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(72) Inventor: **The designation of the inventor has not yet been filed**

(74) Representative: **Nielsen, Henrik Sten et al**
Budde Schou A/S
Vester Søgade 10
1601 Copenhagen V (DK)

(71) Applicant: **Nesa A/S**
2820 Gentofte (DK)

(54) **Lighting system**

(57) The present invention relates to a lighting system. The system comprises a pair of power supply lines, a plurality of light sources connected to said pair of supply lines, a monitoring unit, and an alert receiving unit communicating with said monitoring unit. The pair of power supply lines may constitute a supply line and a return line. The supply line and said return line are connected to said plurality of light sources and through said monitoring unit, the pair of power supply lines providing electrical power to said plurality of light sources. The monitoring unit may comprise a voltage measuring circuit measuring the voltage across said pair of power supply lines. The monitoring unit may further comprise a current measuring circuit measuring the current flowing through said supply line or said return line in response to the electrical power provided to said plurality of light sources. The monitoring unit defines a first time frame and a first point of time during said first time frame, during said first time frame a first steady state situation for said plurality of light sources is achieved. The monitoring unit measures at said first point of time a first voltage level by means of the voltage measuring circuit and the monitoring unit measuring at the first point of time a first current level by means of the current measuring circuit. The monitoring unit determining a first load resistance representing the active load resistance for the plurality of light sources being active during the first time frame based on the first voltage level and the first current level, the monitoring unit defining a second time frame and a second point of time during the second time frame, during the second time frame a second steady state situation for the plurality of light sources is achieved. The second time frame being defined to take place after the first time frame has expired. The monitoring unit measuring at the second point of time a second voltage level by means of the voltage measur-

ing circuit, and a second current level by means of the current measuring circuit, the monitoring unit determining a second load resistance representing the active load resistance for the plurality of light sources being active during the second time frame based on the second voltage level and the second current level. The monitoring unit generates a first alert message provided the difference between the first and second load resistance exceeds a first specific threshold constituting a first alert criterion. The monitoring unit still further comprises a communication unit for sending the first alert message to the alert receiving unit, and the alert receiving unit acting or alerting in response to the reception of the first alert message.

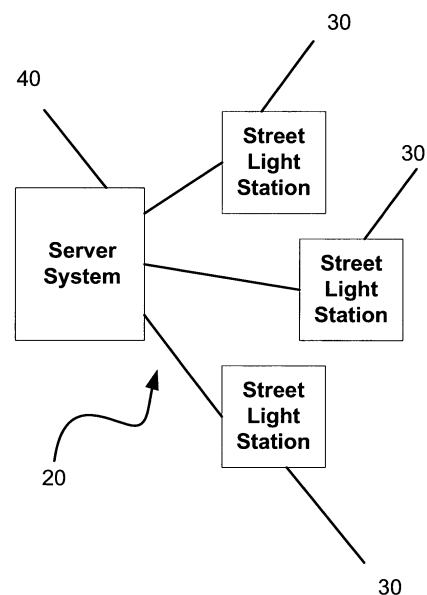


Fig. 1

Description

[0001] The invention relates to a lighting system, and in particular to a road lighting system suitable for use where access to the lights is difficult or dangerous.

[0002] Moreover, the invention relates to a lighting monitoring system and a method of controlling lighting.

[0003] A road lighting system is known from the publication WO 02/067637 A1.

[0004] Good, reliable lighting especially at and near road or street junctions is vital for improving road safety. Accordingly, there is a need to monitor and replace lamps when a significant number have failed.

[0005] Reliable lighting at public places or in an environment where many people pass by or stay is also important for reasons of personal comfort and to avoid theft and attack in a else more dark environment. Accordingly, there is a also here a need to monitor and replace light sources when a significant number of them have failed or has a malfunction, e.g. provides too little light.

[0006] The lamps used in lighting heads of conventional road lights and in public areas have a limited, and variable, life span so there is inevitably a trade-off between replacing failed lamps to maximise road-user and personal safety / comfort and minimising the number of maintenance actions required in order to minimise cost and disruption. It is a known and cumbersome practise that the number of failed lamps within a given stretch of motorway is determined by a manual visual inspection.

[0007] As an example, many road lights are located in positions where it is difficult, dangerous or expensive to reach those lights. For example, lights located on the central reservation of motorways are difficult, dangerous and expensive to access, since extensive traffic management is required which can significantly disrupt normal traffic flow.

[0008] Accordingly, there is a need to minimise the maintenance required for lighting at such locations at locations at public places as well. Furthermore, automatic detection of failure is more complicated than it might at first sight appear. Total failure of a light source may be relatively easy to detect if the light source then draws too little current, but even this is not a reliable measurement to detect the failure, since the light source may be packaged together with ballast, igniter and other controlling components. There are however other failure modes in which light source, e.g. a lamp still draws current but does not provide adequate illumination. For example, sodium street lamps can fail in such a way that they become so-called "red burners", that is lamps that continue to glow red and never warm up to glow bright orange-yellow. Lamps may also start to flicker, which also can be difficult to detect by means of a current measurement.

[0009] Thus, there remains a need for a lighting system and method that can improve lighting reliability whilst keeping maintenance costs at as low a level as possible.

[0010] The term lamp is taken to mean any lamp, bulb, fluorescent lamp, neon light, Hg lamp, sodium street lamp, light emitting diode or light emitting diodes light source or any other source or sources of light suitable for adequate illumination of areas, e.g. in the evening and/or during night hours.

[0011] It is an object of the present invention to provide an alert in case that an increased or decreased load resistance is detected. Accordingly, it is an object of the present invention to provide an alert due to an open circuit and / or circuit parts leading to that either too small or too excessive current runs to light sources connected.

[0012] It is an object of the present invention to provide an alert when a poor connection to or among light sources is detected.

[0013] It is an object of the present invention to provide an alert when one, too, three, etc light sources do/does not draw current. E.g. too little current drawn could be caused if any of the light sources has burned off and/or has some malfunction.

[0014] It is an object of the present invention to provide an alert when one or more light sources is/are defective or malfunctioning.

[0015] It is an object of the present invention to provide an alert when the supply line powering the light source or light source is defective, e.g. due to a short circuit or due to that current erroneously runs to ground, e.g. due to moist or due to that water penetrated the system, e.g. into the electronic circuitry or between lines.

[0016] It is an object of the present invention to provide an alert when the circuitry and/or the lines connecting the light sources has or have some defect.

[0017] It is an object of the present invention to provide an alert when a circuit of the return line and the supply line somewhere has a burnt over connection, a burnt off igniter, a poor or a missing connection and in case when a filament of a bulb or of a light source is off.

[0018] The above object, the above advantage, and the above feature together with numerous other objects, advantages, and features which will be evident from the below detailed description of the present invention and are in accordance with the teaching of the present invention obtained by the following three aspects of the invention, where a first aspect of the present invention is a lighting system comprising:

- a pair of power supply lines,
- a plurality of light sources connected to the pair of supply lines,

a monitoring unit, and
 an alert receiving unit communicating with the monitoring unit,

the pair of power supply lines constituting a supply line and a return line,
 5 the supply line and the return line being connected to the plurality of light sources and through the monitoring unit,
 the pair of power supply lines providing electrical power to the plurality of light sources,
 the monitoring unit comprising a voltage measuring circuit measuring the voltage across the pair of power supply lines,
 the monitoring unit comprising a current measuring circuit measuring the current flowing through the supply line or the
 10 return line in response to the electrical power
 provided to the plurality of light sources,
 the monitoring unit defining a first time frame and a first point of time during the first time frame, during the first time
 frame a first steady state situation for the plurality of light sources is achieved,
 the monitoring unit measuring at the first point of time a first voltage level by means of the voltage measuring circuit,
 the monitoring unit measuring at the first point of time a first current level by means of the current measuring circuit,
 15 the monitoring unit determining a first load resistance representing the active load resistance for the plurality of light
 sources being active during the first time frame based on the first voltage level and the first current level,
 the monitoring unit defining a second time frame and a second point of time during the second time frame, during the
 second time frame a second steady state situation for the plurality of light sources is achieved, the second time frame
 being defined to take place after the first time frame has expired,
 20 the monitoring unit measuring at the second point of time a second voltage level by means of the voltage measuring circuit,
 the monitoring unit measuring at the second point of time a second current level by means of the current measuring circuit,
 the monitoring unit determining a second load resistance representing the active load resistance for the plurality of light
 sources being active during the second time frame based on the second voltage level and the second current level,
 the monitoring unit generating a first alert message provided the difference between the first and second load resistance
 25 exceeds a first specific threshold constituting a first alert criterion,
 the monitoring unit comprising a communication unit for sending the first alert message to the alert receiving unit, and
 the alert receiving unit acting or alerting in response to the reception of the first alert message.

[0019] According to the first aspect of the present invention, the monitoring unit further determining a first time difference
 between the first and second points of time, and determining a ratio of the load resistance change over time as the
 30 difference between the first and second load resistance divided by the determined time difference between the first and
 second points of time, and provided the ratio of the load resistance over time exceeds a second specific level the
 monitoring unit generating a second alert message and the communication unit of the monitoring unit sending the second
 alert message to the alert receiving unit, and the alert receiving unit further acting or alerting in response to the reception
 of the second alert message.

[0020] According to the first aspect of the present invention, the monitoring unit defining a third time frame and a third
 35 point of time during the third time frame, during the third time frame a third steady state situation for the plurality of light
 sources is achieved, the monitoring unit measuring at the third point of time a third voltage level by means of the voltage
 measuring circuit,
 the monitoring unit measuring at the third point of time a third current level by means of the current measuring circuit,
 40 the monitoring unit determining a first power level representing the power for the plurality of light sources being active
 during the third time frame based on the third voltage level and the third current level,
 the monitoring unit defining a fourth time frame and a fourth point of time during the fourth time frame, during the fourth
 time frame a fourth steady state situation for the plurality of light sources is achieved, the fourth time frame being defined
 to take place after the third time frame has expired,
 45 the monitoring unit measuring at the fourth point of time a fourth voltage level by means of the voltage measuring circuit,
 the monitoring unit measuring at the fourth point of time a fourth current level by means of the current measuring circuit,
 the monitoring unit determining a second power level representing the power for the plurality of light sources being active
 during the fourth time frame based on the fourth voltage level and the fourth current level,
 the monitoring unit generating a third alert message provided a second alert criterion is also met as the difference
 50 between the first and second power levels exceeding a third specific threshold.

[0021] According to the first aspect of the present invention, the monitoring unit further determining a second time
 difference between the third and fourth points of time, and determining a ratio of the power level change over time as
 the difference between the first and second power levels divided by the determined time difference between the third
 and fourth points of time, and provided the ratio of the power levels over time exceeds a third specific level the monitoring
 55 unit generating a fourth alert message, the communication unit of the monitoring unit sending the fourth alert message
 to the alert receiving unit, and the alert receiving unit further acting or alerting in response to the reception of the fourth
 alert message.

[0022] According to the first aspect of the present invention, the first and second alert message each indicates one

of following alert situations: one light source being defect or malfunctioning, two light sources being defect or malfunctioning, the plurality of light sources has a defect among some of them or being malfunctioning, the plurality of light sources being defect or being malfunctioning, or the supply line being defective.

[0023] According to the first aspect of the present invention, the third and fourth alert message each indicates one of following alert situations: one light source being defect or malfunctioning, two light sources being defect or malfunctioning, the plurality of light sources has a defect among some of them or being malfunctioning, the plurality of light sources being defect or being malfunctioning, the supply line being defective, or current running to ground.

[0024] According to the first aspect of the present invention, the first time frame being identical to the third time frame and the second point of time being identical to the fourth point of time.

[0025] According to the first aspect of the present invention, the electrical power being an AC power, the first and second voltage level and the first and second current levels are substantially AC levels.

[0026] According to the first aspect of the present invention, the plurality of light sources being selected among a incandescent lamp, a bulb, a fluorescent lamp, a neon light, a Hg lamp, a sodium street lamp, a light emitting diode or a light emitting diodes light source and other sources of light suitable for illumination of areas.

[0027] According to the first aspect of the present invention, the first time frame representing a period of a learn session.

[0028] According to the first aspect of the present invention, the second time frame representing a period of an operating system with the possibility that one or more of the light sources being defective.

