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GB 2418825 A
JP 2003283390 A
JP 2003188778 A
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US 20060227884 A1

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(54) Title of the Invention: **Building management system and method of communication**
Abstract Title: **Power-line communications within a building comprising filters at the input of each lighting power circuit and series inductances in the load circuit**

(57) A system for providing a communications path or network for use within buildings, based on power-line communications (PLC) carried over the lighting power circuits 110, with filters 100 at the input of each circuit 110 and series inductances 160 inserted in the load circuit to create separate communication zones. The electrical filters 100 reduce transmissions at PLC frequencies in both directions and present high load impedance to PLC signals within a zone at the output of the filter 100, the PLC signals being applied between live (phase) and neutral conductors within each zone. PLC transceivers 130 are connected to the lighting power circuits 110 to transmit and receive digital network information within each communication zone. The series inductances/impedances 160 in the load circuit provide increased load impedance at the PLC transceivers 130 over that of lighting fixtures or other loads powered from the circuit. Multi-connection units are distributed in the system, each unit having a plurality of power connectors for connection of electrical loads and containing at least one of the series inductances/ impedances 160 and at least one PLC transceiver 130.

Figure 4/6: Insertion of series 'padding' inductors

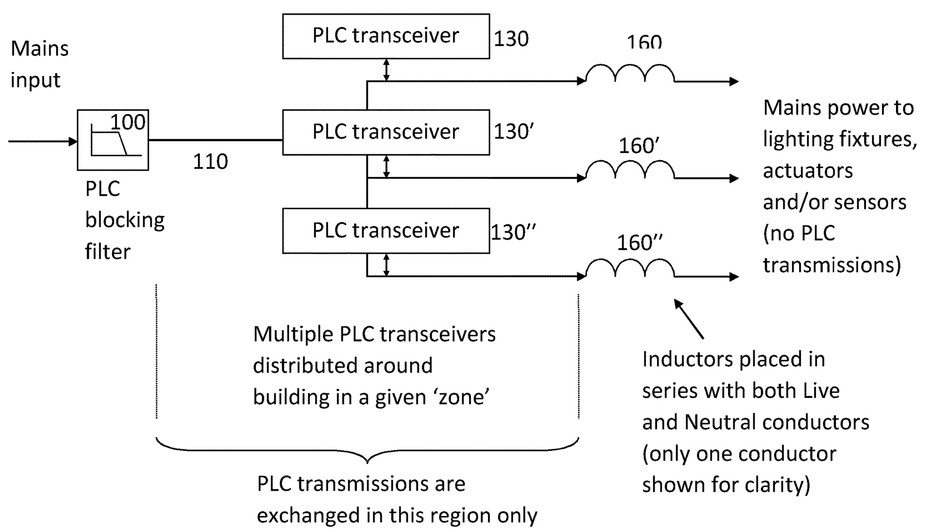

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Figure 1/6 : Using filters to create zones

