(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 4 415 484 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
**14.08.2024 Bulletin 2024/33**

(21) Application number: **23155934.5**

(22) Date of filing: **10.02.2023**

(51) International Patent Classification (IPC):
***H05B 47/18*** *(2020.01)*

(52) Cooperative Patent Classification (CPC):
**H05B 47/18; H05B 47/183**

(84) Designated Contracting States:
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC ME MK MT NL NO PL PT RO RS SE SI SK SM TR**
Designated Extension States:
**BA**
Designated Validation States:
**KH MA MD TN**

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# (54) MAINS PARAMETER ANALYZING DEVICE FOR A LIGHTING CONTROL BUS, AND METHOD OF OPERATING THE SAME

(57) A mains parameter analyzing device (1) for a lighting control bus (5) is provided, comprising: a bus terminal (11), being connectable to the lighting control bus (5); a mains input terminal (12), being connectable to a mains supply; a mains output terminal (13), being connectable to a mains supply rail; a measurement unit (14), being configured to measure, at the mains output terminal (13), parameters of a mains power output to a number of bus-capable lighting drivers (3); a communication unit (15), being configured to receive, via the bus terminal (11), indicative parameters of a respective mains power input of the number of bus-capable lighting drivers (3); and a processing unit (16), being configured to associate the respective bus-capable lighting driver (3) with a respective mains power input using a machine learning algorithm, in accordance with the indicative parameters of the respective mains power inputs and the parameters of the mains power output. This avoids furnishing every bus-capable driver of a lighting system with a mains power monitoring feature.

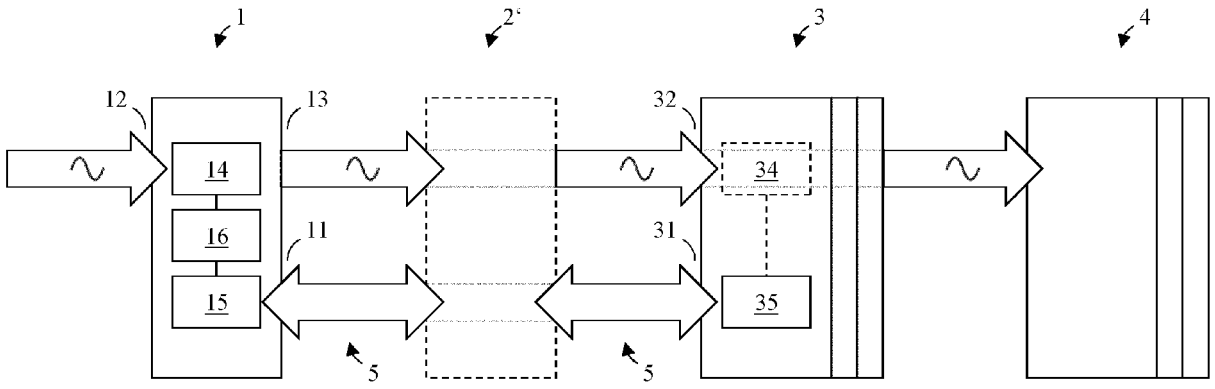


FIG. 1

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## Description

### Technical Field

**[0001]** The present disclosure relates to lighting technology, and in particular, to a mains parameter analyzing device for a lighting control bus, and a method of operating the mains parameter analyzing device.

### Background Art

**[0002]** According to recent progress in standardization of the Digital Addressable Lighting Interface (DALI), every DALI-controlled driver of a lighting system requires a mains power monitoring feature.

**[0003]** Despite the typically limited mains power analyzing accuracy, said feature entails more expensive drivers and a higher system cost, as well as disregard for non-DALI-controlled drivers, DALI controls and sensors, and power supplies for the DALI bus.

### Summary

**[0004]** In view of the above-mentioned drawbacks and limitations, the present disclosure aims to improve mains parameter analysis in bus-controlled lighting systems.

**[0005]** This is achieved by the embodiments as defined by the appended independent claims. Preferred embodiments are set forth in the dependent claims and in the following description and drawings.