[0029] According to the first aspect of the present invention, the monitoring unit being a lighting controller, a street light station or a client.

[0030] According to the first aspect of the present invention, the alert receiving unit being a server.

[0031] According to the first aspect of the present invention, the alert receiving unit being cellular phone.

[0032] According to the first aspect of the present invention, the lighting system comprising two pairs of power supply lines and two of the voltage and current measurement circuits.

[0033] According to the first aspect of the present invention, the lighting system comprising three pairs of power supply lines and three of the voltage and current measurement circuits.

[0034] According to the first aspect of the present invention, the lighting system further comprising a plurality of the monitoring unit.

[0035] According to the first aspect of the present invention, the communication unit sending the alert messages through the pair of power supply lines.

[0036] According to the first aspect of the present invention, the communication unit sending the alert messages through means of a wireless communication, e.g. via GSM.

[0037] According to the first aspect of the present invention, the alert messages are textual messages, e.g. in the form of a SMS.

[0038] According to the first aspect of the present invention, the communication unit receiving commands through the pair of power supply lines.

[0039] According to the first aspect of the present invention, the commands being instruction to switch on or off the plurality of the light sources.

[0040] According to the first aspect of the present invention, the return line being common for two of the pair of power supply lines.

[0041] According to the first aspect of the present invention, the return line being common for three of the pair of power supply lines.

[0042] According to a second aspect of the present invention, the invention comprises a lighting monitoring system comprising:

a monitoring unit and

an alert receiving unit,

the monitoring unit comprising a communication unit communicating with the alert receiving unit,

the monitoring unit having two pairs of connectors constituting a pair of input connectors and a pair of output connectors,

the pair of input connectors being connectable to a pair of power supply lines constituting a supply line and a return line, the pair of power supply lines providing electrical power,

the pair of output connectors being connectable to a plurality of light sources,

the pair of power supply lines providing an electrical power to the plurality of light sources through the monitoring unit,

the monitoring unit comprising a voltage measuring circuit measuring the voltage across the pair of power supply lines across the pair of input connectors or across the pair of output connectors,

the monitoring unit comprising a current measuring circuit measuring the current flowing through the supply line or the return line in response to the electrical power provided to the plurality of light sources, the current flowing between one of the pair of input connectors and one of the pair of output connectors,

the monitoring unit defining a first time frame and a first point of time during the first time frame, during the first time frame a first steady state situation for the plurality of light sources is achieved,
the monitoring unit measuring at the first point of time a first voltage level by means of the voltage measuring circuit,
the monitoring unit measuring at the first point of time a first current level by means of the current measuring circuit,
5 the monitoring unit determining a first load resistance representing the active load resistance for the plurality of light sources being active during the first time frame based on the first voltage level and the first current level,
the monitoring unit defining a second time frame and a second point of time during the second time frame, during the second time frame a second steady state situation for the plurality of light sources is achieved, the second time frame being defined to take place after the first time frame has expired,
10 the monitoring unit measuring at the second point of time a second voltage level by means of the voltage measuring circuit,
the monitoring unit measuring at the second point of time a second current level by means of the current measuring circuit,
the monitoring unit determining a second load resistance representing the active load resistance for the plurality of light sources being active during the second time frame based on the second voltage level and the second current level,
the monitoring unit generating a first alert message provided the difference between the first and second load resistance
15 exceeds a first specific threshold constituting a first alert criterion,
the monitoring unit sending the first alert message through means of the communication unit to the alert receiving unit, and the alert receiving unit acting or alerting in response to the reception of the first alert message.

[0043] According to the second aspect of the present invention, the monitoring unit further determining the time difference between the first and second points of time, and determining a ratio of the load resistance change over time as the difference between the first and second load resistance divided by the determined time difference between the first and second points of time, and provided the ratio of the load resistance over time exceeds a second specific level the monitoring unit generating a second alert message, the communication unit of the monitoring unit sending the second alert message to the alert receiving unit, and the alert receiving unit further acting or alerting in response to the reception of the second alert message.

[0044] According to the second aspect of the present invention, the monitoring unit defining a third time frame and a third point of time during the third time frame, during the third time frame a third steady state situation for the plurality of light sources is achieved,
the monitoring unit measuring at the third point of time a third voltage level by means of the voltage measuring circuit,
the monitoring unit measuring at the third point of time a third current level by means of the current measuring circuit,
30 the monitoring unit determining a first power level representing the power for the plurality of light sources being active during the third time frame based on the third voltage level and the third current level,
the monitoring unit defining a fourth time frame and a fourth point of time during the fourth time frame, during the fourth time frame a fourth steady state situation for the plurality of light sources is achieved, the fourth time frame being defined to take place after the third time frame has expired,
35 the monitoring unit measuring at the fourth point of time a fourth voltage level by means of the voltage measuring circuit,
the monitoring unit measuring at the fourth point of time a fourth current level by means of the current measuring circuit,
the monitoring unit determining a second power level representing the power for the plurality of light sources being active during the fourth time frame based on the fourth voltage level and the fourth current level,
the monitoring unit generating a third alert message provided a second alert criterion is also met as the difference
40 between the first and second power levels exceeding a third specific threshold.

[0045] According to the second aspect of the present invention, the monitoring unit further determining a second time difference between the third and fourth points of time, and determining a ratio of the power level change over time as the difference between the first and second power levels divided by the determined time difference between the third and fourth points of time, and provided the ratio of the power levels over time exceeds a third specific level the monitoring unit generating a fourth alert message, the communication unit of the monitoring unit sending the fourth alert message to the alert receiving unit, and the alert receiving unit further acting or alerting in response to the reception of the fourth alert message.

[0046] According to the second aspect of the present invention, the first and second alert message each indicates one of following alert situations: one light source being defect or malfunctioning, two light sources being defect or malfunctioning, the plurality of light sources has a defect among some of them or being malfunctioning, the plurality of light sources being defect or being malfunctioning, or the supply line being defective.

[0047] According to the second aspect of the present invention, the third and fourth alert message each indicates one of following alert situations: one light source being defect or malfunctioning, two light sources being defect or malfunctioning, the plurality of light sources has a defect among some of them or being malfunctioning, the plurality of light sources being defect or being malfunctioning, the supply line being defective, or current running to ground.

[0048] According to the second aspect of the present invention, the first time frame being identical to the third time frame and the second point of time being identical to the fourth point of time.

[0049] According to the second aspect of the present invention, the electrical power being an AC power, the first and

second voltage level and the first and second current levels being substantially AC levels.

[0050] According to the second aspect of the present invention, the plurality of light sources being selected among a incandescent lamp, a bulb, a fluorescent lamp, a neon light, a Hg lamp, a sodium street lamp, a light emitting diode or a light emitting diodes light source and other sources of light suitable for illumination of areas.

[0051] According to the second aspect of the present invention, the first time frame representing a period of a learn session.

[0052] According to the second aspect of the present invention, the second time frame representing a period of an operating system with the possibility that one or more of the light sources being defective.

[0053] According to the second aspect of the present invention, the monitoring unit being a lighting controller, a street light station or a client.

[0054] According to the second aspect of the present invention, the alert receiving unit being a server.

[0055] According to the second aspect of the present invention, the alert receiving unit being a cellular phone.

[0056] According to the second aspect of the present invention, the monitoring unit having two pairs of input connectors and two pairs of output connectors for connecting two pairs of power supply lines to respective two of the voltage and current measurement circuits.

[0057] According to the second aspect of the present invention, the monitoring unit having three pairs of input connectors and three pairs of output connectors for interconnecting three pairs of power supply lines to respective three of the voltage and current measurement circuits.

[0058] According to the second aspect of the present invention, the communication unit sending the alert messages through the pair of power supply lines.

[0059] According to the second aspect of the present invention, the communication unit sending the alert messages through means of a wireless communication, e.g. via GSM.

[0060] According to the second aspect of the present invention, the alert messages being textual messages, e.g. in the form of a SMS.

[0061] According to the second aspect of the present invention, the communication unit receiving commands through the pair of power supply lines.

[0062] According to the second aspect of the present invention, the received commands being instructions to switch on or off the plurality of the light sources.

[0063] According to a third aspect of the present invention, the invention comprising a method of controlling a lighting system comprising:

a pair of power supply lines,
a plurality of light sources,
a monitoring unit, and

an alert receiving unit communicating with the monitoring unit, the method comprising the steps of:

providing the pair of power supply lines constituting a supply line and a return line, connecting the supply line and the return line to the plurality of light sources through the monitoring unit,

providing electrical power to the plurality of light sources by means of the pair of

power supply lines,

providing a voltage measuring circuit measuring the voltage across the pair of power supply lines in the monitoring unit,

providing a current measuring circuit measuring the current flowing through the supply line or the return line in response to the electrical power provided to the plurality of light sources in the monitoring unit,

defining in the monitoring unit a first time frame and a first point of time during the first time frame and achieving during the first time frame a first steady state situation for the plurality of light sources,

measuring in the monitoring unit at the first point of time a first voltage level by means of the voltage measuring circuit,

measuring in the monitoring unit at the first point of time a first current level by means of the current measuring circuit,

determining in the monitoring unit a first load resistance representing the active load resistance for the plurality of light sources being active during the first time frame based on the measured first voltage level and the measured first current level, defining in the monitoring unit a second time frame and a second point of time during the second time frame, achieving during the second time frame a second steady state situation for the

plurality of light sources, defining the second time frame being to take place after the first time frame has expired, measuring in the monitoring unit at the second point of time a second voltage level by means of the voltage measuring circuit,

measuring in the monitoring unit at the second point of time a second current level by means of the current

measuring circuit,
determining in the monitoring unit a second load resistance representing the active load resistance for the plurality of light sources being active during the second time frame based on the measured second voltage level and the measured second current level,
5 generating in the monitoring unit a first alert message provided the difference between the first and second load resistance exceeds a first specific threshold constituting a first alert criterion,
providing in the monitoring unit a communication unit, and sending by means of the communication unit the first alert message to the alert receiving unit, and
receiving in the alert receiving unit the first alert message and the alert receiving unit acting or alerting in response
10 to the reception of the first alert message.

[0064] According to the third aspect of the present invention, the method further comprising determining by the monitoring unit the time difference between the first and second points of time, and determining a ratio of the load resistance change over time as the difference between the first and second load resistance divided by the determined time difference
15 between the first and second points of time, and provided the ratio of the load resistance over time exceeds a second specific level generating by the monitoring unit a second alert message, sending by the communication unit the second alert message to the alert receiving unit, and the alert receiving unit further acting or alerting in response to the received second alert message.

[0065] According to the third aspect of the present invention, the method, further comprising defining in the monitoring unit a third time frame and a third point of time during the third time frame, during the third time frame a third steady state situation for the plurality of light sources is achieved,
measuring in the monitoring unit at the third point of time a third voltage level by means of the voltage measuring circuit,
measuring in the monitoring unit at the third point of time a third current level by means of the current measuring circuit,
determining in the monitoring unit a first power level representing the power for the plurality of light sources being active
25 during the third time frame based on the third voltage level and the third current level,
defining in the monitoring unit a fourth time frame and a fourth point of time during the fourth time frame, during the fourth time frame a fourth steady state situation for the plurality of light sources is achieved, the fourth time frame being defined to take place after the third time frame has expired,
measuring in the monitoring unit at the fourth point of time a fourth voltage level by means of the voltage measuring circuit,
30 measuring in the monitoring unit at the fourth point of time a fourth current level by means of the current measuring circuit,
determining in the monitoring unit a second power level representing the power for the plurality of light sources being active during the fourth time frame based on the fourth voltage level and the fourth current level,
generating in the monitoring unit a third alert message provided a second alert criterion is also met as the difference between the first and second power levels exceeding a third specific threshold.

[0066] According to the third aspect of the present invention, the monitoring unit further determining a second time difference between the third and fourth points of time, and determining a ratio of the power level change over time as the difference between the first and second power levels divided by the determined time difference between the third and fourth points of time, and provided the ratio of the power levels over time exceeds a third specific level the monitoring unit generating a fourth alert message, the communication unit of the monitoring unit sending the fourth alert message
40 to the alert receiving unit, and the alert receiving unit further acting or alerting in response to the reception of the fourth alert message.