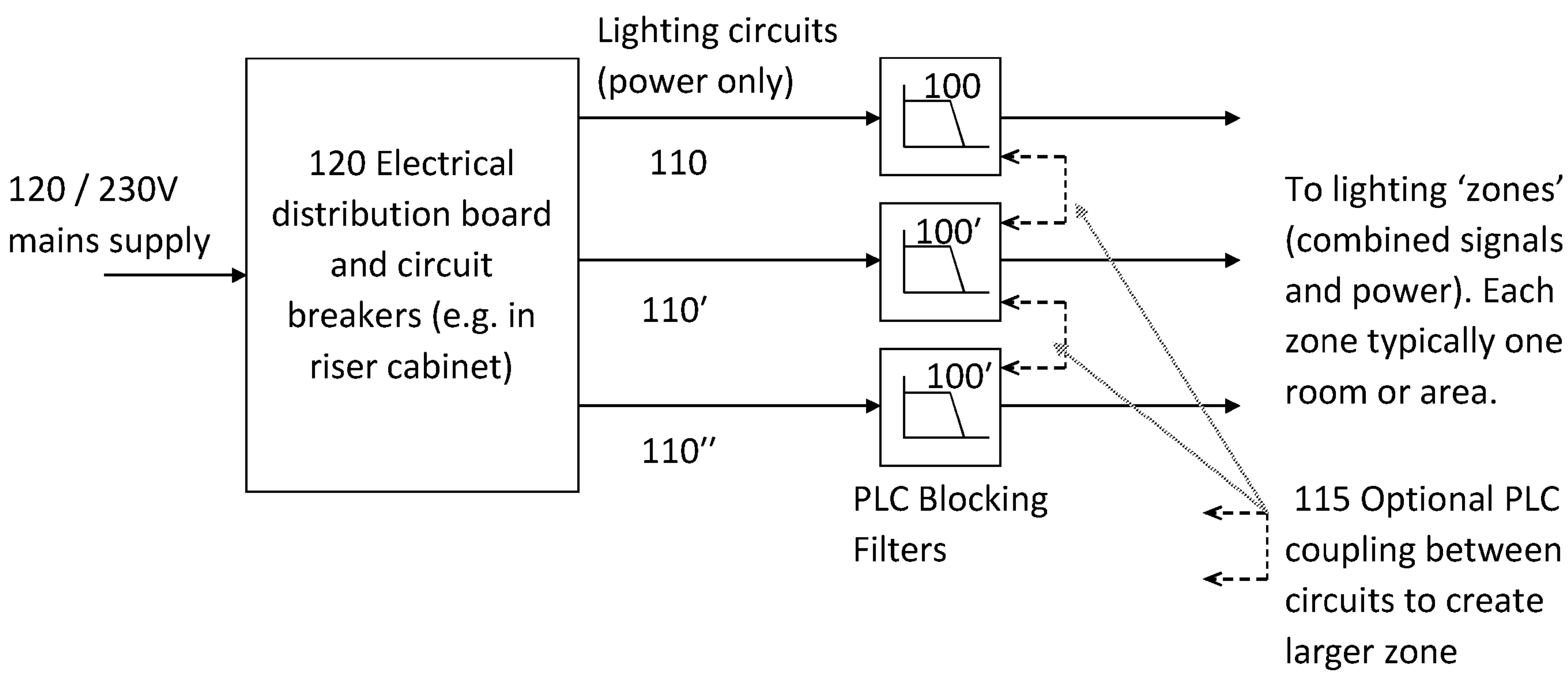


Figure 2/6: A single communications zone

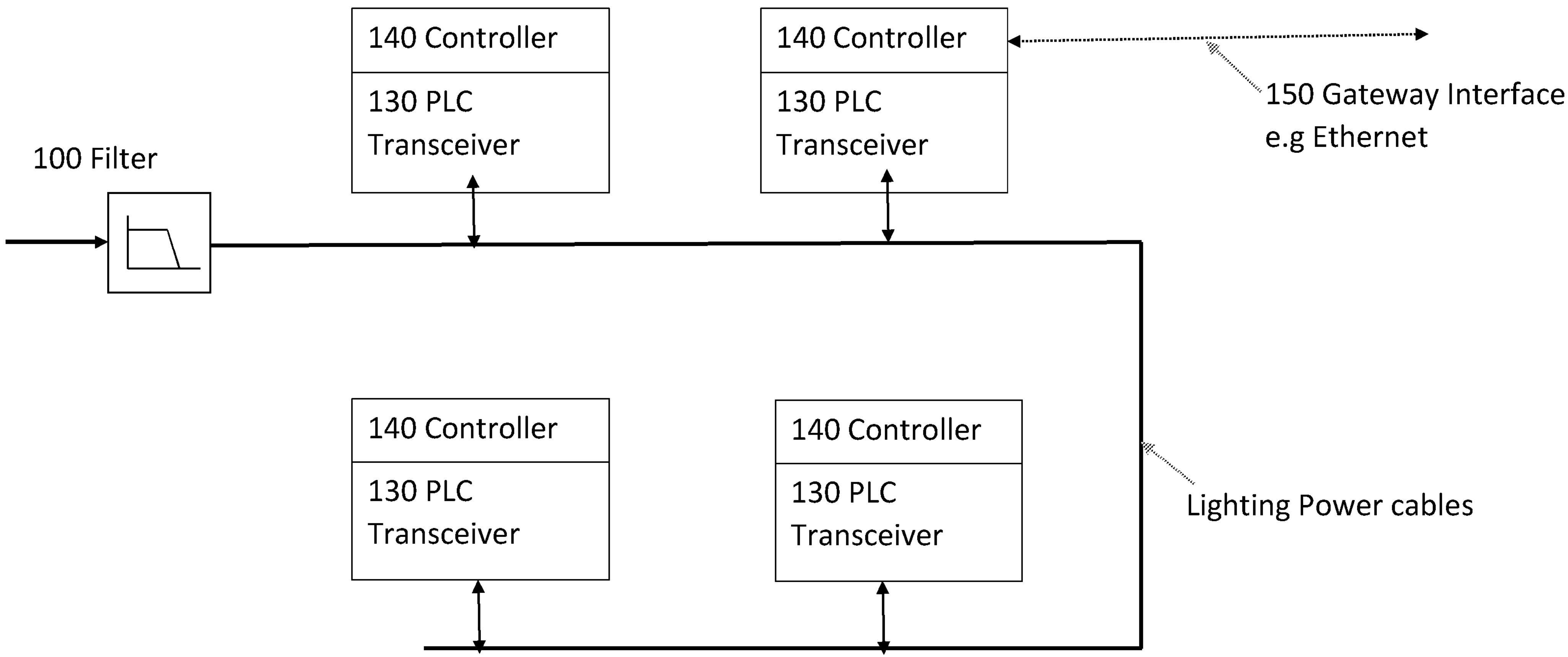


Figure 3/6: Possible filter architecture

