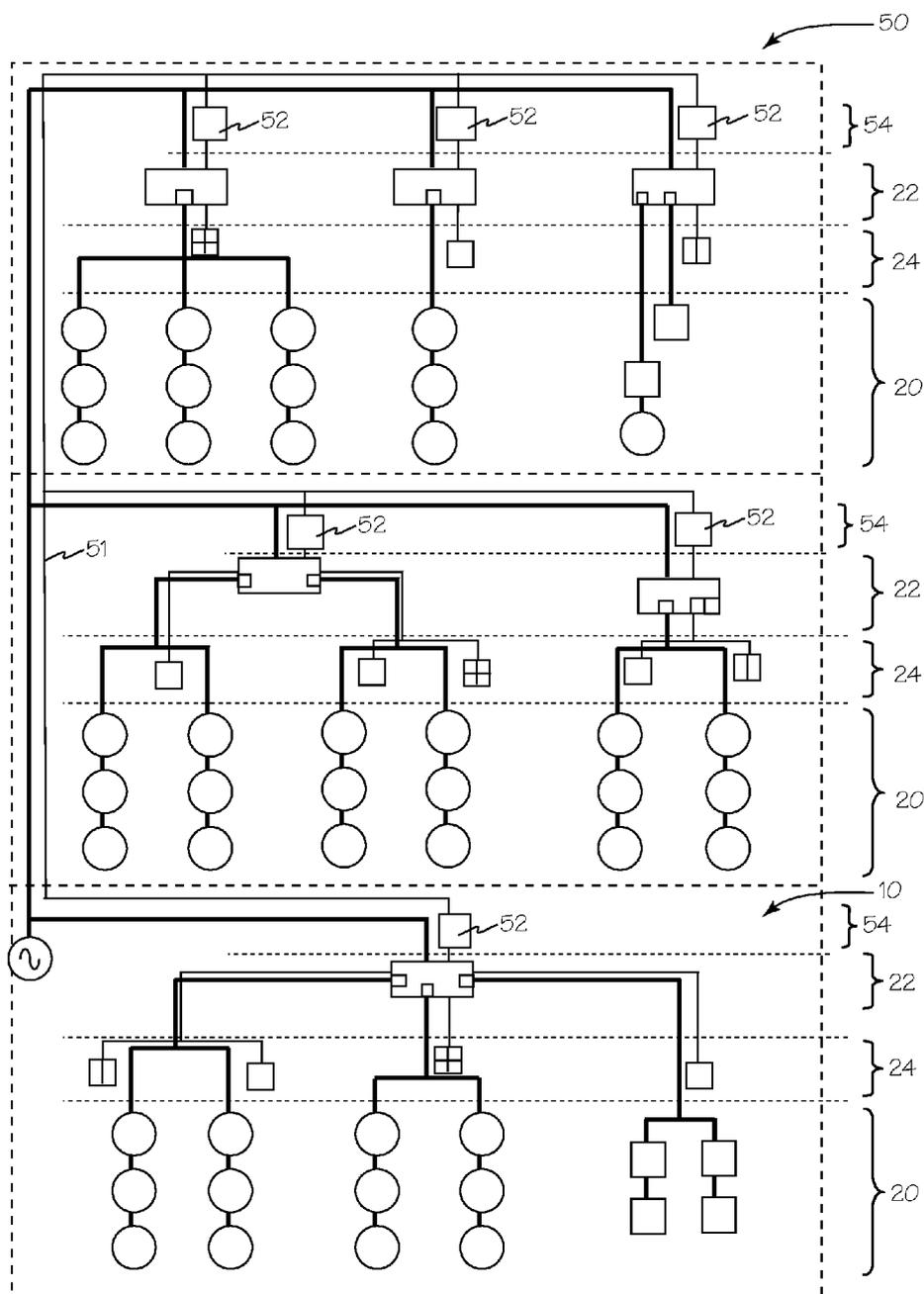


Fig. 2

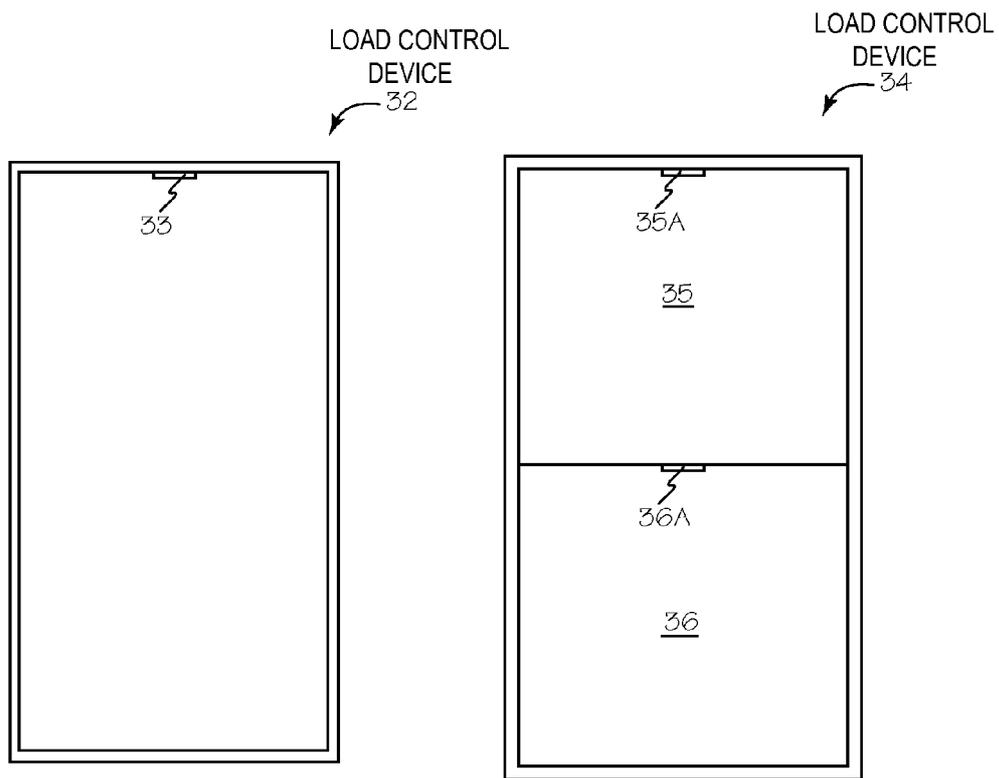


Fig. 3

Fig. 4

**METHOD AND APPARATUS FOR
ELECTRICAL LOAD CONTROL NETWORK**

RELATED APPLICATIONS

This application is a continuation of U.S. Utility applica-
tion Ser. No. 12/773,842 filed May 20, 2010, now U.S. Pat.
No. 8,487,474.

FIELD OF THE INVENTIONS

The inventions described below relate to the field of
electrical load control systems and more specifically to open
topology electrical load control networks.

BACKGROUND OF THE INVENTIONS

Electrical load control systems have developed from
simple knife switch controls to relay control networks with
sensors and switches and network control management
systems. Simple and complex networked load control sys-
tems require strict attention to the network topology required
for the hardware being used. Additionally, once properly
wired, loads and controls require special tools to link a
specific sensor and or control to a specific load.

SUMMARY

The methods and apparatus disclosed are directed to an
electrical load control system that includes a controller
device that is electrically coupled to load control devices.
The system is preferably configured to control or operate
any electrical load in response to control signals generated
by the load control devices. Load control devices are manu-
ally and automatically activated switches as well as motion
sensors, light sensors, heat sensors or a combination thereof.
The load control devices are electrically coupled to the
controller device via cables and cable connectors to form a
communication and low voltage network. The cables and
cable connectors are, for examples CAT-5 cables with RJ-45
connectors.

Load control devices generate control signals to control
the application of electrical line power to electrical loads.
Additionally, each load control device has what is referred
to herein as an automatic initial commissioning or configura-
tion feature. Automatic initial commissioning allows a
new control device to be connected or integrated into the
system network and automatically operate according to the
automatic configuration and communication protocol in the
controller devices. The automatic configuration protocol
initiates when the controller device is powered-on by the
network, whereby the controller device or devices on the
network automatically run a self-configuration or self-com-
missioning program and notify the controller device and/or
other controller devices within the system what kind of
control device it is as well as its rank, seniority or priority.

Alternatively, selective commissioning may be accom-
plished through load control devices transmitting configura-
tion commands to one or more controller devices to
override the automatic configuration and establish an alter-
native commissioning or configuration.

A controller device has the capability to initiate a com-
missioning or configuration mode for all the devices con-
nected to the entire low voltage communication network.
Automatic configuration or commissioning can be initiated
from any component connected to a low voltage communi-
cation network that is acting as a controller device and does

not require a separate commissioning tool or a specific
commissioning control device on the network.

The electrical load control system does allow for use of a
commissioning tool for the convenience of an installer and
user for complex layouts or re-commissioning once the load
control system is installed. However, use of separate con-
figuration tools is completely optional. All configuration can
be done using just the components in the system.