[0067] According to the third aspect of the present invention, the first and second alert message each indicates one of following alert situations: one light source being defect or malfunctioning, two light sources being defect or malfunctioning, the plurality of light sources has a defect among some of them or being malfunctioning, the plurality of light
45 sources being defect or being malfunctioning, or the supply line being defective.

[0068] According to the third aspect of the present invention, the third and fourth alert message each indicates one of following alert situations: one light source being defect or malfunctioning, two light sources being defect or malfunctioning, the plurality of light sources has a defect among some of them or being malfunctioning, the plurality of light sources being defect or being malfunctioning, the supply line being defective, or current running to ground.

[0069] According to the third aspect of the present invention, the first time frame being identical to the third time frame and the second point of time being identical to the fourth point of time.

[0070] According to the third aspect of the present invention, the electrical power being an AC power, the measured first and second voltage level and the measured first and second current levels being substantially AC levels.

[0071] According to the third aspect of the present invention, the plurality of light sources being selected among a incandescent lamp, a bulb, a fluorescent lamp, a neon light, a Hg lamp, a sodium street lamp, a light emitting diode or a light emitting diodes light source and other sources of light suitable for illumination of areas.

[0072] According to the third aspect of the present invention, the first time frame representing a period of a learn session.

[0073] According to the third aspect of the present invention, the second time frame representing a period of an

operating system with the possibility that one or more of the light sources being defective.

[0074] According to the third aspect of the present invention, the monitoring unit being a lighting controller, a street light station or a client.

[0075] According to the third aspect of the present invention, the alert receiving unit being a server.

[0076] According to the third aspect of the present invention, the alert receiving unit being a cellular phone.

[0077] According to the third aspect of the present invention, the method of controlling a lighting system applying two pairs of power supply lines and respective two of the voltage and current measurement circuits.

[0078] According to the third aspect of the present invention, the method of controlling a lighting system applying three pairs of power supply lines and respective three of the voltage and current measurement circuits.

[0079] According to the third aspect of the present invention, the method of controlling a lighting system applying a plurality of the monitoring unit.

[0080] According to the third aspect of the present invention, the method of controlling a lighting system sending by the communication unit the alert messages through the pair of power supply lines.

[0081] According to the third aspect of the present invention, the method of controlling a lighting system sending by the communication unit the alert messages through means of a wireless communication, e.g. via GSM.

[0082] According to the third aspect of the present invention, the alert messages being textual messages, e.g. in the form of a SMS.

[0083] According to the third aspect of the present invention, the method of controlling a lighting system receiving by the communication unit commands through the pair of power supply lines.

[0084] According to the third aspect of the present invention, the received commands being instructions to switch on or off the plurality of the light sources.

[0085] The invention will be explained in more detail below in connection with the preferred embodiments and with reference to the drawings, in which:

fig. 1 is a system overview of an alert receiving unit and three monitoring units and examples of the communication there between,

fig. 2 is a block diagram of the monitoring unit,

fig. 3 is another block diagram of the monitoring unit,

fig. 4 is a block diagram of a CAN bus connection of the monitoring unit,

fig. 5 is a diagram of protection of the CAN bus connector of the monitoring unit,

fig. 6 is a diagram of a modem of the monitoring unit,

fig. 7 is a detailed block diagram of the monitoring unit,

fig. 8 is a temperature sensor input circuit of the monitoring unit,

fig. 9 is a electrical power detection diagram of the monitoring unit,

fig. 10 is a diagram of the protection circuit for the electrical power supplied,

fig. 11 is a diagram of electrical power conversion into current and voltage signal levels,

fig. 12 is a diagram of band pass filter filtering the electrical power supplied,

fig. 13 is a schematic showing the band pass filter characteristic,

fig. 14 is a schematic showing a current transformer,

fig. 15 is a schematic showing a current filter,

fig. 16 is a schematic showing a current filter with low gain,

fig. 17 is a schematic showing a current filter with high gain,

fig. 18 is a schematic showing relay outputs,

fig. 19 is an AD converter block diagram,

fig. 20 is an AD converter circuit diagram,

fig. 21 is a controller block diagram,

fig. 22 is a diagram showing use of the controller,

fig. 23 is a power supply block diagram, and

fig. 24 is a diagram showing implementation of the power supply.

After the block and circuits diagrams, etc discussing the more hardware related parts implementing the invention a more detailed discussion of how to detect light source faults or malfunctions and providing related alert messages thereto follows.

[0086] Throughout the drawings, the same reference numerals indicate identical elements or components. In the present specification, components or elements identical to components or elements, respectively, described previously with reference to a preceding figure are designated the same reference numerals and components or elements differing from previously described components or elements, respectively, however serving the same overall purpose, are designated the same integer as the previously described component or element, however, added a marking for identifying

the structural difference from the previously described component or element.

[0087] The invention as will be discussed in the following may equally well be applied in an airport, e.g. for the lights on the runways or for the airport building. The invention may be applied for light-sources applied to lit up supermarket stores and storage areas as well. It may be applied for other building complexes such as apartments e.g. for staircases or other access areas, where for maintenance or for security reasons there is a need to know if a light source or more light sources has/have malfunction.

[0088] Further example an application of light sources may be diode lights in a green house use to enhance growth of plant, alternatively or additionally light of different wave length may be use to warm up the greenhouse. Furthermore light from various light source may also be applied to provide warm to animals e.g. in a farm.

[0089] fig. 1 is a system overview of an alert receiving unit and three monitoring units and examples of the communication there between.

[0090] The communication between the alert receiving unit and any monitoring unit is handled by means of a build in communication unit, e.g. a modem integral to the monitoring unit.

[0091] The monitoring unit 30 is a device measuring on one, two or three 230V AC lines used for lighting, e.g. street light. It measures on the power line or lines, and can detect if one or more bulbs of e.g. the street light just has blown or e.g. was blown the day before. The monitoring unit 30 is measuring the voltage and current, and calculates the resistance on the one, two or three 230V AC lines, and the power used. In general, depending on the changes on the resistance and power over time, the monitoring unit 30 can detect if one or more bulbs has/have blown or is/are defective.

[0092] The monitoring unit 30 is typical in Europe supplied by a 230V AC line, alternatively the monitoring unit 30 is in USA supplied by a 110V AC line. To send or receive data from the monitoring unit 30, a communication unit (see figure 2), e.g. a GSM modem is used. Data is send to a phone number predefined in the modem. It is also possible for the user to control the monitoring unit 30 through this data channel. An extra CAN port is added for service use. A technician can used this port instead of using the modem connection.

[0093] The alert receiving unit may be a server and is denoted 40, whereas the three monitoring units each individually is denoted 30. In a client server relation the monitoring unit 30 may be seen as a client served by the server. The network of the alert receiving unit 40 and monitoring units 30 is build as a distributed master slave network with the server as master. However, this does mean that the slave or the monitoring unit 30 may perform their own task for longer periods without communicating with the master, server or the alert receiving unit. SMS messaging is e.g. chosen as communication form and/or medium. For these reasons the monitoring units 30 each is provided with a communication unit 32 (see figure 2), which e.g. is a GSM modem. Alternatively, the communication unit 32 communicates, i.e. sends e.g. alert messages and receives commands through a pair of power supply lines 14, which supplies the monitoring unit 30 and on which lines the monitoring unit 30 measures the voltage across and current flowing through the lines.

[0094] As discussed the alert receiving unit 40 may be a server and the monitoring unit 30 may be a client. The alert receiving unit 40 communicating with a plurality of monitoring units 30 may be considered as a network.

[0095] The monitoring unit or units 30 communicate(s) with the alert receiving unit 40, e.g. the server system through a protocol converter, i.e. the communication unit as denoted 32 in figure 2. The communication medium between the server system and the monitoring unit or units 30 is/are transparent, why a new communication medium easily can be implemented by simply exchanging the communication unit. Internally the monitoring unit 30 communicates via a CAN network to the communication unit 32.

[0096] The network is build as a distributed master slave network with the server as master and the client as the slave.

[0097] SMS messaging is in a preferred embodiment of the invention chosen as communication medium, why the communication unit 32 is equipped with a GSM modem.

[0098] The communication unit is transparent for the server, i.e. the alert receiving unit 40.

[0099] The network is addressed with the actual phone number and the CAN ID for the unit.

In the following section a layer description is provided:

[0100] The protocol for the system implements the Physical Layer the Data Link Layer and the Application Layer. The other layers of the OSI model as well known in the art is not discussed for the application.

Physical layer

[0101] The physical layer carrying the communication between the server 40 and the monitoring unit or monitoring units 30 is based on SMS messaging in the first generation of the system.

Data Link layer

[0102] The Data Link layer handles all acknowledging between the server 40 and the monitoring unit or monitoring

units 30.

[0103] All packages from the monitoring unit or monitoring units 30 to the server 40 need to be acknowledged by the server 40. If acknowledge has not been received in 2 minutes the package is transmitted once again. This is repeated 3 times before the package is flushed. The sending unit is responsible for retransmission and keeps track on the different acknowledges.

[0104] All server requests initiates a response from the requested unit, why an acknowledge is not necessary. The server 40 also retransmits packages on no response 3 times with 2 minutes interval.

Application layer

[0105] The Application layer handles the protocol conversion from server messages to CAN packages and vice versa. This is done due to the fact that a CAN package only carries e.g. 8 bytes of data.

[0106] All server messages is repacked in the communication unit 30 and in the receiving unit 40 or server 40.

[0107] The application layer handles the address checking and generation when sending and receiving server messages.

[0108] Due to security reasons the communication unit 32 flushes messages from other phone numbers than these of the server system. Equally, all messages from the monitoring unit 32 is send to a specific phone number.

[0109] It is possible to change the approved phone numbers via a TTY interface, through a GPRS channel and in some constellations through the CAN network.

Server commands

[0110] All messages between the server 40 and the monitoring unit or monitoring units 30 are transferred as raw binary data or ASCII characters. All numbers is presented by means of little endian except timestamps or points of time, which is presented by means of big endian.

[0111] Generally speaking a server message should not be deleted before an acknowledgement or a response has been received. If this ack or response has not been received within 2 minutes the server message is retransmitted. An alarm-message has priority over a response-message, therefore if an alarm occurs and response on a request is to be sent, the response is deleted and the alarm is transmitted instead. There are no message-queue, if a request-message is received before the last one is handled the last request is not processed.

[0112] The following commands are applied:

Msg. type	Description	Description
serv1	Get System status	Request from server on system status.
serv2	System status	Response on serv1 message and alarm situations.
serv3	Operate Watch Function	Enabling/disabling of watch functionality.
serv4	Watch status	Response on serv3 message including watch status.
serv5	Operate Output	Enabling/disabling of ON/OFF relay.
serv6	Output Status	Response on serv5 message including relay status.
serv7	Reset alarms	Reset alarm flags.
serv8	Alarms reset	Response on serv7 message.
serv9	Initiate Learn	Initiate Learn function.
serv10	Learn Result	Response on serv9 message when learn situation has completed.
serv11	Acknowledge Message	Acknowledge message on messages without automatic response.
serv12	Set Power Thresholds	Set alarm threshold for Power alarm
serv13	Power Threshold Status	Response on serv12 message including actual threshold.
serv14	Communication Error	Communication error sent from Communication Unit.
serv15	Set watch intervals	Message setting the ON/OFF intervals for the watch functionality.
serv16	Watch Interval status	Response on serv15 message including actual settings.
serv17	Single Lamp Fail	Send on single lamp fail occurrences
serv18	Multi Lamp Fail	Send on multi lamp fail occurrences
serv19	Voltage Line Fault	Send on detection of low voltage on a active Line
serv20	Light Sensor Fault	Send on inconsistency between Light Sensor status an output voltage status.

EP 1 865 756 A1

[0113] In the following sections each command and use is described. The generic fields are described in the section after.