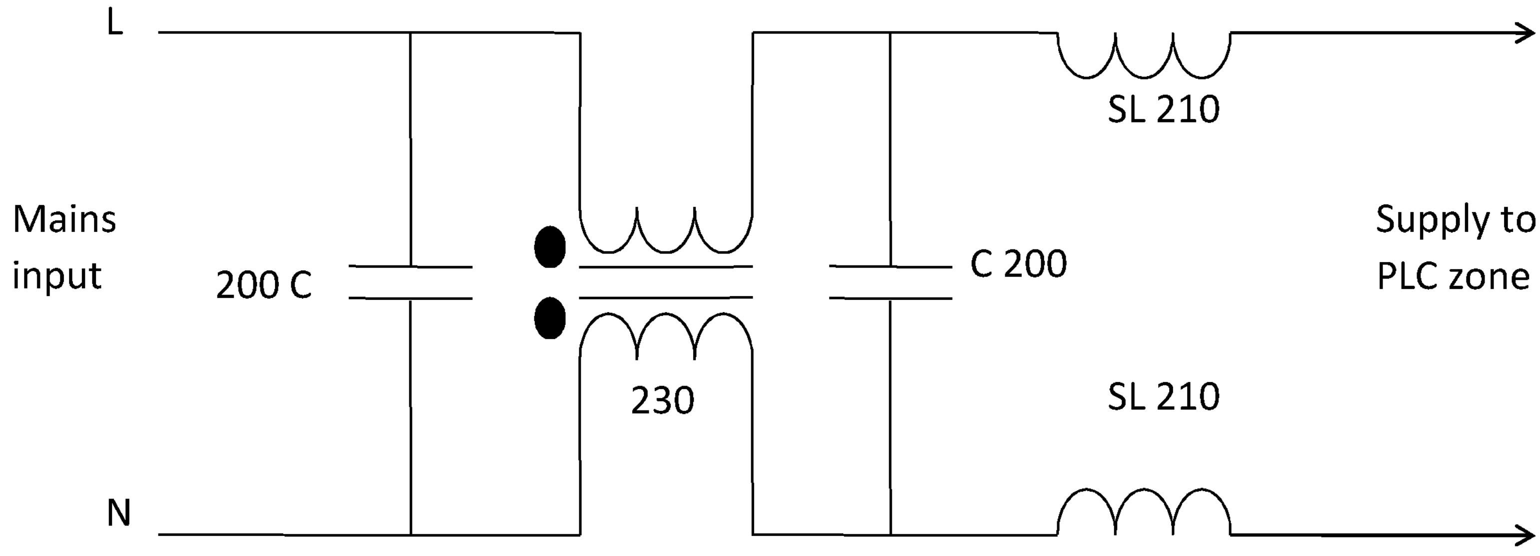


Figure 4/6: Insertion of series 'padding' inductors

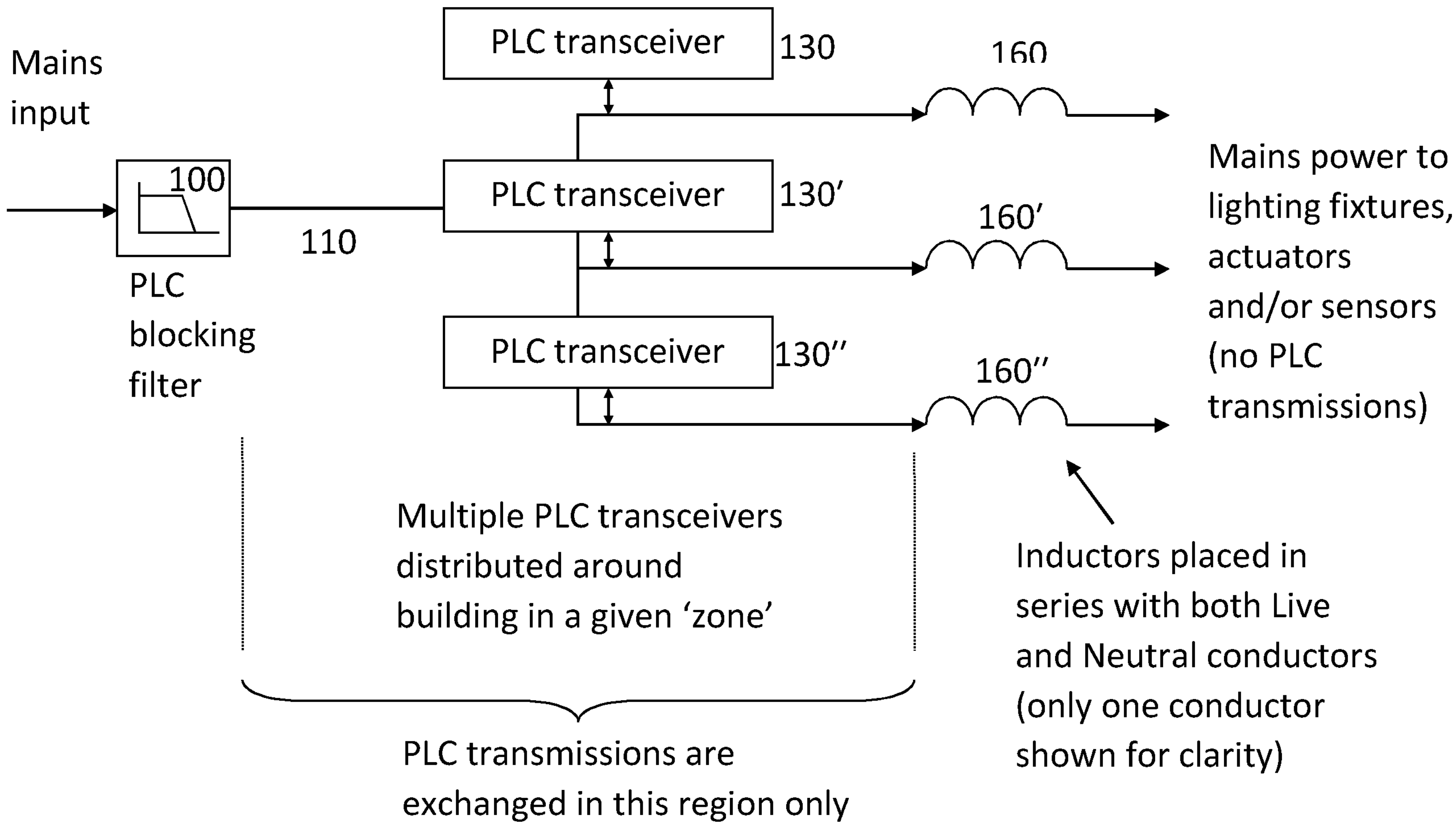
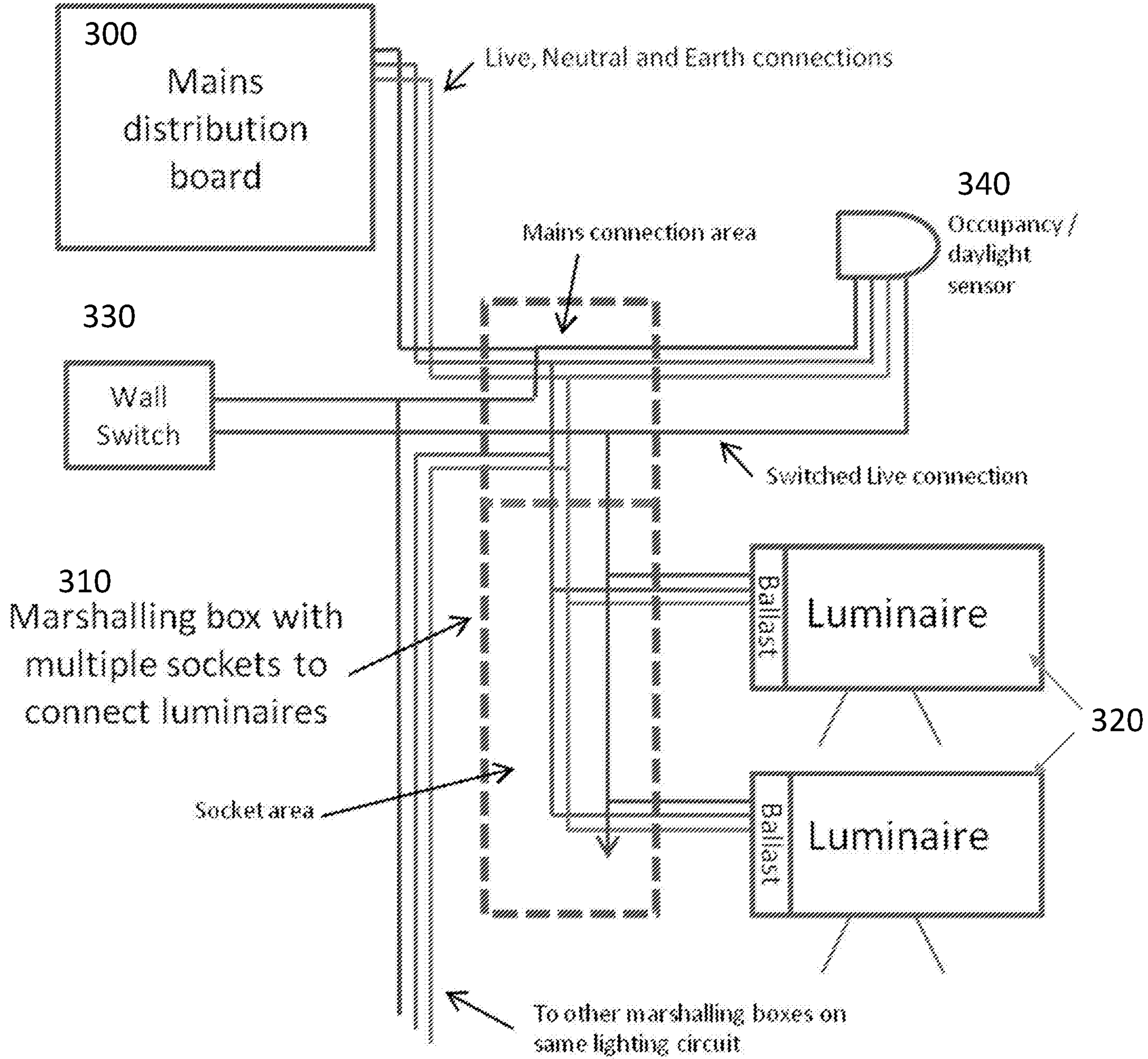