The electrical load control system uses a network model
that is independent of any external network connection,
topology or protocol. Capability may be built into all con-
trollers or just specific models of controllers for expanding
control to multiple rooms and multiple types of loads. In this
context, a "room" may literally be a single space bounded by
walls, floor and ceiling, such as a conference room, or it may
be a series of rooms, such as a pod of classrooms, or it may
be a large convention hall that may be partitioned. As such,
the "room" is really the extent of the network and not a
specific physical space.

The disclosed electrical load control system is based on a
free topology wiring scheme that allows any suitable net-
work topologies. e.g., loop, star, wheel, etc. This frees both
the wiring designer and the wiring installer from burden-
some and time consuming processes that are required using
other topologies that require very specific wiring layouts.
Less time and less resources are used in design and instal-
lation. Thus, energy savings are actually realized sooner in
the home or facility design and in the construction process
than with conventional systems that require careful wiring
layouts in design and installation.

The methods and apparatus described enable automatic
configuration, or commissioning, of controller devices and
load control devices through a low voltage communication
network controlled by one or more controller devices. These
methods and apparatus further enable expansion of the load
control system by connection of additional loads and or load
control devices and or controller devices which will reini-
tialize the low voltage communication network and auto-
matically reconfigure the controller devices and load control
devices connected to the network.

The devices and methods described below provide a
system for controlling the application of electrical power to
electrical loads. In addition to a power network intercon-
necting the electrical loads to line power, the system
includes a low voltage communication network intercon-
necting at least one controller device and one or more load
control devices. Each controller device provides electrical
power to the low voltage communication network and each
load control device receives electrical power from the low
voltage communication network as well as transmitting one
or more identification signals and one or more control
signals through the low voltage communication network.
The one or more control signals indirectly control the
application of electrical power to the electrical loads. Each
controller device includes a configuration means and pro-
cessing means. The processing means for receiving and
processing identification signals from each of the load
control devices, the other controller devices and the loads.
The processing means using the configuration means to
generate and transmit configuration signals to the load
control devices and the other controller devices. The pro-
cessing means further receiving and processing control
signals from the power control elements and directly con-
trolling the application of electrical power to electrical loads
according to the control signals and the configuration sig-
nals.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram of an electrical load control system.

FIG. 2 is a block diagram of an alternate electrical load control system.

FIG. 3 is a front view of a load control device.

FIG. 4 is a front view of an alternate load control device.

DETAILED DESCRIPTION OF THE INVENTIONS

Electrical load control system 10 of FIG. 1 controls the application of line or house power 11 from line power network 12 to loads 20 in space 13. Low voltage power and communication network 14 interconnects one or more controller devices such as controller device 15 to one or more load control devices such as switch 16, sensor switch 17, multi-switch 18 and sensor 19. Loads 20 may be any electrical load such as lights, heaters, HVAC, blinds, motors or other load.

Controller devices such as controller 15 in controller level 22, supply low voltage power to each load control device in load control level 24 using low voltage power and communication network 14. Controller 15 receives any suitable power such as line or house power 11 for internal use as well as for supplying to the loads 20. Controller devices such as controller 15, directly control power delivered to a load such as loads 20. Controller devices may also be provided as plug load controllers such as controller device 26 which are built into electrical sockets such as socket assembly 27 to control power to loads plugged into the socket such as load 28. Plug load controllers generally do not provide low voltage power to load control devices but may be configured to do so.

Load control devices in load control level 24 provide control signals such as load control request 29 through low voltage power and communication network 14 and also display the status of the load or loads that the load control device controls such as switch, switch array, sensor including multiple sensors in a single device or remote controls.

Low voltage power and communication network 14 provides communication path and power path between controller devices in level 22 and load control devices in level 24 using suitable cabling and connectors, and including a suitable communication protocol.

Electrical loads in load level 20 are the line power consuming devices being controlled by the system e.g., lighting, HVAC, shades, etc., wherein the control is typically controlled application of energy, line power to the load such as on/off, dimming, motor speed, etc.

Electrical load control system 30 includes a free topology low voltage communication network 31, and load control devices in load control level 24 such as switches, sensors and the like may be connected in any combination between themselves and/or the controller device or devices in controller level 22 which only needs to be somewhere in the network. There is a practical limit on the number of load control devices, as well as controller devices in multi-controller configurations, due to designed-in capacity limitations in the low voltage power and communication network 14 as noted above. Furthermore, the "free topology" does not require terminators thereby reducing installation errors. Such a system can be based on a current loop scheme, but any suitable network configuration that does not require termination could be used.