**[0006]** A first aspect of the present disclosure relates to a mains parameter analyzing device for a lighting control bus, comprising a bus terminal, being connectable to the lighting control bus; a mains input terminal, being connectable to a mains supply; a mains output terminal, being connectable to a mains supply rail; a measurement unit, being configured to measure, at the mains output terminal, parameters of a mains power output to a number of bus-capable lighting drivers; a communication unit, being configured to receive, via the bus terminal, indicative parameters of a respective mains power input of the number of bus-capable lighting drivers; and a processing unit, being configured to associate the respective bus-capable lighting driver with a respective mains power input using a machine learning algorithm, in accordance with the indicative parameters of the respective mains power inputs and the parameters of the mains power output.

**[0007]** The parameters of the mains power output may comprise one or more of a real power, a reactive power, an apparent power, and a power factor.

**[0008]** The indicative parameters of the respective mains power inputs may comprise one or more of: a bus address, a dim level, a timestamp, and a real power of the respective bus-capable lighting driver.

**[0009]** For associating the respective bus-capable lighting driver with the respective mains power input, the machine learning algorithm may comprise a supervised learning algorithm; and the processing unit may further be configured to train the machine learning algorithm, using the indicative parameters of the respective mains power inputs as input data and the parameters of the mains power output as label data.

**[0010]** The machine learning algorithm may comprise a backpropagation algorithm applied to a feedforward artificial neural network.

**[0011]** For associating the respective bus-capable lighting driver with the respective mains power input, the processing unit may further be configured to selectively send, via the bus terminal, the indicative parameters of the respective mains power input to the respective bus-capable lighting driver.

**[0012]** The measurement unit may further be configured to measure, at the mains input terminal, parameters of a mains power input; and the processing unit may further be configured to relate the parameters of the mains power input and the parameters of the mains power output.

**[0013]** The measurement unit may further be configured to filter the mains power output with respect to the mains power input.

**[0014]** A second aspect of the present disclosure relates to a power supply for a lighting control bus, comprising a mains parameter analyzing device of the first aspect.

**[0015]** A third aspect of the present disclosure relates to a bus-capable lighting driver, comprising a bus terminal, being connectable to a lighting control bus; a mains input terminal, being connectable to a mains supply rail; and a communication unit, being configured to send, via the bus terminal, indicative parameters of a mains power input via the mains input terminal;

**[0016]** The bus-capable lighting driver may further comprise a measurement unit, being configured to measure indicative parameters of a mains power input via the mains input terminal.

**[0017]** The indicative parameters of the mains power input may comprise one or more of: a bus address, a dim level, a timestamp, and a real power of the bus-capable lighting driver.

**[0018]** A fourth aspect of the present disclosure relates to a method of operating a mains parameter analyzing device for a lighting control bus, the method comprising: measuring, at a mains output terminal being connectable to a mains supply rail, parameters of a mains power output to a number of bus-capable lighting drivers; receiving, via a bus terminal being connectable to the lighting control bus, indicative parameters of a respective mains power input of the number of bus-capable lighting drivers; and associating the respective bus-capable lighting driver with a respective mains power input using a machine learning algorithm, in accordance with the indicative parameters of the respective mains power inputs and the parameters of the mains power output.

**[0019]** The method may be performed by a mains parameter analyzing device of the first aspect.

## Advantageous Effects

**[0020]** The present disclosure provides a mains parameter analyzing device for a lighting control bus, which avoid furnishing every DALI-controlled driver of a lighting system with a mains power monitoring feature. Instead, the mains parameter analyzing device disclosed herein is provided centrally, for example in a cabinet in connection with a power supply for the DALI bus. In other words, the mains parameter analyzing device replaces the plurality of mains power monitoring features of a whole DALI-controlled lighting system. This entails a lower component count respective lower system cost, a higher measurement accuracy, and a higher system efficiency. In addition, every DALI-addressable device, such as DALI controls, DALI sensors and DALI bus power supplies, and even non-DALI-addressable drivers may be monitored as well. Also "special events" such as transients on the mains supply may be measured and/or filtered, resulting in a higher system robustness.

**[0021]** The technical effects and advantages described above in relation with the mains parameter analyzing device equally apply to the method of operating said device and to the bus-capable lighting driver respectively having corresponding features, as well as to the power supply comprising said device.

## Brief Description of Drawings

**[0022]** The above-described aspects and implementations will now be explained with reference to the accompanying drawings, in which the same or similar reference numerals designate the same or similar elements.