Figure 5/6: Typical standard marshalling box configuration



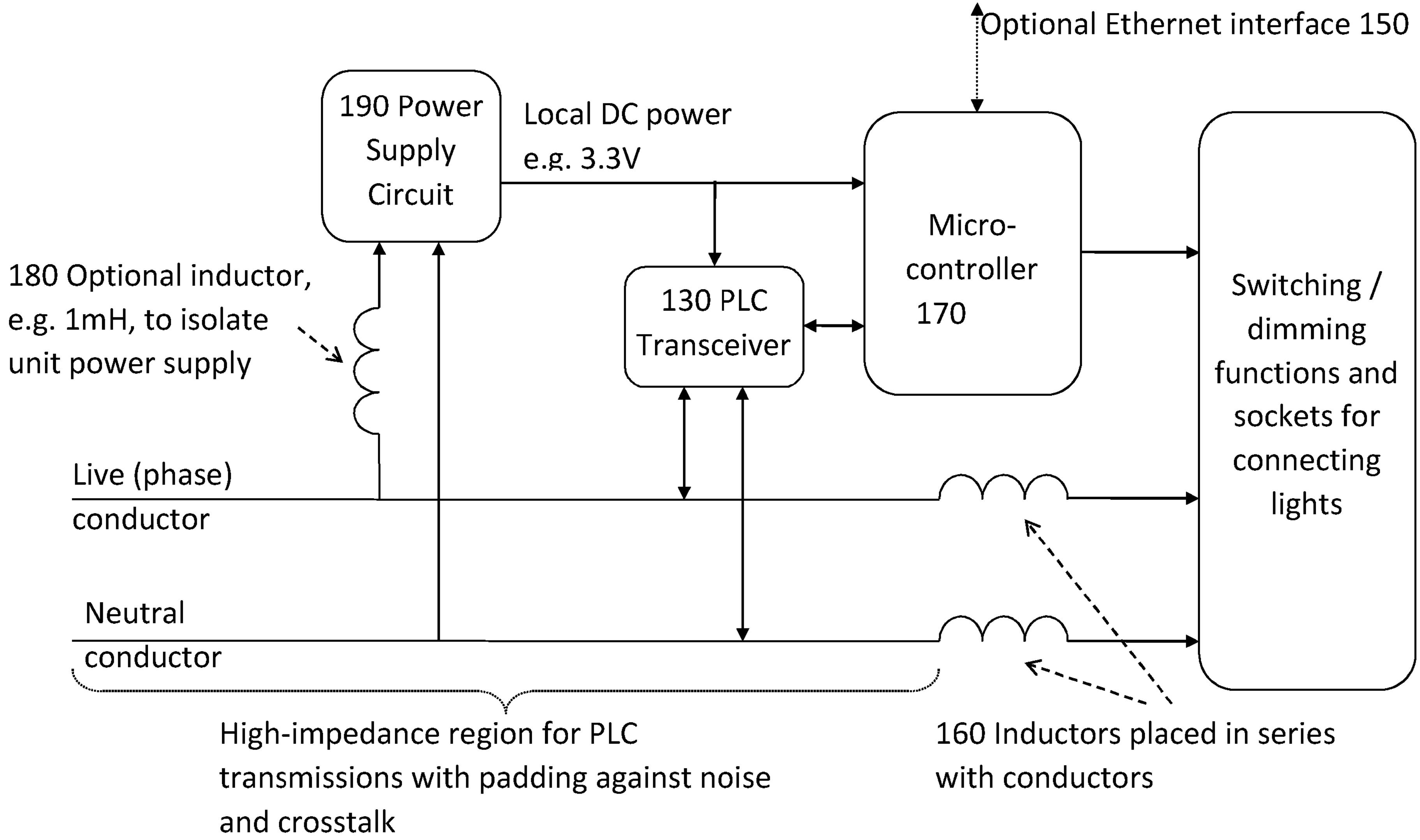


Figure 6/6: Block diagram of PLC-based lighting controller unit

TITLE: BUILDING MANAGEMENT SYSTEM AND METHOD OF COMMUNICATION

FIELD OF THE INVENTION

The present invention relates to a building management system using power line communication to automate the control of building services, in particular on lighting circuits.