[0114] In the following the most common communication scenarios is mentioned:

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Usecase description	Message Type
Alarm Messages	
Single Lamp Fail	SERV17 & SERV11
Module has detected a load loss bigger than the Single Lamp Threshold and smaller than the Multi Lamp Threshold. Message is only send on the first occurrence. A new measurement scenario is started after a Initiate Learn or a Reset command. Multi Lamp Fail also blocks for Single Lamp Fails until next Initiate Learn or Reset Command. Message is acknowledged by the server.	
Multi Lamp Fail	SERV18 & SERV11
Module has detected an accumulated load loss bigger than the Multi Lamp Threshold. Message is only send on the first occurrence. A new measurement scenario is started after a Initiate Learn or a Reset Command. Message is acknowledged by the server.	
Voltage Line Fault	SERV19 & SERV11
Line voltage is low on the indicated line. Fault is only detected, if the line is detected active during the last Learn session. Message is only send on the first occurrence. A new measurement scenario is started after a Initiate Learn or a Reset Command. Message is acknowledged by the server.	
Light Sensor Fault	SERV20 & SERV11
Light Sensor Fault is send when one of the following situations arises: 1. Light Sensor is ON - Output Voltage is OFF. 2. Light Sensor is OFF - Output Voltage is ON. Message is only send on the first occurrence. A new measurement scenario is started after a Initiate Learn or a Reset Command. Message is acknowledged by the server.	
Communication Error	SERV14
A SERV14 message indicates that the module has detected several recurring SMS messages which is aborted before transmission. Module is probably defect and must be send to service.	

55 50 45 40 35 30 25 20 15 10 5

(continued)

Operational Messages		
ON/OFF Relay	Command operating the ON/OFF relay. Relay is set according to command, but automatically turns OFF next time either the Light Sensor or the Watch turns lamps OFF. Status is responded as acknowledge.	SERV5 & SERV6
Watch Control		
Reset alarms	Resets the different alarm flags allowing the module to transmit a new alarm message when an alarm threshold is exceeded next time.	SERV3 & SERV4
Initiate Learn		
Configuration Messages		
Set Power Thresholds	Used to program the threshold levels for detection of Single Lamp Fail and Multi Lamp Fail. Message is acknowledged with the programmed levels.	SERV7 & SERV8
Set Watch Intervals		
Status Messages		
System status	System status message is used to poll the unit for the actual status just now. Response includes status for all inputs, outputs and calculations.	SERV9 & SERV10
Configuration Messages		
Set Power Thresholds	Used to program the threshold levels for detection of Single Lamp Fail and Multi Lamp Fail. Message is acknowledged with the programmed levels.	SERV12 & SERV13
Set Watch Intervals		
Status Messages		
System status	System status message is used to poll the unit for the actual status just now. Response includes status for all inputs, outputs and calculations.	SERV15 & SERV16
Configuration Messages		
Set Power Thresholds	Used to program the threshold levels for detection of Single Lamp Fail and Multi Lamp Fail. Message is acknowledged with the programmed levels.	SERV12 & SERV13
Set Watch Intervals		
Status Messages		
System status	System status message is used to poll the unit for the actual status just now. Response includes status for all inputs, outputs and calculations.	SERV1 & SERV2

EP 1 865 756 A1

[0115] Multilamp and singlelamp fails indicate that two or more light sources and one light source, respectively possibly have a fail.

[0116] In the following is shown how the communication between the alert receiving unit 40, e.g. the server and the monitoring unit 30, e.g. the client is implemented:

5 serv1: Get System Status

Use:

10 Request from server to unit, which generates an serv2 message from unit as response.

Implementation:

[0117]

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Msg. no.	Description	Datafield
serv1	Get System status	<MSGIN> <EQTY> <DUMMY> <CANID> 01 h <MSG#> <SC>

20 *Field Description:*

[0118]

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Field	Len (byte)	Description	Notation
MSGIN	1	Message Indication. - encoding: ? > Request which requires response.	ASCII
EQTY CANID MSG# SC	na	Defined in Generic Field section	na
DUMMY	5	Dummy characters to place CAN ID as character number 13 in the message.	na

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EP 1 865 756 A1

Example:

Data on 8 bit PDU format:

5 Decoded data:

?,741002,-----,04,01,0999,SC

Scenario Description:

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SERVER -> serv1 -> UNIT
<- serv2 <-

15 serv2: System Status
Use:

System status response on serv1 message or Alarm request.

Implementation:

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[0119]

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Msg. no.	Description	Datafield
serv2	System status	<MSGIN> <EQTY> <DUMMY> <CANID> 02h <MSG#> <TS> <RS1> <RS2> <RS3> <RL1> <RL2> <RL3> <PS1> <PS2> <PS3> <PL1> <PL2> <PL3> <PD1> <PD2> <PD3> <RD1> <RD2> <RD3> <SINGLE_PWR> <MULTI_PWR> <LAMPFAIL> <I1> <I2> <I3> <U1> <U2> <U3> <US1> <US2> <US3> <ULF1> <ULF2> <ULF3> <LSS> <LSF> <SC>

Field Description:

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[0120]

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Field	Len (byte)	Description	Notation
MSGIN	1	Message Indication. - encoding: ! > Alarm message. : > Response on message	ASCII
EQTY CANID MSG# SC	na	Defined in Generic Field section	na
DUMMY	5	Dummy characters to place CAN ID as character number 13 in the message.	na
TS	5	Timestamp for the enclosed alarm. Timestamp on the following format YYMMDDHHMM <i>Example:</i> - kl. 21.27 d. 21/10-2003 > 030A15151Bh	Binary
RS1,RS2 RS3 & RL1 RL2,RL3 & RD1 RD2, RD3	2	Average RMS resistance value. - Name: RSx - Resistance, short average time RLx - Resistance, long average time RDx - Resistance, delta value - Range: 0 - 6500hm - Resolution: 0,01Ohm - Presentation: unsigned 16 bit Ohm with 2 decimal places little endian <i>Example:</i> - 26,45Ohm > OA55h	Binary
PS1,PS2 PS3 & PL1,PL2 PL3 & PD1,PD2 PD3	2	Average Power value. - Name: PSx - Power, short average time PLx - Power, long average time PDx - Power, delta value - Range: -32kW - +32kW - Resolution: 1W - Presentation: signed 16 bit Watt with 0 decimal places little endian <i>Example:</i> - 490W > 01EAh	Binary

(continued)

Field	Len (byte)	Description	Notation
SINGLE_ PWR, MULTI_ PWR	1	Set thresholds for lamp fails. - Range: 0 - 250 W - Resolution: 1W - Presentation: unsigned 8 bit 1W 0 requests actual level without change <i>Example:</i> - 40W > 28h	Binary
LAMPFA IL	1	Lamp Fail indication. - Encoding: - > No alarm S > Single Lamp fail detected M > Multi Lamp Fail detected	ASCII
I1,I2,I3	2	Average RMS current value. Averaged over 30 sec. - Range: 0 - 650A - Resolution: 0,01A - Presentation: unsigned 16 bit Amp with 2 decimal places little endian <i>Example:</i> - 6, 5A > 028Ah	Binary
U1,U2,U3	2	Average RMS voltage value. Averaged over 30 sec. - Range: 0 - 650V - Resolution: 0,01 V - Presentation: unsigned 16 bit Volt with 2 decimal places little endian <i>Example:</i> - 225V -> 57E4h	Binary
US1,US2 US3	1	Learn Status per line - One character per line. - encoding: A - Line is Active I - Line is Inactive	ASCII

(continued)

Field	Len (byte)	Description	Notation
		L - Line is in Learn Mode	
ULF1, ULF2, ULF3	1	Voltage line fault indication. One byte per phase. - Encoding: - > No alarm A > line fault present	ASCII
LSS	1	Light sensor status. - Encoding: A > Light sensor active I > Light sensor inactive	ASCII
LSF	1	Light sensor fault indication. - Encoding: - > No alarm A > Light sensor fault present	ASCII

EP 1 865 756 A1

Scenario Description:

Request situation:

SERVER -> serv1 -> UNIT
<- serv2 <-

serv3: Operate Watch Function

[0121] Use:

Request from server to unit, which enables/disables Watch Functionality according to STATUS. Unit responds with serv4 message.

Implementation:

[0122]

Msg. no.	Description	Datafield
serv3	Operate Watch Function	<MSGIN> <EQTY> <DUMMY> <CANID> 03h <MSG#> <STATUS> <SC>

Field Description:

[0123]

Field	Len (byte)	Description	Notation
MSGIN	1	Message Indication. - encoding: ? > Request which requires response.	ASCII
EQTY CANID MSG# SC	na	Defined in Generic Field section	na
DUMMY	5	Dummy characters to place CAN ID as character number 13 in the message.	na
STATUS	1	Requested status. - encoding: E - Enable functionality D - Disable functionality F - Feedback status without change	ASCII

EP 1 865 756 A1

Scenario Description:

Request situation:

SERVER -> serv3 -> UNIT
<- serv4 <-

Serv4: Watch Status

Use:

Response from Unit to Server including status of Watch Functionality.

Implementation:

[0124]

Msg. no.	Description	Datafield
serv4	Watch Status	<MSGIN> <EQTY> <DUMMY> <CANID> 04h <MSG#> <STATUS> <RELAY> <SC>

Field Description:

[0125]

Field	Len (byte)	Description	Notation
MSGIN	1	Message Indication. - encoding: : > Response on message	ASCII
EQTY CANID MSG# SC	na	Defined in Generic Field section	na
DUMMY	5	Dummy characters to place CAN ID as character number 13 in the message.	na
STATUS	1	Requested status. - encoding: E - Enable functionality D - Disable functionality	ASCII
RELAY	1	Relay status. - encoding: A - Watch relay is Active I- Watch relay is Inactive	ASCII

EP 1 865 756 A1

Scenario Description:

Request situation:

SERVER -> serv3 -> UNIT
<- serv4 <-

Serv5: Operate Output

Use:

Request from server to unit, to operate ON/OFF relay according to STATUS. Unit replies with serv6 message.

Implementation:

[0126]

Msg. no.	Description	Datafield
serv5	Operate Output	<MSGIN> <EQTY> <DUMMY> <CANID> 05h <MSG#> <STATUS> <SC>

Field Description:

[0127]

Field	Len (byte)	Description	Notation
MSGIN	1	Message Indication. - encoding: ? > Response on message	ASCII
EQTY CANID MSG# SC	na	Defined in Generic Field section	na
DUMMY	5	Dummy characters to place CAN ID as character number 13 in the message.	na
STATUS	1	Requested status. - encoding: A - Set relay Active I - Set relay Inactive F - Feedback status without change	ASCII

EP 1 865 756 A1

Scenario Description:

Request situation:

SERVER -> serv5 -> UNIT
<- serv6 <-

Serv6: Output Status

Use:

Response from Unit to Server including status of ON/OFF Relay.

Implementation:

[0128]

Msg. no.	Description	Datafield
serv6	Output Status	<MSGIN> <EQTY> <DUMMY> <CANID> 06h <MSG#> <RELAY> <SC>

Field Description:

[0129]

Field	Len (byte)	Description	Notation
MSGIN	1	Message Indication. - encoding: : > Response on message	ASCII
EQTY CANID MSG# SC	na	Defined in Generic Field section	na
DUMMY	5	Dummy characters to place CAN ID as character number 13 in the message.	na
RELAY	1	Relay status. - encoding: A - ON/OFF relay is Active I - ON/OFF relay is Inactive	ASCII

EP 1 865 756 A1

Scenario Description:

Request situation:

SERVER -> serv5 -> UNIT
<- serv6 <-

Serv7: Reset Alarms

Use:

Request from server to unit, resetting all alarm flags.

Implementation:

[0130]

Msg. no.	Description	Datafield
serv7	Reset Alarms	<MSGIN> <EQTY> <DUMMY> <CANID> 07h <MSG#> <SC>

Field Description:

[0131]

Field	Len (byte)	Description	Notation
MSGIN	1	Message Indication. - encoding: ? > Request which requires response.	ASCII
EQTY CANID MSG# SC	na	Defined in Generic Field section	na
DUMMY	5	Dummy characters to place CAN ID as character number 13 in the message.	na

EP 1 865 756 A1

Scenario Description:

SERVER -> serv7 -> UNIT
<- serv8 <-

Serv8: Alarms Reset
Use:

Response on reset alarm request.