**[0023]** The features of these aspects and implementations may be combined with each other unless specifically stated otherwise.

**[0024]** The drawings are to be regarded as being schematic representations, and elements illustrated in the drawings are not necessarily shown to scale. Rather, the various elements are represented such that their function and general purpose become apparent to those skilled in the art.

FIG. 1 illustrates schematically an exemplary lighting system, including a mains parameter analyzing device in accordance with the present disclosure for a lighting control bus, a power supply for the lighting control bus, a number of bus-capable lighting drivers in accordance with the present disclosure, and a number of non-bus-capable lighting drivers;

FIG. 2 illustrates schematically another exemplary lighting system, including a power supply for a lighting control bus in accordance with the present disclosure, comprising a mains parameter analyzing device in accordance with the present disclosure for the lighting control bus, a number of bus-capable lighting drivers in accordance with the present disclosure, and a number of non-bus-capable lighting drivers; and

FIG. 3 illustrates schematically a flow chart of a method of operating a mains parameter analyzing device in accordance with the present disclosure for the lighting control bus.

## Detailed Descriptions of Drawings

**[0025]** FIG. 1 illustrates schematically an exemplary lighting system, including - from left to right - a mains parameter analyzing device 1 in accordance with the present disclosure for a lighting control bus 5, a power supply 2' for the lighting control bus 5, a number of bus-capable lighting drivers 3 in accordance with the present disclosure, and a number of non-bus-capable lighting drivers 4.

**[0026]** The mains parameter analyzing device 1 comprises a bus terminal 11, a mains input terminal 12 and a mains output terminal 13.

**[0027]** The bus terminal 11 of the mains parameter analyzing device 1 is connectable to the lighting control bus 5 being represented by a block arrow to the right of the bus terminal 11.

**[0028]** The lighting control bus 5 may be a Digital Addressable Lighting Interface (DALI) bus, in particular.

**[0029]** The mains input terminal 12 of the mains parameter analyzing device 1 is connectable to a mains/grid supply being represented by a block arrow to the left of the mains input terminal 12 and being indicated by a sine wave symbol.

**[0030]** The mains output terminal 13 of the mains parameter analyzing device 1 is connectable to a mains supply rail/line/connection being represented by a block arrow to the right of the mains output terminal 13 and also being indicated by the sine wave symbol.

**[0031]** The mains parameter analyzing device 1 further comprises a measurement unit 14, a communication unit 15 and a processing unit 16.

**[0032]** The measurement unit 14 of the mains parameter analyzing device 1 is configured to measure, at the mains output terminal 13, parameters of a mains power output to the number of bus-capable lighting drivers 3, and optionally to the number of non-bus-capable lighting drivers 4 shown to the right of FIG. 1, if any.

**[0033]** As such, the parameters of the mains power output to the whole installation is measured centrally. In other words, the mains parameter analyzing device 1 replaces the plurality of mains power monitoring features of a whole DALI-controlled lighting system.

**[0034]** This entails a lower component count respective lower system cost, a higher measurement accuracy, and a higher system efficiency. In addition, every DALI-addressable device, such as DALI controls (not shown), DALI sensors (not shown), DALI bus power supplies 2', DALI-addressable drivers 3, and even non-DALI-addressable drivers 4 may be monitored as well.

**[0035]** In particular, the parameters of the mains power output may comprise one or more of: a real power, a reactive power, an apparent power, and a power factor.

**[0036]** The optional power supply 2' for the lighting control bus 5 in FIG. 1 may include a direct current (DC) power supply, such as a familiar DALI power supply if the lighting control bus 5 comprises a DALI bus.

**[0037]** The respective bus-capable lighting driver 3 of the number of bus-capable lighting drivers 3 shown in FIG. 1 comprises a bus terminal 31 and a mains input terminal 32.

**[0038]** The bus terminal 31 of the respective bus-capable lighting driver 3 is connectable to the lighting control bus 5 being represented by a block arrow to the left of the bus terminal 31.

**[0039]** The mains input terminal 32 respective bus-capable lighting driver 3 is connectable to the mains supply rail being represented by a block arrow to the left of the mains input terminal 32 and being indicated by the sine wave symbol.