BACKGROUND OF THE INVENTION

A conventional Building Management System (BMS) has intelligent controls which operate the fixed building services such as lighting, heating, ventilation and air-conditioning systems, in order to reduce energy consumption while maintaining comfort. UK Building regulations require a degree of intelligent control for heating and lighting, especially in commercial buildings, making BMS systems compulsory for all but a few exceptions. Also, it may be important to have the facility of network communication between BMS devices to allow central control and management of the services or to allow different parts of the building services to share information such as daylight levels, occupancy or weather information.

There are various types of communication network used for BMS systems, including systems such as shared networks with other data, dedicated cabled networks such as Bacnet or Lonworks, wifi or combinations of the above. Wired networks can have a prohibitive cost due to the need to break into the walls, floors and ceilings to install the additional cabling. Not only is such disruption costly, it is frequently impractical in a working building and, in the case of precious or listed buildings, highly undesirable and damaging.

Radio based systems such as WiFi or 2.4GHz radio communication overcome some of the problems with installation but, in a typical commercial building whose construction may include many steel parts and substantial wall and floor thicknesses, the propagation of radio signals can be adversely affected and highly dependent on precise positioning of the transceivers, requiring careful planning and often over-specification. For example it can become necessary to add strategically positioned ‘repeaters’, the need for which is often only determined once installation has begun. As well as the general issue of indoor transmission range, signal “fading” may also occur due to multi-path effects. In addition, radio interference from equipment within the building, and even from adjacent buildings with similar radio networks, can also be a significant factor in reducing the performance of such systems.

One type of network that avoids both the problems of dedicated control wiring and radio communication is Power Line Communication (PLC) where data communication is transmitted over the same cables installed for power distribution by using high frequency signals. This offers an advantage over wireless or dedicated network installations as it requires less infrastructure installation and therefore could reduce installation costs and complexity.

However, because of the variety of electrical devices in buildings, PLC communication can face many challenges. The difficulties are as follows:

- High attenuation caused by very low line impedances and multiple connected loads, which may be time-varying, either due to changes in configuration (loads connected, disconnected, turned on or off) or more rapidly changing due to the non-linear current sinking characteristics of switched-mode power supplies etc;

- Electrical noise conducted from nearby equipment interfering with the PLC signals; this can be tonal noise (specific frequencies, e.g. from switched-mode power supplies), low frequency impulsive noise (repeated pulses at twice the line frequency, e.g. from triac dimmers), high frequency impulsive noise (e.g. from electric motors) or combinations of all of these;

- Signal distortion due to line impedances and reactive loads producing unpredictable frequency responses, which may also be time-varying;

- Frequency-selective fading due to signal reflections causing multi-path effects, which again may be time-varying as the network topology changes.

In commercial buildings, these problems are exacerbated over and above those seen in domestic premises, partly due to the physical scale of the buildings, which leads to very large and complex power networks with many electrical loads, and partly due to the presence of items such as power-factor correction capacitors and possibly heavy machinery, which are not commonly seen in domestic buildings.

The above difficulties with the power line as a transmission medium have caused the eventual failure of several previous attempts at producing a viable and widely applicable PLC-based communications and control system for non-domestic buildings.

SUMMARY OF THE INVENTION

The present invention is a system for providing a communications path or network for use within buildings, based on powerline communications (PLC) carried over the lighting power circuits in a building, the system comprising:

one or more electrical filters at the input of each lighting power circuit for reduction/blocking of transmissions at PLC frequencies in both directions, to create separate communication zones for PLC signals within the building and to present a high load impedance to PLC signals within the zone at the output of the filter, the PLC signals being applied between Live (Phase) and Neutral conductors within each zone, PLC transceivers connected to the lighting power circuit to transmit and receive digital network information within each communication zone,

series inductances/impedances in the load circuit, for increased effective load impedance at the PLC transceivers over that of lighting fixtures or other loads powered from the circuit, to create separation of the wiring within each of the above communication zones into a region for transmission of both electrical power and PLC signals, to which electrical loads (e.g. lighting fixtures) are not directly connected, and one or more regions for transmission of electrical power only to which multiple electrical loads may be connected, and

multi-connection units distributed in the system, each unit having a plurality of power connectors for connection of electrical loads and containing at least one of the above series inductances/impedances and at least one PLC transceiver.

These inductors are described as load padding inductors, which are specifically selected to overcome the problem with power factor correction circuits common in lighting ballasts, but it will be apparent to one skilled in the art that other impedances could be selected depending on the type of loads connected.

In this way, the present invention may provide a network for BMS controls, which are low in cost, simple to install and do not interfere with other data networks or electrical devices.

Preferably, the series inductances/impedances are inserted into both the Live (Phase) and Neutral conductors of the circuit, although in some embodiments it may be acceptable to insert them in one or other of the conductors only.

The present invention also provides a controller apparatus comprising an enclosure for mounting within the building infrastructure to provide a plurality of connectors for powering and control of electrical loads and containing at least one PLC transceiver, and at least one inductor connected in series between the PLC transceiver and the load connectors to increase the load impedance seen by the PLC transceiver caused by the electrical loads connected to the unit.

Preferably the apparatus may also include a series connected inductor between the PLC transceiver and other circuitry within the unit, e.g. a power supply circuit or interference suppression filter, such that the load impedance presented by the other circuitry to the PLC transceiver is substantially increased.

Furthermore, the present invention also includes a microcontroller for receiving and transmitting control signals via the PLC interface and which is operable to control the connected loads and/or to interface with connected sensors and/or actuators for building management.

According to another aspect of the present invention, there is provided an additional communications interface to receive or transmit signals from outside the PLC transmission zone, e.g. from units in other zones or from a separate network, such as a Local Area Network or the Internet. In one embodiment of the invention this interface may be an Ethernet interface. In another embodiment of the invention this interface may be a wireless interface. It will be clear to a person skilled in the art that connection to other types of communication network would be possible.