Referring now to FIGS. 3 and 4, each load control device such as load control device 32 has an indicator, preferably an

LED indicator or an LCD display, such as indicator 33 that shows the status of the load to which it is configured or bound and that it controls. In a first configuration, an indicator on each load control devices is ON when electrical line power is applied to the load and is OFF when no electrical line power is applied to the load.

In an alternate configuration, load control device 34 includes two or more load control assemblies such as first load control button 35 and second load control button 36.

The load control device must receive a confirming message such as confirmation signal 37 from controller device 26 that load 28 is truly ON before the load control device 34 can display the ON status by illuminating indicator 35A. This improvement allows an error condition to be sent to a load control device and displayed accordingly. LED blinking patterns or multiple LEDs may be used to indicate the status of loads that may have multiple levels of operation, such as a dimming level or a bi-level setting.

Controller devices preferably have separate switches or power control elements such as power control elements 15A, 15B, 15C, 15D and 15E such as for applying electrical line power to the load or loads connected to them. This is useful for testing purposes during installation. Controller devices and load control devices also preferably have status indicators such as component health or operational status, which can be separate or can be a single indicator that performs multiple functions. For example, a single LED may be used to indicate power "on" and load health status.

Status indicators may also be different from load health indicators, e.g., by using different color LEDs, so that the status or "health" of the component can be easily differentiated from the load power status. In another configuration, the prominence of a health indicators is minimized to minimize distractions to users except in the case of activation of a health monitor. Since the low voltage power and communication network 14 is purposefully limited in the number of components that can functionally interconnect through it, it is also important for overload monitoring on the network in the case that too many components are connected. Overload monitoring preferably includes a technique to disable network power as needed and indicate this fault condition.

The electrical load control system includes the capability for automatic as well as manual commissioning or configuring of load control devices and corresponding loads in each and every component of the system without the need for special commissioning tools or complex protocols.

In order to identify each component of the system, a standard Media Access Control (MAC) address is assigned at the time of manufacture to each component. The preferred technique is to have the identity preassigned, however, any unique identification scheme may be used. Since the MAC address of every single device is unique, the value of the MAC address is used to assign Master/Slave, priority status, rank or heirarchy for devices interconnected through the system. For example, controller devices may be configured in a master/slave relationship so that only one controller device on the network establishes the automatic commissioning assignments.

In a preferred configuration, the controller device having the highest value MAC address is the master in a multi-controller configuration such as controller device 38 in electrical load control system 30. In addition, MAC address blocks are reserved for families of products to create an inherent hierarchy. For example, a controller device designed to drive 2 loads such as controller device 39 will automatically be assigned a MAC address that will be higher

than any controller designed to drive only one load such as controller device **40**, thereby ensuring that the 2-load controller will be the master in a configuration employing both a 2-load and a 1-load controller as in space **41**. This dual use of the MAC address for prioritization is unique and provides two advantages in a self-commissioning network: a) it provides a way for all devices on a network to establish a hierarchy for the purposes of control and communication within the network; and 2) it provides a way to ensure that certain devices are always assigned a higher ranking or priority than other family devices to advantageously utilize characteristics in certain devices that are not present in other devices.

Upon the initial application of system, house or line power **11**, each device interconnected in a network, such as devices in levels **22** and **24**, broadcasts its MAC address to all other devices connected to the network. The controller devices in level **22** arbitrate to work out which one is the master if multiple controller devices are installed such as in networks **31** and or **42**, otherwise the single controller device is the master by default. The master controller then uses the established MAC address precedence to assign identifiers to each controlled load in the system. Controller device identifiers such as identifier **43** are assigned in ascending order starting with the master controller (highest MAC address). For example, a two-load master controller would be assigned load identifiers **LD1** and **LD2**, while a slave two-load master controller would be assigned load identifiers **LD3** and **LD4**. The same two advantages noted above for device prioritization hold true for using the MAC address for load identification, i.e., a hierarchy of loads is easily established and certain loads will always be higher in the prioritization than other loads, which may facilitate installation. For example, it will be easy to wire emergency lighting to a master controller device by simply inspecting the MAC address printed on the controller's label thereby ensuring that emergency lighting always gets the highest enumerated load identification that may facilitate standardization in a large commercial installation. In addition, the master controller device preferably assumes full responsibility for supplying power to the load control devices so that multiple controllers are not all trying to supply power. However, other controller devices may be asked to supply additional power (in parallel) depending on the number of controller devices attached to the network and the power handling capability of the network media.