**[0040]** The respective bus-capable lighting driver 3 further comprises a communication unit 35, and may further comprise a measurement unit 34.

**[0041]** The communication unit 35 of the respective bus-capable lighting driver 3 is configured to send, via the bus terminal 11, indicative parameters of a mains power input via the mains input terminal 12.

**[0042]** In particular, the indicative parameters of the mains power input may comprise one or more of: a bus address, a dim level, and a timestamp of the respective bus-capable lighting driver 3.

**[0043]** Note that the sending of the indicative parameters of the mains power input via the mains input terminal 12 may require a stimulus by the mains parameter analyzing device 1 in the form of a corresponding query of the respective bus-capable lighting driver 3 via the lighting control bus 5.

**[0044]** The measurement unit 34, if any, of the respective bus-capable lighting driver 3 may be configured to measure the indicative parameters of the mains power input via the mains input terminal 12, in particular a real power of the mains power input.

**[0045]** In that case the indicative parameters of the mains power input may comprise one or more of a bus address, a dim level, a timestamp, and the real power of the respective bus-capable lighting driver 3.

**[0046]** Note that the measuring and sending of the real power of the respective bus-capable lighting driver 3 is impossible without the above-mentioned mains power monitoring feature.

**[0047]** Note that the measuring and sending of the real power of the respective non-bus-capable lighting driver 4 is impossible from the outset.

**[0048]** Returning to the mains parameter analyzing device 1, its communication unit 15 is configured to receive, via the bus terminal 11, the indicative parameters of the respective mains power input of the number of bus-capable lighting drivers 3.

**[0049]** Evidently, the indicative parameters of the respective mains power inputs may comprise one or more of: a bus address, a dim level, a timestamp, and a real power of the respective bus-capable lighting driver 3.

**[0050]** The processing unit 16 of the mains parameter analyzing device 1 is configured to associate the respective bus-capable lighting driver 3 with its respective mains power input using a machine learning algorithm, in accordance with the indicative parameters of the respective mains power inputs and the parameters of the mains power output of the mains parameter analyzing device 1.

**[0051]** For associating the respective bus-capable lighting driver 3 with the respective mains power input, the machine learning algorithm may particularly comprise a supervised learning algorithm; and the processing unit 16 may further be configured to train the machine learning algorithm using the indicative parameters of the respective mains power inputs (i.e., current state information including the indicative parameters of the respective mains power inputs of the number of bus-capable lighting drivers 3) as input data and the parameters of the mains power output (due to the number of bus-capable lighting drivers 3 and the number of non-bus-capable lighting drivers 4, if any) as label data.

**[0052]** In particular, the machine learning algorithm may comprise a backpropagation algorithm applied to a feedforward artificial neural network included in the processing unit 16.

**[0053]** This way, the mains parameter analyzing device 1 may be able to distinguish the respective mains power input of each bus-capable lighting driver 3 within the installation, not only of the whole installation.

**[0054]** The mains parameter analyzing device 1 may continuously listen to the lighting control bus 5 so it gets the information of when which luminaire (i.e., included bus-capable lighting driver 3) has which dim level. This information helps to distinguish the respective mains power input per DALI address out of the mains power output of the mains parameter analyzing device 1. As more dimming and as more standby cycles are done, the better the mains parameter analyzing device 1 can distinguish the respective mains power input per DALI address.

**[0055]** If the mains power output of the mains parameter analyzing device 1 drops without any change of dim level on the DALI bus 5, then the mains parameter analyzing device 1 may conclude that this is due to non-bus-capable lighting drivers 4 not being connected to the DALI bus 5 (e.g. fixed output luminaires switched by mains switches). As more switching cycles of non-bus-capable lighting drivers 4 are done, the better the mains parameter analyzing device 1 may evaluate the number of non-bus-capable lighting drivers 4 being connected.

**[0056]** If the mains power output of the mains parameter analyzing device 1 fails to drop upon a change of dim level on the DALI bus 5, then the mains parameter analyzing device 1 may conclude that the addressed component is defect.

**[0057]** In case there are bus-capable lighting drivers 3 having the above-mentioned mains power monitoring feature, the mains parameter analyzing device 1 may be able to obtain the indicative parameters of the respective mains power inputs very fast and to evaluate the amount of the other components faster as well. Since the integrated mains power monitoring feature is usually is not very accurate, the mains parameter analyzing device 1 may then fine-tune the respective mains power input over time.