A further embodiment of the present invention has a plurality of controller apparatus as described above which communicate with each other by means of PLC to form a network or sub-network, and which are all powered from a single lighting circuit within a building, the said lighting circuit having an electrical filter at its input to substantially reduce or block transmissions at PLC frequencies in both directions thus creating an isolated communications zone within the building, the said filter also being configured to present a suitably high load impedance to PLC signals within the zone at the output of the filter.

Preferably the subnetworks each have their own PLC blocking filter, exchange control or other signals between sub-networks using the additional communications interface such as wireless or ethernet mentioned above.

In another embodiment of the present invention, the separate lighting circuits are isolated from each other by the use of PLC blocking filters, and the said filters are also configured to have a PLC connection port to allow PLC signals but not mains frequencies to be passed, thereby permitting a larger subnetwork or communication zone which combines more than one lighting circuit to be formed using simple wired connections.

The present invention also provides a method for providing a communications path or network for use within buildings, using powerline communications (PLC) carried over the lighting power circuits in a building, the method comprising:

reducing/blocking transmissions at PLC frequencies in both directions using filters also presenting a high load impedance to PLC signals within the zone at the output of the filter, the PLC signals being applied between Live (Phase) and Neutral conductors within each zone,

connecting PLC transceivers to a lighting power circuit to transmit and receive digital network information within each communication zone,

inserting series inductances/impedances in the load circuit, for increased effective load impedance seen by the PLC transceivers above that of lighting fixtures or other loads powered from the circuit, to create separation of the wiring within each of the above communication zones into a region for transmission of both electrical power and PLC signals, to which electrical loads (e.g. lighting fixtures) are not directly connected, and one or more regions for transmission of electrical power only to which multiple electrical loads may be connected

installing multi-connection units in the system, each unit having a plurality of power connectors for connection of electrical loads and containing at least one of the above series inductances/impedances and at least one PLC transceiver.

The method may be carried out by inserting a series inductance/impedance either in the Live (Phase) conductor or in the Neutral conductor of the circuit, or both the Live (Phase) and Neutral conductors of the circuit.

ADVANTAGES OF THE PRESENT INVENTION

Advantages of the present invention are elimination of additional control wires and the integration of the majority of necessary components into a multi connection unit thereby to reduce installation cost and complexity.

A further advantage is the inclusion of load padding inductors on the outlet connections of the controller in combination with filters at the supply point of electrical circuits, ensuring the PLC signal strength is maintained even in large networks thus overcoming the difficulties previously experienced using PLC for complex networks.

APPLICATIONS OF THE PRESENT INVENTION

The present invention relates to a communication networking system and method using power line communications for use in domestic and residential buildings, additionally in office, commercial and industrial environments.

The present invention is particularly suited to building management systems for control and monitoring of fixed building services, especially for installation in existing buildings as a retrofit measure.

BRIEF DESCRIPTION OF THE DRAWINGS

In order that the invention may more readily understood, a description is now given, by way of example only, reference being made to various embodiments of the present invention, in which:-

FIGURE 1 is a block diagram of a lighting distribution circuit showing the filters installed as one embodiment of the present invention**;**

FIGURE 2 is a block diagram of a single lighting circuit showing the installed filter and transceivers in one embodiment in the present invention;

FIGURE 3 is an electrical circuit diagram of one embodiment of the filters used by the present invention;

FIGURE 4 is a block diagram of a lighting circuit showing the positioning of the padding inductors in one embodiment of the present invention.;

FIGURE 5 is a block diagram showing a prior art marshalling box or multi-connection unit;

FIGURE 6 is a block diagram of a lighting controller unit forming one embodiment of the present invention.

DETAILED DESCRIPTION OF THE DRAWINGS

Referring now to Figure 1, an exemplary arrangement shows PLC Blocking filters 100, 100′ (electrical band-stop or low-pass filters) placed in each lighting circuit 110, 110′, immediately after the fuse or circuit breaker (typically adjacent to the electrical distribution board 120, often housed in a building riser cabinet). These ‘blocking’ filters significantly reduce the ingress of noise to each circuit at PLC frequencies and also block PLC signals in both inward and outward directions, thus creating separate communication ‘islands’ or ‘zones’ within the building, the zones initially corresponding to the separate lighting circuits, with the PLC signals confined to the region downstream of the filter. Figure 1 also shows optional PLC coupling 115′ between the zones whereby the filters have an additional PLC port which will transmit the PLC signal between cables without passing the mains power.

Figure 2 shows one zone with multiple PLC transceivers 130, 130′, 130″ connected to the mains power wiring 110 at different points within each zone, each communicating with other transceivers solely in that zone, and each transceiver being associated with, and typically housed within, a controller unit 140 with embedded intelligence. These controller units with PLC interfaces are distributed throughout the building and provide the required automation or management functions, e.g. lighting control. Also shown is a gateway interface 150 which may be used to link to another zone to allow coordinated operation of the system across the whole building, and may also be connected to an external computing device for system management purposes.

Figure 3.shows a typical filter architecture. A pair of capacitors 200, 200′, together with a common-mode choke 230, are used for noise filtering and a pair of series inductors 210, 210′ are used to isolate the PLC transmissions from their low impedance. The current-carrying capacity of the filters depends on where, within the power supply architecture of the building, they are installed. The power architecture typically forms a tree-like topology, where the conductors branch out at various distribution points from a central power input for the whole building to where the various loads (e.g. lighting circuits etc.) are located. In general, the more branches are present upstream, the lower the current carried by the conductors at a given point in the architecture. There is therefore a choice of whether to install fewer filters with a higher current capacity further upstream within the power architecture (and hence create larger PLC zones), or to install more filters with a lower current capacity further downstream (smaller PLC zones).

In practice, the preferable option is dictated by the desirability of maintaining standard wiring practices within the building to facilitate easy retro-fit and minimum retraining of installers and re-planning of wiring. This typically means installing filters immediately downstream of existing circuit breakers at the usual distribution panels.