In likewise manner, the load control devices in level **24** are enumerated. For example, multiple two-button switch devices on the network have their buttons numbered according to the MAC address hierarchy such that the highest MAC address switch is assigned switch identifiers **BT1** and **BT2**, the next highest MAC address switch is assigned identifiers **BT3** and **BT4**, and so on. This scheme may also be used to facilitate installation. Sensor devices, such as occupancy sensors or daylighting sensors, are similarly self-identified. Plug load devices are also similarly self-identified. Such a configuration is cumbersome in prior art systems that require careful wiring installation, mapping and commissioning with advanced commissioning tools.

Once load and device identification is complete, the master Controller broadcasts a message **44** to the network that all devices should perform their specific automatic or self-configuring (self-commissioning) algorithm such as algorithm **45** in controller device **40**. Each device is programmed using an algorithm in the controller device that designates or binds load control devices to loads in a way that covers most load control scenarios while maintaining

adherence to energy-saving building code requirements. Switches with multiple buttons will bind their individual buttons to loads such that the first button is bound to the first load, the second button is bound to the second load, and so on. If there are more buttons than loads, the remaining buttons remain unbound and indicate this status when pushed. For example, a bound button may turn on its LED indicator when its load is activated by a button press whereas an unbound button may simply flash its LED indicator a few times when pressed. If there are more loads than buttons, the last remaining button is bound to the remaining loads. For example, if there are 2 buttons and 5 loads, then button **1** controls load **1**, button **2** controls loads **2** through **5**. This technique ensures that every load is bound, or configured to a switch on a load control device. In simple installations where the number of buttons equals the number of loads, binding is done on power-up and the installer need not perform any other tasks. This is especially true if the installer is trained to pay attention to the MAC address hierarchy when connecting controller devices to their corresponding loads. Controller devices with more than one load may have their internal load hierarchy for the controller printed on them for easy reference during this process. For example, controllers with two relay outputs may have the relays labeled **A** and **B** so the installer will know that relay **A** will be assigned the lowest load number for that controller. In addition, testing of the installation is easy since the installer will know exactly how the system will perform on power-up. Thus, the installer does not need to spend extra time commissioning or binding switches and loads with a commissioning tool therefore, the cost and schedule of an installation are both improved.

An occupancy sensor such as sensor **46** may be treated like a one-button switch wherein it is assigned to all controller loads during initial self-configuration. This helps meet energy saving standards once self-configuration is completed, but without the need to perform complex manual configuration to meet those same standards. In addition, the occupancy sensor may be automatically configured for energy saving modes of operation, for example, the sensors may be automatically configured to manual on/automatic off operation for only the highest numbered load and automatic on/off for the remaining loads (automatic refers to the sensor controlling the state of the load directly). Daylighting sensors such as sensor **47** may be similarly self-configured, but some manual configuration is anticipated since mapping of particular lighting loads and daylighting sensors to the proximity of windows, skylights, or work spaces may not have been done. Also, in the preferred embodiment, plug loads are mapped only to occupancy sensors and not to switches during self-configuration since most installations prefer that sensors control plug loads; some manual configuration is also anticipated since the layout of cubicles and other workspaces may be not known at the time of installation.

The electrical load control system such as system **30** automatically self-configures to a basic state of operation that may be suitable for many installations and that meet minimum requirements for energy savings. The automatic configuration may be selected to automatically establishes system operation consistent with energy code requirements such as California Title 24 and ASHRAE 2010. Examples:

A 2-load on/off Room Controller and a 2-button wall switch—each button is bound to one load each for manual on/manual off operation.

A 2-load on/off Room Controller, a 2-button wall switch, and an occupancy sensor—each button is bound to one load

each for manual on/off, the sensor controls the first load as automatic on/off (overrides the switch to turn load off automatically) and manual on (via the switch)/automatic off for the second load.

A 2-load on/off room controller and an occupancy sensor—each load is controlled by the sensor as automatic on/off.

A 2-load on/off room controller, a 3-button switch, an occupancy sensor, and a plug load controller—the first two buttons are bound one each to the two loads, the third button is unbound, the first load is controlled by the occupancy sensor for automatic on/off (sensor overrides the switch for automatic off) and the second load is controlled by the sensor for manual on/automatic off, the plug load is automatically controlled only by the occupancy sensor for automatic on/off.

Priority Array State Machine

The priority array state machine is the algorithm that determines the state of an electrical load and the algorithm is driven by control signals which are called events. Events feeding the state machine arrive via the low voltage communication network or bus. The device originating the event is irrelevant to the state machine processing, however, system level events like Shed and Schedule can also originate in the low voltage communication network.