**[0058]** For associating the respective bus-capable lighting driver 3 with the respective mains power input, the processing unit 16 may further be configured to selectively send, via the bus terminal 11, the indicative parameters of the respective mains power input to the respective bus-capable lighting driver 3.

**[0059]** That is to say, the mains parameter analyzing device 1 may even perform a "fast self- learning" procedure by stimulating the respective mains power input of the respective bus-capable lighting driver 3 (e.g., in accordance with a particular dim level) and in turn receiving corresponding indicative parameters of the respective mains power input of the respective bus-capable lighting driver 3 at its bus terminal 11 as well as measuring corresponding parameters of the mains power output at its mains output terminal 13.

**[0060]** For example, the mains parameter analyzing device 1 may be configured to dim each single DALI address to gather respective mains power input, and/or instruct a user to switch on/off singe non-DALI components.

**[0061]** The measurement unit 14 may further be configured to measure, at the mains input terminal 12, parameters of a mains power input, and the processing unit 16 may further be configured to relate the parameters of the mains power input and the parameters of the mains power output.

**[0062]** This way, the mains parameter analyzing device 1 may be able to detect special events such as transients on the mains supply.

**[0063]** The measurement unit 14 may further be configured to filter the mains power output with respect to the mains power input.

**[0064]** This way, the mains parameter analyzing device 1 may be able to filter detected special events such as transients on the mains supply, resulting in a higher system robustness.

**[0065]** FIG. 2 illustrates schematically another exemplary lighting system, including - from left to right - a power supply 2 for a lighting control bus 5 in accordance with the present disclosure, comprising a mains parameter analyzing device 1 in accordance with the present disclosure for the lighting control bus 5, a number of bus-capable lighting drivers 3 in accordance with the present disclosure, and a number of non-bus-capable lighting drivers 4.

**[0066]** The mode of operation of the mains parameter analyzing devices 1 in FIGs. 1 and 2 is the same, the only difference being the integration of the mains parameter analyzing device 1 into the power supply 2 for the lighting control bus 5.

**[0067]** FIG. 3 illustrates schematically a flow chart of a method 6 in accordance with the present disclosure of operating a mains parameter analyzing device 1 in accordance with the present disclosure for the lighting control bus 5.

**[0068]** The method 6 comprises a step of measuring 61, at a mains output terminal 13 being connectable to a mains supply rail, parameters of a mains power output to a number of bus-capable lighting drivers 3.

**[0069]** The method 6 further comprises a step of receiving 62, via a bus terminal 11 being connectable to the lighting control bus 5, indicative parameters of a respective mains power input of the number of bus-capable lighting drivers 3.

**[0070]** The method 6 further comprises a step of associating 63 the respective bus-capable lighting driver 3 with a respective mains power input using a machine learning algorithm, in accordance with the indicative parameters of the respective mains power inputs and the parameters of the mains power output.

**[0071]** The method 6 may be performed by a mains parameter analyzing device 1 of the first aspect.

## Claims

**1.** A mains parameter analyzing device (1) for a lighting control bus (5), comprising

- a bus terminal (11), being connectable to the lighting control bus (5);
- a mains input terminal (12), being connectable to a mains supply;
- a mains output terminal (13), being connectable to a mains supply rail;
- a measurement unit (14), being configured to
  - measure, at the mains output terminal (13), parameters of a mains power output to a number of bus-capable lighting drivers (3);
- a communication unit (15), being configured to
  - receive, via the bus terminal (11), indicative parameters of a respective mains power input of the number of bus-capable lighting drivers (3); and
- a processing unit (16), being configured to
  - associate the respective bus-capable lighting driver (3) with a respective mains power input using a machine learning algorithm, in accordance with the indicative parameters of the respective mains power in-

puts and the parameters of the mains power output.

**2.** The mains parameter analyzing device (1) of claim 1, the parameters of the mains power output comprising one or more of:

- a real power,
- a reactive power,
- an apparent power, and
- a power factor.