Lighting circuits in commercial buildings are often rated at 10 Amps, which means using a filter on each circuit rated at 10 Amps. This is a preferred embodiment but, for lighting circuits with higher rated circuit breakers and distribution points, a filter with a higher current rating would be used.

Suitable inductance values for series inductors 210, 210' depend on the characteristics of the PLC transceivers and expected loads, however typically values in the range 300 to

600 uH are appropriate. Required filter attenuation depends on transceiver characteristics (more sensitive receivers and/or more powerful transmitters within the transceiver function will require higher attenuation to maintain separation between PLC zones). A typical attenuation of 50 dB in each direction is suitable. This provides sufficient attenuation for a transceiver with a transmitted power of up to 120 dBuV rms and a typical receiver sensitivity of 40 dBuV rms, whilst maintaining a reasonable performance margin. It should be noted that power line attenuation, both inside and outside the PLC transmission zone, will affect the actual filter attenuation achieved in practice, whereas nominal filter attenuation values specified and quoted by filter suppliers generally assume standard 50 Ohm source and load impedances. Therefore a higher-than-expected nominal attenuation is required in order to achieve the desired performance in practice. Various filter designs may be employed to achieve the required attenuation. Capacitor values of, say, 500 nF are generally appropriate in combination with the series inductor values mentioned above. The common-mode choke is not strictly part of the filter as far as PLC is concerned, as it does not block differential signals - however a common mode choke with a typical inductanceof 40 mH would be suitable to help reduce unhelpful common mode noise in the system.

Figure 4 shows the load padding inductors 160, 160′, 160″ installed on the lighting circuit 110, between the PLC transceiver 130 and the lighting fixtures. Many older commercial buildings, typical of those requiring retrofit of intelligent controls, employ standard magnetic ballasts for fluorescent lighting which are highly inductive components. Therefore, power factor correction capacitors are routinely distributed across all lighting fixtures, with typical capacitance values of several microfarads connected between Live and Neutral conductors at each fixture. At PLC signal frequencies, these capacitors represent an extremely low impedance, especially when many are connected in parallel, and hence result in a heavy load to the signals, leading to severe signal attenuation and therefore poor transmission, depending on other line-related impedances and the noise in the system.

In addition to these capacitors across the line, the lighting ballasts themselves often contain parasitic capacitance to ground from both Live and Neutral conductors of several nanofarads. If high-frequency electronic ballasts or, in the case of LED lighting, switched mode power supplies are present then these too are likely to contain capacitors from Live to Earth and Neutral to Earth respectively in order to suppress electromagnetic emissions (sometimes called ‘Y capacitors’). These capacitors produce a significant and undesirable ‘leakage’ path for PLC signals between zones, allowing signals intended for one zone to propagate to another via the Earth wiring, which can mitigate against the identified advantages of zoning.

In order to isolate the PLC signals from the effects of the low impedance power factor correction capacitors and simultaneously to reduce the inter-zone crosstalk caused by the EMC or Y capacitors, high-current passive inductors 160 are inserted in series with both Live and Neutral lines to electrically separate the lighting loads from the PLC signals. I.e. the inductors create an attenuator or ‘pad’ between the PLC transmission environment and the lighting fixtures.

In combination with the series inductors 210 present in the zone filters 100, shown in Figure 3, this has the effect of dramatically increasing the load impedance experienced by the PLC transceivers 130, thereby significantly increasing the signal levels, improving the signal to noise ratio and reducing signal distortion, leading to reliable transmission. It also significantly reduces the ‘leakage’ of messages (crosstalk) between zones through the Earth via Y-capacitors, making the system easier to manage and reducing data collisions. At the same time it serves to protect the PLC signals from any noise generated by the loads, e.g. switching noise from power supplies etc

Figure 5 shows a typical prior art multi connection unit (marshalling box) configuration. The multi-connection unit 310, or marshalling box, is typically intended for installation in the void above suspended ceilings. These are available from several manufacturers and act as distribution points for connecting mains power to multiple lighting fixtures 320 (luminaires). They have a single mains power input and several (typically between 4 and 12) outputs with multi-pole sockets connected in parallel, allowing lights to be connected to the power circuit by simply plugging in to the sockets using standard connectors. In this way, lighting fixtures can safely be disconnected for maintenance.

The multi-connection units in Figure 5 have additional inputs for ‘switched live’ connections to allow groups of lights to be turned on or off under the action of an external switch 330 or daylight sensor 340. Generally, however, there is no built-in intelligence or communication ability.

Mains power from the electrical distribution board 300 may be connected to a number of multi-connection units 310 on each circuit, the number of units being determined by the number of lighting fixtures (luminaires) to be powered by each circuit and the number of sockets available on each unit.

Figure 6 shows a block diagram of an exemplary controller designed according to the present invention. The main blocks within the controller unit are: a PLC transceiver 130 and a microcontroller 170, both supplied with DC power from an on-board AC-DC power supply 190, plus a block containing the required functions to control the connected electrical loads and/or sensors, e.g. switching or dimming circuitry to control lighting, interface circuits for connecting occupancy or light level sensors etc.
In the exemplary system shown, 200uH load padding inductors 160 are used in Live (Phase) and Neutral lines for padding against the low impedances, noise and cross-talk associated with the typical lighting loads seen in commercial buildings. The PLC transceiver 130 applies PLC signals between Live and Neutral conductors but is separated from the loads themselves by the padding inductors.

If, as is typical, the unit’s on-board AC-DC power supply circuitry 190 contains an EMC (electromagnetic compatibility) input filter with capacitance across the line, then a further inductor 180 is preferably included to avoid the additional load of this capacitance affecting the PLC transmissions. This inductor can typically be larger in inductance value than the other padding inductors, as its current rating is typically much smaller and therefore suitable low-cost and physically small inductors are easily obtainable. Alternatively, the AC-DC power supply 190 could have its live feed taken from the other side of the padding inductors whilst omitting the larger inductor, however this would not provide as much separation between the PLC signals and the EMC capacitance.