Implementation:

[0132]

Msg. no.	Description	Datafield
serv8	Alarms Reset	<MSGIN> <EQTY> <DUMMY> <CANID> 08h <MSG#> <SC>

Field Description:

[0133]

Field	Len (byte)	Description	Notation
MSGIN	1	Message Indication. ASCII - encoding: : > Response on message	
EQTY CANID MSG# SC	na	Defined in Generic Field section	na
DUMMY	5	Dummy characters to place CAN ID as character number 13 in the message.	na

EP 1 865 756 A1

Scenario Description:

SERVER -> serv7 -> UNIT
<- serv8 <-

Serv9: Initiate Learn
Use:

Request from Server to Unit initiating learn sequence. Unit responds with result after Learn Sequence has been fulfilled.

Implementation:

[0134]

Msg. no.	Description	Datafield
serv9	Initiate Learn	<MSGIN> <EQTY> <DUMMY> <CANID> 09h <MSG#> <SC>

Field Description:

[0135]

Field	Len (byte)	Description	Notation
MSGIN	1	Message Indication. - encoding: ? > Request which requires response.	ASCII
EQTY CANID MSG# SC	na	Defined in Generic Field section	na
DUMMY	5	Dummy characters to place CAN ID as character number 13 in the message.	na

EP 1 865 756 A1

Scenario Description:

Request situation:

SERVER -> serv9 -> UNIT
<- serv10 <-

Serv10: Learn Result

Use:

Response from Unit to Server including result of learn session.

Implementation:

[0136]

Msg. no.	Description	Datafield
serv10	Learn Result	<MSGIN> <EQTY> <DUMMY> <CANID> 0Ah <MSG#> <US1> <US2> <US3> <SC>

Field Description:

[0137]

Field	Len (byte)	Description	Notation
MSGIN	1	Message Indication. - encoding: : > Response on message	ASCII
EQTY CANID MSG# SC	na	Defined in Generic Field section	na
DUMMY	5	Dummy characters to place CAN ID as character number 13 in the message.	na
US1, US2, US3	1	Learn Status per line - One character per line. - encoding: A - Line is Active I - Line is Inactive L - Line is in Learn Mode	ASCII

EP 1 865 756 A1

Scenario Description:

Request situation:

5 SERVER -> serv9 -> UNIT
 <- serv11 <-
 <- serv10 <-
 -> serv11 ->

10 *Comment:*

Messages is responded with acknowledge due to long process time of learn function (30 minutes). If Learn function is active while a new request is initiated, message is acknowledged, and the learn session continued.

15 Serv11: Acknowledge Message
 Use:

Acknowledge on messages without response.

20 *Implementation:*

[0138]

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Msg. no.	Description	Datafield
serv11	Acknowledge Message	<MSGIN> <EQTY> <DUMMY> <CANID> OBh <MSG#> <ACKMSG#> <SC>

Field Description:

[0139]

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Field	Len (byte)	Description	Notation
MSGIN	1	Message Indication. - encoding: . > ACK on message without response	ASCII
EQTY CANID MSG# SC	na	Defined in Generic Field section	na
DUMMY	5	Dummy characters to place CAN ID as character number 13 in the message.	na
ACKMSG#	2	MSG# on the message which is ACK'ed	Binary

EP 1 865 756 A1

Scenario Description:

Request situation:

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SERVER    <- serv2 <-    UNIT
          -> serv11 ->
```

Serv12: Set Min. Power

Use:

Request from server to unit, setting threshold level for Power Alarms. Unit responds with serv13 message.

Implementation:

[0140]

Msg. no.	Description	Datafield
serv12	Set Power Thresholds	<MSGIN> <EQTY> <DUMMY> <CANID> 0Ch <MSG#> <SINGLE_PWR> <MULTI_PWR> <SC>

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Field Description:

[0141]

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Field	Len (byte)	Description	Notation
MSGIN	1	Message Indication. - encoding: ? > Request which requires response.	ASCII
EQTY CANID MSG# SC	na	Defined in Generic Field section	na
DUMMY	5	Dummy characters to place CAN ID as character number 13 in the message.	na
SINGLE_ PWR, MULTI PWR	1	Set thresholds for lamp fails. - Range: 0 - 250 W - Resolution: 1W - Presentation: unsigned 8 bit 1W 0 requests actual level without change <i>Example:</i> - 40W > 28h	Binary

EP 1 865 756 A1

Scenario Description:

SERVER -> serv12 -> UNIT
 <- serv13 <-

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Serv13: Min. Power Set
Use:

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Response on serv12 message including present level.

Implementation:

[0142]

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Msg. no.	Description	Datafield
serv13	Min. power set	<MSGIN> <EQTY> <DUMMY> <CANID> 0Dh <MSG#> <SINGLE_PWR> <MULTI_PWR> <SC>

Field Description:

[0143]

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Field	Len (byte)	Description	Notation
MSGIN	1	Message Indication. - encoding: : > Response on message	ASCII
EQTY CANID MSG# SC	na	Defined in Generic Field section	na
DUMMY	5	Dummy characters to place CAN ID as character number 13 in the message.	na
SINGLE_ PWR, MULTI_ PWR	1	Returns actual threshold levels for lamp fails. - Range: 0-250W - Resolution: 1W - Presentation: unsigned 8 bit 1W <i>Example:</i> - 40W > 28h	Binary

EP 1 865 756 A1

Scenario Description:

SERVER -> serv12 -> UNIT
<- serv13 <-

Serv14: Communication Error
Use:

Communication error sent from Communication Unit to Server if internal bus problems appear.

Implementation:

[0144]

Msg. no.	Description	Datafield
serv14	Communication Error	<MSGIN> <DUMMY> <CANID> 0Eh <SC>

Field Description:

[0145]

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Field	Len (byte)	Description	Notation
MSGIN	1	Message Indication. ASCII - encoding: ! > Alarm message.	
CANID SC	na	Defined in Generic Field section	na
DUMMY	11	Dummy characters to place CAN ID as character number 13 in the message.	na

EP 1 865 756 A1

Scenario Description:

Request situation:

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SERVER    <- serv14 <-  UNIT
          -> serv11 ->
```

Serv15: Set Timer Intervals

Use:

Request from Server to Unit setting actual On/Off intervals for Watch function.

Implementation:

[0146]

Msg. no.	Description	Datafield
serv15	Set timer intervals	<MSGIN> <EQTY> <DUMMY> <CANID> 0Fh <MSG#> <ON1> <OFF1> <ON2> <OFF2> <SC>

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Field Description:

[0147]

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Field	Len (byte)	Description	Notation
MSGIN	1	Message Indication. - encoding: ? > Request which requires response.	ASCII
EQTY CANID MSG# SC	na	Defined in Generic Field section	na
DUMMY	5	Dummy characters to place CAN ID as character number 13 in the message.	na
ON1 OFF1 ON2 OFF2	4	On/Off time for watch functionality. Each time fills one byte. - Range: 0-24 time on day. - Resolution: 1 hour - Presentation: unsigned 8 bit 1 hour 25 is OFF. 26 requests status without change <i>Example:</i> - turn On at 6PM, Off at 2AM, On at 5AM and Off at 9AM -> 02050912h	Binary

EP 1 865 756 A1

Scenario Description:

SERVER -> serv15 -> UNIT
 <- serv16 <-

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Serv16: Timer Interval Status
Use:

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Response on serv16 message including present level.

Implementation:

[0148]

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Msg. no.	Description	Datafield
serv16	Timer Interval status	<MSGIN> <EQTY> <DUMMY> <CANID> 10h <MSG#> <ON 1 > <OFF1 > <ON2> <OFF2> <SC>

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Field Description:

[0149]

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Field	Len (byte)	Description	Notation
MSGIN	1	Message Indication. - encoding: : > Response on message	ASCII
EQTY CANID MSG# SC	na	Defined in Generic Field section	na
DUMMY	5	Dummy characters to place CAN ID as character number 13 in the message.	na
ON1 OFF1 ON2 OFF2	4	On/Off time for watch functionality. Each time fills one byte. - Range: 0-24 time on day. - Resolution: 1 hour - Presentation: unsigned 8 bit 1 hour 25 is OFF. <i>Example:</i> - turn On at 6PM, Off at 2AM, On at 5AM and Off at 9AM -> 02050912h	Binary

EP 1 865 756 A1

Scenario Description:

SERVER -> serv15 -> UNIT
-< serv16 <-

Serv17: Single Lamp Fail

Use:

Alarm messages from module to server send when a Single Lamp Fail occurs.

Implementation:

[0150]

Msg. no.	Description	Datafield
serv17	Single Lamp Fail	<MSGIN> <EQTY> <DUMMY> <CANID> 11 h <MSG#> <PWR> <SC>

Field Description:

[0151]

Field	Len (byte)	Description	Notation
MSGIN	1	Message Indication. - encoding: ! > Alarm message	ASCII
EQTY CANID MSG# SC	na	Defined in Generic Field section	na
DUMMY	5	Dummy characters to place CAN ID as character number 13 in the message.	na
PWR	1	Amount of lost power. - Range: 0-250 W - Resolution: 1W - Presentation: unsigned 8 bit 1W <i>Example:</i> - 40W > 28h	Binary

EP 1 865 756 A1

Scenario Description:

Request situation:

SERVER <- serv17 <- UNIT
 -> serv11 ->

Serv18: Multi Lamp Fail

Use:

Alarm messages from module to server, send when a Multi Lamp Fail occurs.

Implementation:

[0152]

Msg. no.	Description	Datafield
serv18	Multi Lamp Fail	<MSGIN> <EQTY> <DUMMY> <CANID> 12h <MSG#> <PWR> <SC>

Field Description:

[0153]

Field	Len (byte)	Description	Notation
MSGIN	1	Message Indication. - encoding: ! > Alarm message	ASCII
EQTY CANID MSG# SC	na	Defined in Generic Field section	na
DUMMY	5	Dummy characters to place CAN ID as character number 13 in the message.	na
PWR	1	Amount of lost power. - Range: 0 - 250 W - Resolution: 1W - Presentation: unsigned 8 bit 1W <i>Example:</i> - 40W > 28h	Binary

EP 1 865 756 A1

Scenario Description:

Request situation:

SERVER <- serv18 <- UNIT
 -> serv11 ->

Serv19: Voltage Line Fault

Use:

Alarm messages from module to server, send when voltage is detected low on an active line.

Implementation:

[0154]

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Msg. no.	Description	Datafield
serv19	Voltage Line Fault	<MSGIN> <EQTY> <DUMMY> <CANID> 13h <MSG#> <ULF1> <ULF2> <ULF3> <SC>

Field Description:

[0155]

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Field	Len (byte)	Description	Notation
MSGIN	1	Message Indication. - encoding: ! > Alarm message	ASCII
EQTY CANID MSG# SC	na	Defined in Generic Field section	na
DUMMY	5	Dummy characters to place CAN ID as character number 13 in the message.	na
ULF1, ULF2, ULF3	1	Voltage line fault indication. One byte per phase. - Encoding: - > No alarm A > line fault present	ASCII

EP 1 865 756 A1

Scenario *Description*:

Request situation:

SERVER <- serv19 <- UNIT
 -> serv11 ->

Serv20: Light Sensor Fault *Use*:

Alarm messages from module to server send on inconsistency between Light Sensor output and voltage output.

Implementation:

[0156]

Msg. no.	Description	Datafield
serv20	Light Sensor Fault	<MSGIN> <EQTY> <DUMMY> <CANID> 14h <MSG#> <FAULT> <SC>

Field Description:

[0157]

Field	Len (byte)	Description	Notation
MSGIN	1	Message Indication. - encoding: ! > Alarm message	ASCII
EQTY CANID MSG# SC	na	Defined in Generic Field section	na
DUMMY	5	Dummy characters to place CAN ID as character number 13 in the message.	na
FAULT	1	Fault type. - encoding: 1 - Sensor is ON, Voltage is OFF 2 - Sensor is OFF, Voltage is ON	ASCII

Scenario Description:
Request situation:

SERVER <- serv20 <- UNIT
 -> serv11 ->

Generic Field description

[0158]

Field	Len (byte)	Description	Notation
MSGIN	1	Message Indication. - encoding: ? > Request which requires response. ! > Alarm message. . > ACK on message without response : > Response on message	ASCII
EQTY	6	Equipment Type. Search string to server to make it possible to distinguish between different system types. <i>Example:</i> - <i>NESA Monitoring unit Street Lighting Surveillance</i> > 741002 > 373431303032h	ASCII
DUMMY	<12	Place holders to position CAN ID at right position in message. Need to be placed as character number 13.	Don't care
CANID	1	CAN-address in the actual Monitoring unit. Always 04 in Monitoring unit.	Binary
MSG#	2	Message number on the actual number. All server messages are numbered. Rolls over to zero at 1.000. - Range: 0-1.000 - Presentation: little endian <i>Example:</i> - <i>Message number 447</i> > 1BFh	Binary
SC	1	Sum check. Sum of total message including SC must equal zero	Binary

EP 1 865 756 A1

[0159] Examples on handling of errors during SMS communication Handling is similar for the monitoring unit.