Each controller includes a priority array state machine for every load it controls. A suitable priority array state machine may have a binary output or it may have multiple levels to accommodate dimming loads or other similar device demands. Some events may be internally generated by the state machine. Different types of events have different priorities, the active event with the highest priority is determines action taken by the controller.

Automatic Commissioning

Most energy-efficient scenario

Sensor only: Auto-ON

Sensor and Switch: Manual-ON/Auto-ON, 2-relay RC:

Relay 1: Auto-ON

Relay 2: Manual-ON

Controller devices arbitrate to decide Master

Device **10** and MAC address

Highest becomes master controller device

Master controller device in charge of load enumeration

Low Voltage Power and Communication Network Characteristics

Provides default behavior upon initial installation of devices in the network

On Power Up the controller devices arbitrate to decide who becomes the Master controller device

Master controller device is in charge of:

Enumerating the Loads (assigning individual IDs).

Commission Load Switches

Commission Scene Switches

Commission Sensors

Master Arbitration and Load Enumeration

Each controller device has a Device Type ID and a MAC address

An RC-101 and an RC-102 do not have the same Device Type ID

Higher Device Type ID has precedence

Within the same Device Type **10**, higher MAC address has precedence

The controller device with highest Device Type ID/MAC address will become the master controller device.

Precedence level is maintained for Load Enumeration, thus the assignment of Load IDs is predictable (next slide has the details)

If automatic initial commissioning has not been locked out then it will happen every time the system powers up.

Manual restart of automatic initial commissioning will be needed in special circumstances.

If when adding a new RCI it gets powered up BEFORE plugging the RJ45 jack

When adding an controller device that had been previously commissioned in another network.

Switch and Load Binding

It is always predictable, you will know which Push Button in the Switch will control which Load or set of loads at the time they are been wired

Each switch binds its buttons to the Loads in the space so that no Load is left unbound (you can control all loads in the space from every switch)

Two easy to remember rules are followed by each Switch:

1. If number of buttons > number of loads then Each button is bound to each load in sequence, the extra buttons will control nothing and will blink 3 times at a 1/2 hz Hz rate

2. If number-of-buttons <= number-of-loads then Buttons get assigned to individual loads, the last button on every switch controls all remaining loads

For example, In a room with 5 loads, an 5W-102 switch and an 5W-103 switch

Button **1** of 5W-102 will control load **1**

Button **2** of 5W-102 will control loads **2, 3, 4** and **5**

Button **1** of 5W-103 will control load **1**

Button **2** of 5W-103 will control load **2**

Button **3** of 5W-103 will control loads **3, 4** and **5**

It is expected that most rooms will have switches with the same number of buttons as loads are to be installed, PnG is all these rooms will ever need.

Selective Commissioning

Config button and LED to enter/exit

Press & hold config button for 2 sec on any device

Config LED of ALL devices blink

1st load turns on, all other loads are off

Assigned button LED lights. Pressing the button will deselect

Selecting/Unselecting loads with sensors is done via up/down buttons

Press ANY config button, system goes to next load

Press & hold ANY config button for 2 sec will exit PnL

Press & hold ANY config button for 10 sec will clear ALL devices and restart PnG

Power Failure Memory

Provides customized behavior without the need of a commissioning tool

Master RC arbitration and Load enumeration from PnG remain valid

PnL allows:

Custom binding between Switches and Loads

Area separation based on Dcc Sensor coverage (not required by Marketing)

Scene assignments

Room Modules configuration

Selective Commissioning Sequence of Operation

Config Button and Config LED

Every IRB device has a Config button and LED that allows the IRB network to enter into PnL mode

Pressing the config button for two seconds gets the device into local Config mode (we are not in PnL mode yet). Local Config mode is dependant on the device

Pressing the Config button again for two extra seconds will cause the IRB to get into PnL mode (if it hasn't been locked out)

PnL mode

PnL is controlled by the Master controller device upon entering PnL all devices will flash their Config LED and the Master RC will shut down all loads except the 1st one (only one Load is active during PnL)

While the load is active switches that have button(s) bound to such load will turn ON the respective LED(s)

The user can then create or destroy bindings by pressing the push buttons only those with the LED turned ON will be bound to the active load. Other devices (Room Modules, Occ Sensors, etc) behave differently during PnL

Pressing the Config button briefly (anywhere) will instruct the Master RC to go to the next load in the sequence.