The PLC transceiver is connected to and controlled by a suitable microcontroller 170, which also provides the required intelligence and other interfaces to operate actuators to control the lighting and possibly other building services. If the unit is a Gateway unit, the microcontroller also provides an Ethernet or other suitable interface 150 for management by a user and inter-zone communications.

All of the above functions are housed within a unit resembling a standard multi-connection unit with sockets to connect the lighting. Because all units are constructed in the same way, and because all electrical loads are connected using the sockets on the units rather than directly to the power wiring, and because of the upstream filtering at the input to each lighting circuit, a transmission environment is maintained between the units which is suitable for high integrity robust PLC-based communications.

CLAIMS

1. A system for providing a communications path or network for use within buildings, based on powerline communications (PLC) carried over the lighting power circuits in a building, the system comprising:

one or more electrical filters at the input of each lighting power circuit for reduction/blocking of transmissions at PLC frequencies in both directions, to create separate communication zones for PLC signals within the building and to present a high load impedance to PLC signals within the zone at the output of the filter, the PLC signals being applied between Live (Phase) and Neutral conductors within each zone,

PLC transceivers connected to the lighting power circuit to transmit and receive digital network information within each communication zone,

series inductances/impedances in the load circuit, for increased effective load impedance at the PLC transceivers over that of lighting fixtures or other loads powered from the circuit, to create separation of the wiring within each of the above communication zones into a region for transmission of both electrical power and PLC signals, to which electrical loads (e.g. lighting fixtures) are not directly connected, and one or more regions for transmission of electrical power only to which multiple electrical loads may be connected, and

multi-connection units distributed in the system, each unit having a plurality of power connectors for connection of electrical loads and containing at least one of the above series inductances/impedances and at least one PLC transceiver.

2. The system of claim 1 in which the series inductance/impedance is inserted either in the Live (Phase) conductor or in the Neutral conductor of the circuit.

3. The system of claim 1 in which series inductance/impedance is inserted in both the Live (Phase) and Neutral conductors of the circuit.

4. A controller apparatus for use in the system of any of claims 1 to 3 comprising:

an enclosure for mounting within the building infrastructure providing a plurality of connectors for powering and control of electrical loads and containing:

at least one PLC transceiver, and

at least one inductor connected in series between the PLC transceiver and the load connectors for increasing the load impedance seen by the PLC transceiver caused by the electrical loads connected to the unit.

5. The apparatus of claim 4 which further includes a series connected inductor between the PLC transceiver and other circuitry within the unit, e.g. a power supply circuit or interference suppression filter, for increased load impedance presented by the other circuitry to the PLC transceiver.

6. The apparatus of claim 4 or claim 5 which further includes a microcontroller for receiving and transmitting control signals via the PLC interface and which is operable to control the connected loads and/or to interface with connected sensors and/or actuators for building management.

7. The apparatus of claim 6 which further provides an additional communications interface to receive or transmit signals from outside the PLC transmission zone, e.g. from units in other zones or from a separate network, such as a Local Area Network or the Internet.

8. The apparatus of claim 7 where the additional communications interface is an Ethernet interface.

9. The apparatus of claim 7 where the additional interface is a wireless interface.

10. The apparatus of claim 7 for PLC communication with a plurality of similar apparatus all powered from a single lighting circuit within a building, the said lighting circuit having an electrical filter at its input for reduction/ blocking of transmissions at PLC frequencies in both directions to create an isolated communications zone within the building, the said filter also being configured to present high load impedance to PLC signals within the zone at the output of the filter.

11. The apparatus of Claim 10 operable to exchange control or other signals between sub-networks on different lighting circuits using an additional communications interface.

12. The apparatus of Claim 10 wherein the said filter unit is operable to reduce/block transmissions at PLC frequencies in both directions and also comprises a PLC connection port to allow passage of only PLC signals between multiple communication zones by wire connections between the PLC connection ports on the associated filters of each zone, to create one PLC communication zone combined from several individual ones.

13 A method for providing a communications path or network for use within buildings, using powerline communications (PLC) carried over the lighting power circuits in a building, the method comprising:

reducing/blocking transmissions at PLC frequencies in both directions using filters also presenting a high load impedance to PLC signals within the zone at the output of the filter, the PLC signals being applied between Live (Phase) and Neutral conductors within each zone,

connecting PLC transceivers to a lighting power circuit to transmit and receive digital network information within each communication zone,

inserting series inductances/impedances in the load circuit, for increased effective load impedance seen by the PLC transceivers above that of lighting fixtures or other loads powered from the circuit, to create separation of the wiring within each of the above communication zones into a region for transmission of both electrical power and PLC signals, to which electrical loads (e.g. lighting fixtures) are not directly connected, and one or more regions for transmission of electrical power only to which multiple electrical loads may be connected

installing multi-connection units in the system, each unit having a plurality of power connectors for connection of electrical loads and containing at least one of the above series inductances/impedances and at least one PLC transceiver.

14. The method of claim 13 further comprising inserting a series inductance / impedance either in the Live (Phase) conductor or in the Neutral conductor of the circuit.

15. The method of claim 13 further comprising inserting a series inductance / impedance in both the Live (Phase) and Neutral conductors of the circuit.

Intellectual Property Office

Application No:	GB1516797.6	**Examiner:**	Dan Hickery
Claims searched:	1 to 15	**Date of search:**	16 May 2016

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
Y	1-5, 13-15 at least	JP 2003188778 A (TDK) whole document, especially figures 1 and 2
Y	1-5, 13-15 at least	US 2010/151701 A1 (YAMASHITA) figure 1, paragraphs 0072-0076
A	-	GB 2418825 A (AGILENT)
A	-	US 2006/227884 A1 (KOGA)
A	-	US 4973940 A (SAKAI)
A	-	JP 2003283390 A (NT&T)

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^X :

Worldwide search of patent documents classified in the following areas of the IPC

H04B

The following online and other databases have been used in the preparation of this search report

Online: EPODOC, WPI

Intellectual Property Office

International Classification:

Subclass	**Subgroup**	**Valid From**
H04B	0003/56	01/01/2006