**3.** The mains parameter analyzing device (1) of claim 1 or claim 2,
the indicative parameters of the respective mains power inputs comprising one or more of:

- a bus address,
- a dim level,
- a timestamp, and
- a real power of the respective bus-capable lighting driver (3).

**4.** The mains parameter analyzing device (1) of any of the preceding claims,

for associating the respective bus-capable lighting driver (3) with the respective mains power input, the machine learning algorithm comprising a supervised learning algorithm; and
the processing unit (16) further being configured to

- train the machine learning algorithm, using the indicative parameters of the respective mains power inputs as input data and the parameters of the mains power output as label data.

**5.** The mains parameter analyzing device (1) of claim 4, the machine learning algorithm comprising a back-propagation algorithm applied to a feedforward artificial neural network.

**6.** The mains parameter analyzing device (1) of any of the preceding claims,
for associating the respective bus-capable lighting driver (3) with the respective mains power input, the processing unit (16) further being configured to

- selectively send, via the bus terminal (11), the indicative parameters of the respective mains power input to the respective bus-capable lighting driver (3).

**7.** The mains parameter analyzing device (1) of any of the preceding claims,

the measurement unit (14) further being configured to

- measure, at the mains input terminal (12), parameters of a mains power input; and

the processing unit (16) further being configured to

- relate the parameters of the mains power input and the parameters of the mains power output.

**8.** The mains parameter analyzing device (1) of claim 7, the measurement unit (14) further being configured to

- filter the mains power output with respect to the mains power input.

**9.** A power supply (2) for a lighting control bus (5), comprising

- a mains parameter analyzing device (1) of any of the preceding claims.

**10.** A bus-capable lighting driver (3), comprising

- a bus terminal (31), being connectable to a lighting control bus (5);
- a mains input terminal (32), being connectable to a mains supply rail;
- a communication unit (35), being configured to

- send, via the bus terminal (11), indicative parameters of a mains power input via the mains input terminal (12).

**11.** The bus-capable lighting driver (3) of claim 10, further comprising

- a measurement unit (34), being configured to

- measure indicative parameters of a mains power input via the mains input terminal (12).

**12.** The bus-capable lighting driver (3) of claim 10 or claim 11,
the indicative parameters of the mains power input comprising one or more of:

- a bus address,
- a dim level,
- a timestamp, and
- a real power of the bus-capable lighting driver (3).

**13.** A method (6) of operating a mains parameter analyzing device (1) for a lighting control bus (5), the method (6) comprising

- measuring (61), at a mains output terminal (13) being connectable to a mains supply rail, parameters of a mains power output to a number of bus-capable lighting drivers (3);
- receiving (62), via a bus terminal (11) being connectable to the lighting control bus (5), indicative parameters of a respective mains power input of the number of bus-capable lighting drivers (3); and
- associating (63) the respective bus-capable lighting driver (3) with a respective mains power input using a machine learning algorithm, in accordance with the indicative parameters of the respective mains power inputs and the parameters of the mains power output.

**14.** The method (6) of claim 13, being performed by a mains parameter analyzing device (1) of any of the claims 1 to 12.