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Server action	SMS msg#- dir.	Communication Unit action	CAN msg#-dir.	DISCOS unit action (Unit: Optl, Master,...)
Multiple BAY STATUS REQUEST				
Get Bay status, Unit #y	serv1 ->	SMS to CAN conversion.	EXT_MSG ->	Unit #y returns Bay
Get Bay status, Unit #y	serv1 ->	SMS to CAN conversion.	EXT_MSG ->	Unit #y drops request, because only one sms is handled at a time.
Status is interfaced for SCADA system.	serv2 <-	CAN to SMS conversion.	EXT_MSG <-	Status data for server system (response on 1 st request).
Acknowledge on serv2 message	serv11 ->	SMS to CAN conversion.	EXT_MSG ->	Removal of message from buffer
BAY STATUS Respond lost				
Get unit status, Unit #y	serv1 ->	SMS to CAN conversion.	EXT_MSG ->	Unit #y returns unit
BAY STATUS Respond lost				
Status is lost	serv2 <-	CAN to SMS conversion.	EXT_MSG <-	status for server system.
Status is interfaced for SCADA system.	serv2 <-	CAN to SMS conversion.	EXT_MSG <-	After 2 min. and still no ack, the status-sms is retransmitted.
Acknowledge on serv2 message	serv11 ->	SMS to CAN conversion.	EXT_MSG ->	Removal of message from buffer
Ack lost				
Get Bay status, Unit #y	serv1 ->	SMS to CAN conversion..	EXT_MSG ->	Unit #y returns Bay
Status is interfaced for SCADA system.	serv2 <-	CAN to SMS conversion..	EXT_MSG <-	status for server system.
Acknowledge on serv2 message	serv11 ->	SMS to CAN conversion.	EXT_MSG ->	Ack is lost
Ack lost				
Status is interfaced for SCADA system.	serv2 <-	CAN to SMS conversion.	EXT_MSG <-	After 2 min. and still no ack, the status-sms is retransmitted.
Acknowledge on serv2 message	serv11 ->	SMS to CAN conversion.	EXT_MSG ->	Removal of message from buffer
BAY STATUS				
Get Bay status, Unit #y	serv1 ->	SMS to CAN conversion.	EXT_MSG ->	Unit #y returns Bay
Status is interfaced for SCADA system.	serv2 <-	CAN to SMS conversion..	EXT_MSG <-	Alarm occurs in unit #y and the response is dropped and alarm- sms is transmitted instead
Acknowledge on serv8 message	serv11 ->	SMS to CAN conversion.	EXT_MSG ->	Removal of message from buffer

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(continued)

2 min. after the 1 st Get Bay status, the request is retransmitted	serv1 ->	SMS to CAN conversion.	EXT_MSG ->	Unit #y returns Bay
BAY STATUS				
Status is interfaced for SCADA system.	serv2 <-	CAN to SMS conversion.	EXT_MSG <-	status for server system.
Acknowledge on serv2 message	serv11 ->	SMS to CAN conversion..	EXT_MSG ->	Removal of message from buffer

Registration on server

[0160] Monitoring unit units 30 are registered manually at the server. Only the phone number and the CAN ID are used as the identification.

fig. 2 is a block diagram of the monitoring unit. As can be seen in the figure the monitoring unit 30 is provided with a communication unit - denoted 32 - equipped with a GSM modem.

[0161] To and through the monitoring unit 30 one or more sets of power supply lines 14 is/are provided. Here in an exemplary embodiment three sets of AC power supply lines 14 are provided, denoted R, S and D. Alternatively, two sets of AC power supply lines 14 are provided or only one set of AC power supply lines 14 is provided. The corresponding common return line is not shown. It may alternatively be the case that the return line is not common, or it is common for two or three sets of power supply lines. The electrical power supply provides electrical power, e.g. 230 V or 110 VAC power to - as an exemplary embodiment to a string of 6 light sources 16, typically the light sources are connected in parallel along the pair of the two supply lines. However, any other connection, e.g. a series connection of two or more light sources are equally well possible, moreover the series connection may be combined with one or more parallel couplings of light sources.

[0162] The AC electrical power may alternatively be a DC power or a combination of the AC and the DC power.

[0163] Further, the monitoring unit 30 may be supplied with a light sensor which controls a relay to make it possible to switch on the light sources 16 during evening and night hours.

[0164] fig. 3 is another block diagram of the monitoring unit. The monitoring unit 30 has a build in / integral communication unit 32 denoted "modem". The modem communicates with the monitoring unit 32 by means of a CAN bus as well known in the art. The modem 32 is provided with an internally generated 5 VDC of the monitoring unit 30. Figure 5 shows how the CAN bus is protected, e.g. against overvoltage.

[0165] fig. 4 is a block diagram of a CAN bus connection of the monitoring unit. It shows a block diagram of the CAN bus connection of the monitoring unit 30. The protection circuit denoted "protection" can be seen in the next figure. The CAN bus connection is connected to the integral communication unit 32 denoted "modem" of the monitoring unit 30. Light diodes "3 x LED" are applied to show status information from the modem.

[0166] The CAN block is used for converting data from a SPI bus to a CAN bus. The SPI bus is used for communication between the communication unit 32, e.g. a modem and the CAN controller. To protect the CAN bus i/o's, a protection circuit must be placed on its outputs. This circuit must protect against incorrect wire connections, ESD and over current.

[0167] fig. 5 is a diagram of protection of the CAN bus connector of the monitoring unit 30. The figure shows how the CAN bus of the monitoring unit 30 from figure 3 is protected. D25 and D26 each works as an over voltage protection in connection with the coil L5 on the CAN bus lines: CANH and CANL.

[0168] To protect the CAN bus connector against ESD, two protection diodes are used. If a spike larger than 9V, the diodes is clamping to 0V. To remove common-mode noise a filter is used.

[0169] The CAN connector is used for service purpose. The service employee can connect to this port, instead of communication to the monitoring unit 32 by using a GSM modem.

[0170] Before the CAN bus signal can be used, they have to be converted to logic level signals. A CAN driver may do this. To convert the CAN protocol to a SPI protocol, a CAN controller must be used. The CAN controller is supplied by the same 4VDC supply as the modem. This is done to ensure that the CAN controller and the Modems i/o's have the same voltage level. 5VDC supply the rest of the system. The modem is used for wireless communication between the monitoring unit 30 and the alert receiving unit 40, e.g. a GSM server.

[0171] 3 different LED may be available for the modem. These are:

1. Modem OK. (Green)
2. Modem Fail (Red)
3. Online/Communicating (Green)

[0172] fig. 6 is a diagram of a modem of the monitoring unit. The modem 32 is an example of the communication unit of the monitoring unit 30. The circuit exemplifies how the applicant has implemented the modem 32, the chips in the middle of the figure has the function of an UART, which is well known in the art. The circuit consists of the following:

PART LIST OF MODEM IN FIGURE 6

[0173] The modem can be connected to connector J12. A connector J 8 is connected to the modem, and is used for debugging purpose.

A CAN controller called MCP2515, from Microchip, is used for converting the SPI protocol to a CAN protocol. For level converting the CAN signals a driver called MCP2551, also from Microchip, is used. Because the signal RXCAN on the controller and the RXD on the driver isn't compatible, an AND gate is applied as a level converter. The two devices are

EP 1 865 756 A1

not compatible since they are supplied at two different DC voltage levels.

The SPI bus from the modem could be connected directly to the controller.

[0174] The modem is connected to 3 different LED. They are used for indication. Two of the LED's are a double diode. It has a red and a green led. If both of the LED is turned on, the colour is yellow. The third LED is green, and is used for indicating when the modem is communicating, and is online. When the modem is online, the LED it turned on. When the modem is communicating, the LED is flashing.

Pin out for modem connector (J12)

[0175]

Pin	Fun	Pin	Function	Pin	Function	Pin	Function	Pin	Function	Pin	Function
1	4VDC	11	0VDC	21	UART1_T XD1	31	0VDC	41	NC	51	LED1
2	4VDC	12	0VDC	22	NC	32	NC	42	0VDC	52	NC
3	4VDC	13	3V3_EXT	23	UART1_R TS1	33	NC	43	SI	53	LED2
4	4VDC	14	3V3_EXT	24	UART1_R XD1	34	NC	44	SO	54	NC
5	4VDC	15	0VDC	25	Reset	35	NC	45	!CS	55	NC
6	4VDC	16	0VDC	26	UART0_C TS1	36	NC	46	INT	56	NC
7	0VDC	17	NC	27	NC	37	UART0_ TXD0	47	NC	57	NC
8	0VDC	18	NC	28	NC	38	UART0R_XD0	48	NC	58	NC
9	0VDC	19	NC	29	NC	39	NC	49	NC	59	0VDC
10	0VDC	20	0VDC	30	NC	40	NC	50	NC	60	0VDC

EP 1 865 756 A1

Pin out for modem data connector COM1 (J8)

[0176]

Pin	Function	Pin	Function
1	3V3_EXT	11	UART0_C TS1
2	UART1_T XD1	12	UART0_T XD0
3	UART1_R TS1	13	UART0_R XD0
4	UART1_R XD1	14	0VDC

[0177] fig. 7 is a detailed block diagram of the monitoring unit. Here is an embodiment of the monitoring unit 30 which is designed to measure on three pairs of the power supply lines 14, the monitoring unit 30 is thus provided with three sets of the current measurement circuit 36 and the voltage measurement circuit 34.

[0178] Each set of a current measurement circuit 36 and a voltage measurement circuit 34 measures the current flowing to the light sources 16 and the voltages across the light sources 16, respectively.

[0179] The I/O is used for connect to external signals. The following i/o's be available:

- A 4-20mA temperature sense input
- A 230VAC detection input.
- 3 x inputs for 230VAC measurements.
- 3 x input for current measurements.
- A relay output.

[0180] The 4 - 20mA input is a temperature sense input, used for connecting an external temperature sensor. The temperature sensor is used for measuring the temperature inside the monitoring unit 30.

[0181] The input signal has to be converted from a current signal to a voltage signal, before is can be used.

[0182] The 230VAC input is used for detecting the status on a light detector. The light detector is used for detecting if the light source, e.g. the street light has to be turned on or off. The 230VAC input must be galvanic isolated from the rest of the electronics.

[0183] To measure the power supply line voltage, e.g. the street light voltage lines, 3 different analogue inputs must be available. These inputs must be able to measure on 3 x 0.4kV lines, in the interval 200VAC to 260VAC, with the resolution of 1mVAC. The inputs must be able to measure the phase on a voltage line, with the accuracy of $\pm 200\mu\text{s}$.

[0184] Each the inputs must be protected against ESD, and transformed to a lower voltage before it can be used. The 230VAC must also be galvanic isolated from the rest of the electronics. The AC signal must be send through a band pass filter, to correct the shape of the AC signal. This must be done, because the AC signal can contain a lot of harmonic noise.

[0185] To measure the AC current from power lines, e.g. the street light voltage lines, 3 current inputs must be available. These current inputs must be able to measure a current from an inductor, and convert it to a voltage. The AC signals must be sent through a band pass filter, to correct the shape of the AC signal. This must be done, because the AC signal can contain a lot of harmonic noise. The current measurements must have an accuracy of 1mAAC. The range must be from 30mAAC to 50AAC.

[0186] A relay output must be available to activate or deactivate light source, e.g. the street light lamp. The relay is used for handling an external relay and must be able to handle 250VAC / 10A.