Pressing the Config button (anywhere) for two seconds will instruct the Master RC to exit selective commissioning Low Voltage Power and Communication Network Characteristics:

Free Topology up to 1000 feet of wire

Communications and Power are delivered using CATS cable (RJ45 connectivity at every device)

Up to 48 devices can be connected for communication

Power provided by the controller devices

Additive power (if code allows)

Power Supply(ies) limit the number of devices that can be connected.

protocol:

Supports up to 64 loads (not the same as CONTROLLER DEVICES) in the room

Collision avoidance and collision detection implemented Load and Scene control support PnG and PnL capable Unicast} Multicast and Broadcast addressing types available

Network Load and Scene Control

Load Control

Switch buttons can be explicitly bound to control individual loads or a group of them.

There can be as many different groups as there are buttons in the low voltage power and communication network

Switch buttons know which loads are part of their group, thus they can track them down to display the status of the group

Scene Control

IRB networks can be logically separated in up to 4 areas, normally Dcc Sensor

coverage will determine such areas (is this required? Let's discuss later)

Each Load in the IRB can belong to only one area

Each area has 16 scenes associated with them, 8 are free for the user to configure, the rest are reserved by the IRB protocol (Dcc Sensors, Daylight

Controllers and System Level events)

Scene control devices (Scene Switch, Dcc Sensor, Daylight Control, etc) do not necessarily need to know which loads respond to the Scene Commands

Unique identifier in each device allows multiples of the same device type to coordinate the numbering of each input or output on each device, referred to enumeration within the context of establishing an ordered list, a master-slave(s) relationship, or a priority level. It is preferred that the highest number establish the first in the list, the master, or the first priority.

Secondary unique identifier scheme is used amongst device families, e.g., a 2-load room controller identifier would be selected from a group with a higher sequence of numbers than a 1-load room controller identifier, thereby ensuring the a 2-load room controller will always have a higher numbered identifier than a 1-load room controller,

e.g., to guarantee that a 2-load room controller will always be a master to a 1-load room controller in an installation using one of each type of room controller.

On initial application of power to the system, each device broadcasts its identifier to establish enumeration with devices of the same type or family using an arbitration process. The result is that each device on the low voltage power and communication network 14 establishes a unique identifier for each of its inputs and outputs, thereby establishing an ordered list of inputs and an ordered list of outputs for the low voltage power and communication network 14 as a whole. It is preferred that the enumeration process be disabled once the system has been manually commissioned so that, in the event of power loss, the system does not attempt to re-enumerate and erase bindings set by the manual commissioning process.

The electrical load control system automatically establishes system operation consistent with energy code requirements such as California Title 24 and ASHRAE 2010.

Examples:

A 2-load on/off Room Controller and a 2-button wall switch—each button is bound to one load each for manual on/manual off operation.

A 2-load on/off Room Controller, a 2-button wall switch, and an occupancy sensor—each button is bound to one load each for manual on/off, the sensor controls the first load as automatic on/off (overrides the switch to turn load off automatically) and manual on (via the switch)/automatic off for the second load.

A 2-load on/off room controller and an occupancy sensor—each load is controlled by the sensor as automatic on/off.

A 2-load on/off room controller, a 3-button switch, an occupancy sensor, and a plug load controller—the first two buttons are bound one each to the two loads, the third button is un bound, the first load is controlled by the occupancy sensor for automatic on/off (sensor overrides the switch for automatic off) and the second load is controlled by the sensor for manual on/automatic off, the plug load is automatically controlled only by the occupancy sensor for automatic on/off.

6. Plug 'n Go automatically binds loads to switches and adjusts for an unequal number of loads versus switches.

Examples:

a. A 3-load on/off room controller and a 1-button wall switch—all loads are bound to the 1-button.

b. A 3-load room controller and a 2-button wall switch—the first load is bound to the first button, the remaining loads are bound to the second button.

c. A 3-load room controller and a 3-button wall switch—each load is bound to just one button, first-to-first, second-to-second and third-to-third.

d. A 3-load room controller and a 4-button wall switch—the first three loads are bound to the first three buttons as described above, the fourth button is unbound and blinks its LED when pressed to indicate its unbound status.

Referring now to FIG. 2, electrical load control system networks such as systems 10 and 50 may be connected to one another through a standard backbone such as BACNet (Building Automation and Control Network 51. In this case, low voltage power and communication network 14 must have special capability to interface to such a backbone. A separate interface module such as building network modules 52 in layer 54 is attachable to controller devices to establish the link between the low voltage power and communication network 14 and the backbone 51. The unique feature of this interface is that it makes this interface transparent to either

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side of it. The backbone appears to be just another Room Device or Room Controller to the Room Network, and the Low voltage power and communication network **14** components appear to be standard components of the chosen backbone system. This unique feature allows easy connection to the chosen backbone system and easy control the Low voltage power and communication network **14** components by the master controller in the backbone system. This setup now allows Room Devices **10** control loads outside of the Room Network. Indeed, this is a good example of a situation wherein it is advantageous to allow the number of logical loads in the Low voltage power and communication network **14** to be greater than the number of physical loads on the Room Network.