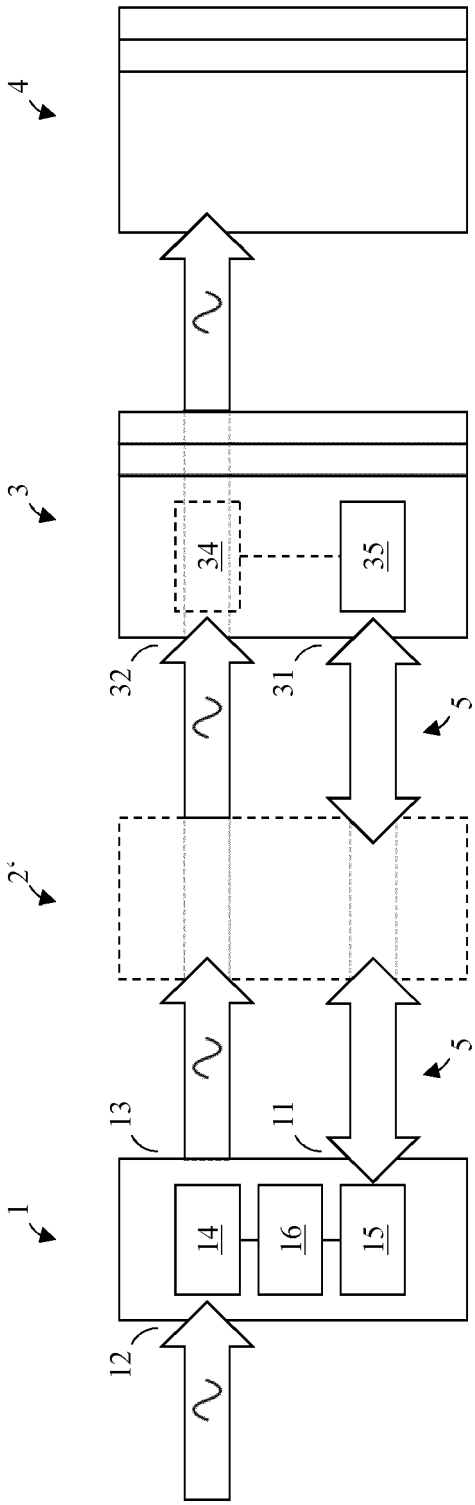


FIG. 1

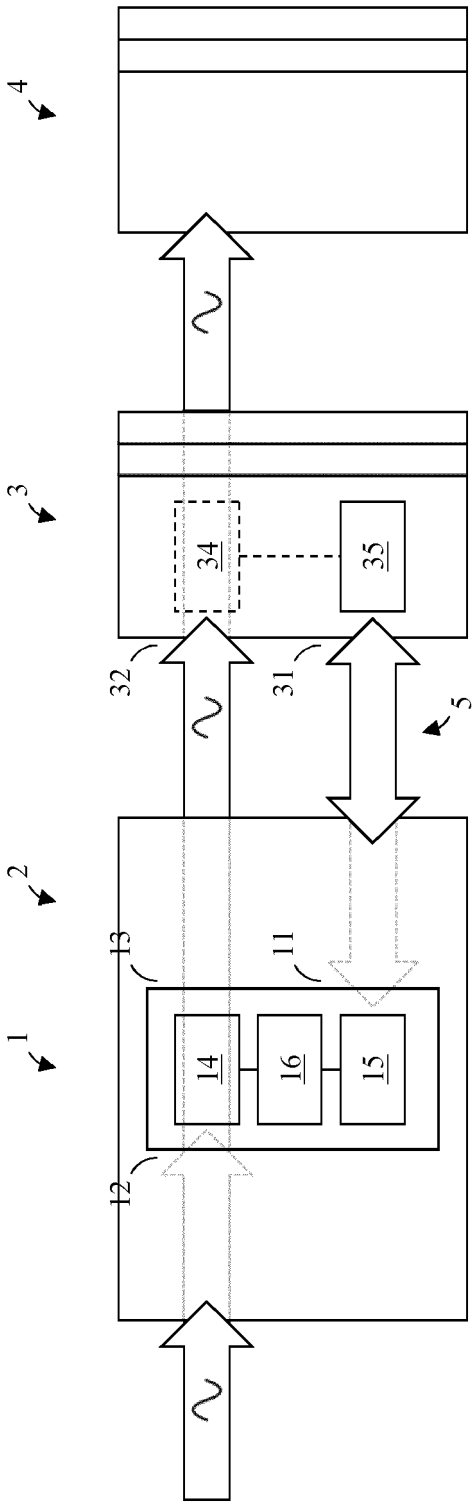


FIG. 2

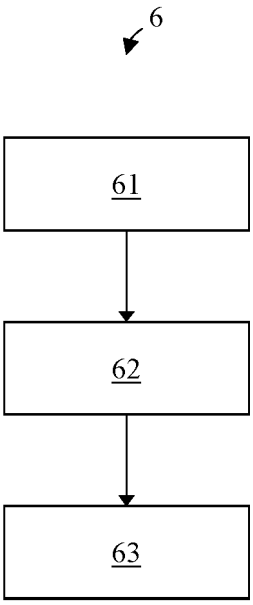


FIG. 3

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Application Number
EP 23 15 5934

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The present search report has been drawn up for all claims

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CATEGORY OF CITED DOCUMENTS

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EPO FORM 1503 03.82 (P04C01)

# ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 23 15 5934

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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