[0187] In the design of the circuit discussed above the applicant has used the following specification:

PARAMETERS	SYMBOL	MIN	TYP	MAX	UNITS
Max. input voltage	V_{4-20}	0	-	5	V
Input current max.	I_{4-20}	0	-	40	mA

[0188] 230VAC input:

EP 1 865 756 A1

PARAMETERS	SYMBOL	MIN	TYP	MAX	UNITS
Voltage	V_{230VAC}	200	230	250	VAC
ESD protection	$V_{ESD,230}$	-	-	8	kV
Frequency	f_{230}	-	50	-	Hz

[0189] 3 x 230VAC:

PARAMETERS	SYMBOL	MIN	TYP	MAX	UNITS
Voltage	$V_{Voltage}$	150	230	300	VAC
Accuracy	$A_{Voltage}$	-	1		mVAC
ESD protection	$V_{ESD,230}$	-	-	8	kV
Frequency	f_{230}	-	50	-	Hz

[0190] 3 x AC current:

PARAMETERS	SYMBOL	MIN	TYP	MAX	UNITS
Voltage	$V_{Current}$	-	-	5	VDC
Current	$I_{Current}$	0,03	-	50	AAC
Accuracy	$A_{Current}$		1		mAAC

[0191] Relay output:

PARAMETERS	SYMBOL	MIN	TYP	MAX	UNITS
Voltage	V_{Relay}	-	230	300	VAC
Current	I_{Relay}	-	10	12	AAC
ESD protection	$V_{ESD,230}$	-	-	8	kV

[0192] fig. 8 is a temperature sensor input circuit of the monitoring unit. In an embodiment of the invention, the monitoring unit 30 is provided with a temperature sensor, which can be seen in the figure.

[0193] The 4 - 20 mA input is used for measuring the temperature using an external temperature sensor. The temperature sensor has to be placed inside the monitoring unit 30.

[0194] The 5VDC output is used as supply for the temperature sensor. It is protected against over current by e.g. the 62mA fuse F4.

[0195] The sense input is protected against wrong polarisation by using the diode D8.

[0196] A current represents the temperature from 4mA to 20mA. This current is converted to a voltage so it's possible to measure the value with an Analogue to Digital Converter. A 5V supply is available for the temperature sensor. It can deliver 62mA.

[0197] fig. 9 is a electrical power detection diagram of the monitoring unit. The monitoring unit 30 need know when there is electrical power provided. To this end the diagram shown is applied. The power is galvanic separated by means of the opto coupler D24. From D24 a digital signal "Dig input" is generated indicating whether or not 230 V AC electrical power is present. In the spirit of the invention a circuit detecting 110 V AC, e.g. for USA is possible to implement, e.g. by selecting for example a lower resistor value for R81 and/or another type for the opto coupler D24.

[0198] The 230 VAC input is used for detecting the state on an external relay. The input is galvanic separated by an opto coupler. The opto coupler also works as a level converter.

[0199] The 3 x 230 VAC inputs are used for measuring the voltage on e.g. 3 different street light voltage lines.

[0200] Each of the 230VAC, zero and ground inputs is protected against spikes. If a spike larger than 4kV occurs between zero and ground, a protection circuit is protecting the inputs. The protection circuit is shown on the figure. If a spike larger than e.g. 4kV occurs, a spark will appear between the PCB tracks at the air gab and the resistor R59 then transfers it to ground. The air gab is drawn as two triangles with a rectangle between them on the schematic of the figure.

[0201] In particular SG1, the spark gab works as an over-voltage protection in connection with the fuse F1.

[0202] fig. 10 is a diagram of the protection circuit for the electrical power supplied. In an embodiment of the invention, the protection circuit may be used to individually protect the current measurement circuit 36 and the voltage measurement circuit 34 of figure 7. The two circuits 36 and 34 measure the current flowing to the light sources 16 and the voltages across the light sources 16, respectively.

[0203] fig. 11 is a diagram of electrical power conversion into current and voltage signal levels. The lines "Current" and "Voltage" to the right in the figure is the result of the measurement of current and voltage by means of the current measurement circuit 36 and the voltage measurement circuit 34, respectively. These two circuits are integral to the monitoring unit 30. In case the monitoring unit is to measure on two pairs of power supply lines, it is provided with respective two current measurement circuits 36 and two voltage measurement circuits 34. Accordingly, as an alternative when the monitoring unit is to measure on three pairs of power supply lines it is provided with respective three current measurement circuits 36 and three voltage measurement circuits 34.

[0204] As can be seen in the figure the voltages of three supply lines - of three corresponding 230 V AC electrical power sources connected to the connector J13 - are converted to the lower AC voltages by means of three respective transformers or set of coils, L2, L3 and L4 respectively. In series with the three respective transformers or set of coils is three respective over voltage protective circuits connected to a common ground or return line. As a result the voltage and current levels for a selected one of the three electrical power sources, i.e. the selected supply line, is provided to the right in the figure. The selection of the supply line measured upon is performed by means of the two digital inputs "select A0" and "select A1" and the two analogue results of the current and Voltage measurements can be obtained from the lines denoted 8 "Current" and 9 "Voltage", respectively.

[0205] If a spike occurs between 230VAC input and zero, the resistance in the varistor on the input will decrease. This means that the voltage on the primary side of the transformer also decreases. Each of the 230VAC inputs is converted to a lower voltage with e.g. a 19:1 transformer. The transformer is also used as a galvanic isolator. Each output on the secondary sides of the transformers has a protection diode to protect against voltage spikes.

[0206] A capacitor is used for changing the DC offsets to 2,048V DC. This is done to generate a zero crossing value for all AC measurements. A multiplexer is used for selecting which input is being measured. The multiplexer has been selected in order to for minimising the amount of used components. In this way only one filter is needed for 3 voltage measurements, and accordingly only one AD converter is needed.

[0207] fig. 12 is a diagram of band pass filter filtering the electrical power supplied.

[0208] The voltage output on the multiplexer is connected to the band pass filter. The band pass filter is used to limit the input frequency band. This is done to remove unwanted frequency information from the input.

[0209] fig. 13 is a schematic showing the band pass filter characteristic. Here the band pass filter characteristics from the foregoing figure is shown graphically.

[0210] fig. 14 is a schematic showing a current transformer. The first configuration for the inductor, used for measuring the current, was to use an inductor made on a flexible PCB, with a PCB layout as a Rogowski inductor known in the art. As an alternative the applicant chose to drop the first configuration due to a large deviation in the measurement at the connection point between the edges of the PCB.

[0211] Another configuration was then selected. The new solution was to connect a HF3A current transformer from EATON | Holec on each input. The coil is working as a current to current converter. If it is measuring 100A, it will deliver 1A on its output.

[0212] The schematic shows the original layout. The inputs have a resistor in parallel. The resistor on each input is e.g. 0.5Ω / 2W. This means that when the coil is measuring 10A, the voltage on the resistor is 50mV.

[0213] Calculation:

$$U_R = \frac{I_{in} \cdot 0.5\Omega}{100}$$

fig. 15 is a schematic showing a current filter. A multiplexer is used for selecting which current input is being measured. The multiplexer is added for minimizing the amount of used components. This way only one filter is needed for all 3 current measurements, and only one AD converter is needed.

[0214] The current output on the multiplexer is connected to a band pass filter. The band pass filter is used to limit the input frequency band. This is done to remove unwanted frequency information from the input. The output of the band pass filter is connected to an amplifier. The amplifier has two different gains. The first gain is 1.83, see figure 16 for the current filter with the low gain. The second gain is 11.83, see figure 17 for the current filter with the high gain. The gain can be selected on a multiplexer. These gain values is not calculated, but defined by testing. The amplifier is inserted

to increase the resolution at lower current measurements.

fig. 16 is a schematic showing a current filter with low gain.

Gain = 1.83 @ 50Hz equ. 19.278dB

[0215] On the figure, a simulation of the filter is shown. The filter is with the low gain. The simulation shows that the centre frequency is almost at 50Hz. It also shows that the filter is decreasing the low- and high frequencies by 40dB/decade.

fig. 17 is a schematic showing a current filter with high gain,

Gain = 11.83 @ 50Hz equ. 35.475dB

[0216] On the figure, a simulation of the filter is shown. The filter is with the high gain.

[0217] The gain difference between the two filters should be 6.45, according to the 3 resistors R17, R18 and R19 in the last gain shift. The simulations confirm that the gain difference is identical to the calculated.

[0218] Resistor calculations for figure 14:

$$Low\ gain = \frac{10k}{12k} + 1 = 1.83 \qquad High\ gain = \frac{10k}{\left(\frac{1k \cdot 12k}{1k + 12k}\right)} + 1 = 11.83$$

fig. 18 is a schematic showing relay outputs. The 2 relays are used for handling external equipment. One of the relays is used for handling an external relay. The other relay output is made to have an extra relay output.

[0219] To operate the relays, a MOSFET are used on each relay. This is done to operate the relays at TTL level. The 2 outputs on connector J3, work as an on/off switch. A 250V/10A fuse protects each of the outputs.

[0220] fig. 19 is an AD converter block diagram. The AD converter is user for measuring the voltages and current. To make sure that the phase accuracy on a 50Hz voltage or current measurement¹, the AD converter must be able to sample more than 5000 smpl/sec. The AD converter must be able to measure from the 3 voltage and the 3 current inputs. To read from the AD converter a SPI bus must be used. A controller handles the SPI bus.

[0221] Minimum resolution for the voltage measurement:

$$Volt\ ADC_{min.res} = \frac{LOG\left(\frac{260VAC}{1mVAC}\right)}{LOG(2)} = 17.988bits \approx 18bits$$

[0222] Minimum resolution for the current measurement:

$$Current\ ADC_{min.res} = \frac{LOG\left(\frac{50AAC}{1mAAC}\right)}{LOG(2)} = 15.6bits \approx 16bits$$

Parameters

[0223] Analogue inputs:

PARAMETERS	SYMBOL	MIN	TYP	MAX	UNITS
Input voltage range	Va,in	0	-	V _{supply,5}	V
Input current	Ia,in,max	-	-	1	mA

[0224] SPI bus:

PARAMETERS	SYMBOL	MIN	TYP	MAX	UNITS
Voltage range	V_{SPI}	0	-	V_d	V
I/O current	I_{SPI}	-10	-	10	mA

[0225] fig. 20 is an AD converter circuit diagram. The figure is an implementation of the previous figure. A 16 bit AD converter with 2 inputs is chosen. An input is for the voltage measurement, and the other one is for the current measurement. Since the 3 current- and the 3 voltage measurements are multiplexed only 2 inputs is needed on the AD converter. The 16 bit AD converter can not meet the 1mVAC demands for the voltage resolutions it self. A gain shift has to be made, or an AD converter with a higher resolution has to be used.

[0226] No gain shift is used on the current input. This result in the resolution for the current input, still fulfil the demands in the specification for the current resolution. Possibly noise then has a big affect on the measured signal.

[0227] Another AD converter with a higher resolution could be chosen, but the 16bit is selected because of price and speed, and the voltage resolution is then compromised.

[0228] Voltage resolution:

$$V_{res} = \frac{260VAC}{2^{16} bit} = 3.967mVAC / bit$$

[0229] Current resolution:

$$I_{res} = \frac{50AAC}{2^{16}} = 0.763mAAV / bit$$

[0230] fig. 21 is a controller block diagram. The controller equals the CPU shown in e.g. figure 3. The main CPU in the monitoring unit 30 handles all the digital and analogue I/O's and accordingly computes thereon.

[0231] A PIC18F8585 micro controller from microchip is used. This is selected because of its high speed and large memory, and especially because it has a CAN bus.

A controller with a fewer I/O's and a smaller memory may be used.

[0232] Minimum specification for microcontroller/ μ Controller or CPU:

- A CAN bus.
- A voltage ref. input for the 4.096V reference.
- 3 x Analog inputs
- A SPI bus.
- 1 x Digital input.

2 x Digital outputs

[0233] fig. 22 is a diagram showing use of the controller. The figure is an implementation of the previous figure. A PIC18F8585 is chosen a controller. On the schematic above is written PIC18F8X20 but should read PIC18F8585.

[0234] The reset circuit holds the reset input on the μ Controller, until the digital power (+5) is stable. The LED D17 is turned off when the μ Controller is being reset.

The connector ICSP1 is used for debugging and programming the μ Controller.

[0235] The 9 LED's to the right, are used for different indications.