The discussion above uses line power to designate electrical power delivered to loads to perform work. In the United States line power is 60 cycle, 110 volt AC power. Any other suitable power source may be used as line power with appropriate component configuration for higher power demands.

While the preferred embodiments of the devices and methods have been described in reference to the environment in which they were developed, they are merely illustrative of the principles of the inventions. Other embodiments and configurations may be devised without departing from the spirit of the inventions and the scope of the appended claims.

We claim:

1. A system for controlling the application of electrical line power to a plurality of electrical loads in a building comprising:

a line power network operatively connected to the plurality of electrical loads and separate from a first low voltage power and communication network;

one or more first load control devices operatively connected to the first low voltage power and communication network, each first load control device using electrical power from the first low voltage power and communication network and transmitting one or more identification signals and one or more control signals through the first low voltage power and communication network, the one or more control signals for indirectly controlling the application of electrical power to one or more of the plurality of electrical loads;

a building control network;

at least one first controller device operatively connected to the line power network and to the one or more first load control devices through the first low voltage power and communication network and through the building control network to a second low voltage power and communication network, said at least one first controller device having a configuration means and providing electrical power to the first low voltage power and communication network;

one or more second load control devices operatively connected to the second low voltage power and communication network, each second load control device using electrical power from the second low voltage power and communication network and transmitting one or more identification signals and one or more control signals through the second low voltage power and communication network and through the building control network to the first low voltage power and communication network, the one or more control signals for indirectly controlling the application of electrical power to one or more of the plurality of electrical loads;

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at least one second controller device operatively connected to the line power network and to the one or more second load control devices through the second low voltage power and communication network and to the building control network, said at least one second controller device having a configuration means and providing electrical power to the second low voltage power and communication network;

processing means in each of the at least one first and second controller devices, said processing means for receiving and processing identification signals from each of the one or more first and second load control devices and each of the one or more first and second controller devices and the plurality of loads and using the configuration means to generate a plurality of configuration signals upon initial application of electrical power to the system, the processing means transmitting the plurality of configuration signals to the one or more first and second load control devices and the one or more first and second controller devices, the processing means further for receiving and processing one or more control signals from the one or more first and second load control devices and directly controlling the application of electrical power to one or more of the plurality of electrical loads according to the one or more control signals and the plurality of configuration signals.

2. The system of claim **1** wherein each of the at least one first and second controller devices further comprises:

one or more line power control elements for controlling the application of line power to one or more of the plurality of loads;

wherein the processing means in each of the at least one first and second controller devices receives and processes configuration signals from each of the one or more first and second load control devices and associates the control signals from a first or second load control device to one or more of the one or more line power control elements according to the configuration signals, the processing means further for receiving and processing one or more control signals from the one or more first and second load control devices and operating the line power control elements associated with the one or more control signals according to the one or more control signals.

3. A system for controlling the application of electrical line power to a plurality of electrical loads comprising:

a line power network operatively connected to the plurality of electrical loads and separate from a low voltage power and communication network;

one or more load control devices operatively connected to the low voltage power and communication network, each load control device using electrical power from the low voltage power and communication network and transmitting one or more identification signals and one or more control signals through the low voltage power and communication network, the one or more control signals for indirectly controlling the application of electrical power to one or more of the plurality of electrical loads;

at least one controller device operatively connected to the one or more load control devices through the low voltage power and communication network, said at least one controller device having a configuration means and providing electrical power to the low voltage power and communication network;

processing means in each of the at least one controller devices, said processing means for receiving and processing identification signals from each of the one or more load control devices and each of the one of more controller devices and the plurality of loads and using 5 the configuration means to generate a plurality of configuration signals upon initial application of electrical power to the system, the processing means transmitting the plurality of configuration signals to the one or more load control devices and the one of more 10 controller devices, the processing means further for receiving and processing one or more control signals from the one or more load control devices and directly controlling the application of electrical power to one or more of the plurality of electrical loads according to the one or more control signals and the plurality of con- 15 figuration signals.

4. The system of claim 1 wherein the at least one first controller device provides line power to a first portion of the plurality of electrical loads and the at least one second 20 controller provides line power to a second portion of the pluralith of electrical loads.

5. The system of claim 3 wherein the at least one first controller device provides line power to a first portion of the plurality of electrical loads. 25

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