- | | | | |
|----|------------------|-----------|--------------|
| 1. | System OK/Fail : | Red/Green | (Double LED) |
| 2. | Light sensor | : | Green |
| 3. | Time / Sensor | : | Green |

EP 1 865 756 A1

(continued)

4.	L1 Active	:	Red
5.	L2 Active	:	Red
6.	L3 Active	:	Red
7.	SMS Relay	:	Green
8.	Timer Relay	:	Green

[0236] The μ Controller is measuring the voltage level on the output on the DC/DC converter, the +5V and +4V supply. This is done to be able to indicate if something is wrong with the supply.

[0237] A temperature sensor (R52) is also mounted on the PCB. This is done to be able to measure the temperature in the box in which the monitoring unit is located.

[0238] To communicate on the CAN bus, an output driver MCP2551 is used. It is used for communication to the modem. An external CAN port is available on the connector J11. It may be used for service purpose.

[0239] fig. 23 is a power supply block diagram. The supply and reference delivers supply voltages and references voltages.

[0240] The input is protected against ESD, over current, over voltage and by a fuse.

[0241] The 230VAC may be converted to 12VAC by a 38:1 transformer; this also works as a galvanic isolation. The AC is rectified to DC which is converted to a 4VDC and 5VDC.

[0242] The 4V DC is for the communication unit, e.g. the modem and the 5 VDC is for the rest of monitoring unit.

[0243] To make all AD measurements more precise, a stable voltage reference is used. The 4.096VDC reference is used because the ADC has a resolution of 2^{16} bits (The reference must be dividable by 2^{16} bits, to produce a simple LSB), which gives a LSB of $63\mu\text{V}$

[0244] Another voltage references must be used when measuring AC signals. This reference is used to remove the negative part of the AC signal by creating a DC- offset. This is selected as the half of the 4.096V reference, which is 2.048V.

[0245] Voltage references for 4V:

PARAMETERS	SYMBOL	MIN	TYP	MAX	UNITS
Output voltage	$V_{\text{supply},4}$				V
Source and sink current output	$I_{\text{supply},4}$				mA
Output voltage Temperature Coefficient	$\text{TCV}_{\text{supply},4}$				PPM/°C

[0246] Voltage references for 5V:

PARAMETERS	SYMBOL	MIN	TYP	MAX	UNITS
Output voltage	$V_{\text{supply},5}$				V
Source and sink current output	$I_{\text{supply},5}$				mA
Output voltage Temperature Coefficient	$\text{TCV}_{\text{supply},5}$				PPM/°C

[0247] Voltage references for 4.096V:

PARAMETERS	SYMBOL	MIN	TYP	MAX	UNITS
Output voltage	$V_{\text{ref},4}$	4.010	4.096	4.180	V
Source and sink current output	$I_{\text{ref},4}$	-5	-	5	mA
Output voltage Temperature Coefficient	$\text{TCV}_{\text{ref},4}$	-	-	50	PPM/°C

[0248] Voltage references for 2.048V:

PARAMETERS	SYMBOL	MIN	TYP	MAX	UNITS
Output voltage	$V_{\text{ref},2}$	4.010	2.048	4.180	V

(continued)

PARAMETERS	SYMBOL	MIN	TYP	MAX	UNITS
Source and sink current output	$I_{ref,2}$	-5	-	5	mA
Output voltage Temperature Coefficient	$TCV_{ref,2}$	-	-	50	PPM/°C

[0249] fig. 24 is a diagram showing implementation of the power supply. The figure is an implementation of the previous figure. The monitoring unit is supplied by 230 VAC when implemented in most European countries. Alternatively, for the United States 230 VAC supply the monitoring unit. The supply input may have 4 different inputs:

1. Earth
2. 230VAC Phase as an example of a supply line
3. Zero 1 as an example of a return line
4. Zero 2

[0250] Zero 1 is the zero for the 230VAC supply. The zero 2 input is the zero line for the 3 x 230VAC inputs, connected to the transformers. Earth is used for protection. It is only used for protecting against voltage spikes higher than 4kV.

[0251] To protect the 230VAC-supply input on the monitoring unit, a 1.6A fuse is connected in series with the phase, e.g. a power supply line. A resistor and a Varistor are used for protecting against higher voltages between the phase and zero, e.g. a power return line. If the input voltage gets too high, the resistance in the Varistor decreases and the input voltage on the transformer is limited. The transformer may be used for transforming the 230VAC voltage to a 6VAC voltage. The AC voltage is send through a rectifier, and 3 electrolytic capacitors are used for smoothing the ripple voltage. Two different voltage regulators are used for converting the rectified AC voltage into two different DC voltage supplies. The first voltage supply is a 5V DC supply. The other is a 4V Dc supply. The 5V Dc supply is used by the electronic in the monitoring unit. The 4V DC supply is used by the modem. Because the 4V DC supply has to be very stable, 4 electrolytic capacitors with a low ESR are used. To create a reference voltage at 4.096V DC a LM4120AIM5-4.1 (U12) may be used. It creates a reference voltage, used for AD measurements. The system is using another reference voltage that is exact the half of this voltage. This voltage is generated by means of two identical resistors. A buffer B1 is used, to be able to deliver enough current on the output. An operational amplifier U4 is used for regulating the output buffer, because the input and output on the buffer, is not totally identical.

[0252] A more detailed discussion of how to detect light source faults or malfunctions and providing related alert messages now follows.

[0253] The invention may be applied in a lighting monitoring system having two basic elements: the monitoring unit 30 and the alert receiving unit 40. The monitoring unit 30 has the build in communication unit 32, which transfers alerts via SMS to the alert receiving unit 40. The alert receiving unit 40 can transfer commands back to the monitoring unit 30 via the communication unit 32.

[0254] The invention may also be applied in a bigger system - the lighting system - using the lighting monitoring system as discussed above. The lighting monitoring system is connected to one, two or three pairs of power supply line and to the plurality of light sources, which thereby may be monitored.

[0255] The monitoring unit 30 has at least two pairs of connectors. The two pair of connectors constitutes a pair of input connectors and a pair of output connectors.

[0256] To the pair of input connectors a respective pair of power supply lines constituting a supply line and a return line may be connected. Typically the supply line provides 230 V AC, where the return line may be denoted 0 V AC.

[0257] In case an application is needed where it is required supply two phase to some light sources, accordingly there is a need to measure on two phases, i.e. on two times 230 V AC, the monitoring unit 30 then is provided with four pairs of connectors. The four pair of connectors then constitutes two pair of input connectors and two pair of output connectors. To each pair of input connectors a respective 230 V AC with its return line 0 V AC is connected. Accordingly, from each pair of output connectors the 230 V AC with its return line 0 V AC is connected to respective light sources. In this case the light sources may be connected between the two phases or some of them between the first phase and a corresponding return line, and correspondingly other light sources being connected between the second phase and the return line associated with the second phase. Alternatively or additionally, the return line or the two return lines may be common for the two phases.

[0258] In case an application is needed where it is required to provide high power to some light sources, e.g. to supply three supply lines to some light sources, voltage and current measurements are required on 3 phases, i.e. on three times 230 V AC. The monitoring unit 30 then may be provided with six pairs of connectors. The six pair of connectors then constitutes three pair of input connectors and three pair of output connectors. To the three pair of the input connectors

three respective set of 230 V AC with their return lines, 0 V AC are connected. Accordingly, from every of the three pair of output connectors the 230 V AC with its respective return line 0 V AC is connected to respective light sources. This embodiments can be seen in figure 2 where R denotes a supply line with it return line, likewise S and T each also denotes the respective supply line and return line. Alternatively or additionally, the three return lines may be common for the three supply lines.

[0259] In a practical application the applicant has provided the monitoring unit 30 with four input connectors for the three phases, 3 x 230 VAC and the common return line. Accordingly, the applicant has provided the monitoring unit 30 with output connectors for the three phases having the same common return line wired through the monitoring unit. It is hereby an advantage that a technician in the field can choose to apply one, two or three phases to the input connectors. Accordingly, one, two or three phases leaves the output connectors, which may be connected to a desired number of light sources, which are to be monitored by means of the monitoring unit.

[0260] The monitoring unit 30 has a voltage measuring circuit 34 measuring the voltage, e.g. AC voltage across the pair of power supply lines connected to it. The measurement takes place either across the pair of input connectors or across the pair of output connectors used.

[0261] Correspondingly, the monitoring unit is provided with a current measuring circuit 36. The circuit measures the current flowing through the supply line or the return line in response to the electrical power, e.g. 230 V AC or 110 V AC, which is provided to the plurality of light sources connected to the output connectors.

[0262] As discussed the monitoring unit has a microcontroller/ μ Controller or a CPU. In general the task of the microcontroller, μ controller or the CPU are discussed in terms of the monitoring unit, since the steps are performed within this unit. The monitoring unit controls the following steps aiming to detect whether light sources are defect::

[0263] The monitoring unit defines a first time frame and a first point of time during the first time frame. Measurements during the first time frame are e.g. used for learning how the impedance, in particular the resistance is of the light sources. It is thus assumed that measurements during the first time frame represent the status of the light sources at that time. For example if all light sources at that time work properly, i.e. they all draw current to lit up, the status from the first time frame then represents a set of error free and properly working light sources. In practice the status for the light sources is obtained by measuring the voltage over the lines powering the light sources and the current flowing through the line. From these two factors, the total power consumption in the line may be determined. The power consumption can be separated into an active and reactive part, where the reactive part is an expression of the load of the light sources in terms of the resistance.

[0264] In order to measure correctly it is a prerequisite during the first time frame that a steady state situation for the plurality of light sources is achieved. This means the light sources with igniters and ballasts, etc have heated up and have a stable power consumption, i.e. they draw a stable current. Typically 30 minutes are sufficient time to reach the steady state situation.

[0265] Accordingly during the learn session, the monitoring unit measures at the first point of time a first voltage level by means of the voltage measuring circuit and measures at the same point of time, i.e. at the first point of time a first current level by means of the current measuring circuit.

[0266] Hereby it is possible for the monitoring unit to determine a first load resistance representing the active load resistance for the plurality of light sources being active, i.e. turned on during the first time frame of the learn session. The first load resistance is determined and based on the measured first voltage level and the measured first current level. The power consumption in terms of the current be separated into an active and reactive part, where the reactive part is an expression of the load of the light sources in terms of the first load resistance.

[0267] Later on, i.e. after learn session new measurements of the current drawn and the voltage supplied are performed, i.e. the monitoring unit defines a second time frame and a second point of time during the second time frame in which measurements are to take place. Measurements during the second and later time frame are e.g. used for determining how the impedance, in particular the resistance is of the light sources - and possible also including the resistance of the connection between the light sources - when powered also in a steady state situation. It is assumed that measurements during the second time frame represent the status of the light sources at the time of an operating system, e.g. an operating lighting system. Due to wear, poor electrical connections, a "red burner" light source, flickering light sources, lamps that never reach operating temperature due to an internal error or malfunction, etc it is now possible that fewer light sources work properly, i.e. draws less than the expected correct current, i.e. less than the current as compared to that in the first time frame.

[0268] For example if just one of the light sources at this point of time does not work properly, i.e. it draws to little current to lit up, the status from the second time frame then represents a set working light sources having a faulty light source. Accordingly, more faulty light sources may be detected.

[0269] In order to also here to measure correctly it is a precondition that during the second time frame another and second steady state situation for the plurality of light sources powered is achieved. This means that the light sources have had sufficient time to warm up and to enter a stable current consumption. The second time frame of course is defined to take place after the first time frame of the learning session has gone.

[0270] Accordingly, the monitoring unit measures at the second point of time a second voltage level by means of the voltage measuring circuit as used before. Moreover, the monitoring unit measures at the second point of time a second current level by means of the current measuring circuit used to measure during the first time frame.

[0271] The monitoring unit may determine a second load resistance representing the active load resistance for the plurality of light sources being powered and active during the second time frame. The second load resistance is based on the second voltage and current level.

[0272] Now the monitoring unit has information about the first and second load resistance from the measured voltages and current, i.e. the load resistance from the learn session and another load resistance from the later period of the operating lighting system. The latter may have errors or defects on the light sources powered.

[0273] At this stage the monitoring unit computes the difference between the first and second load resistance, and in case the difference exceeds a specific threshold, i.e. the difference is too big and thus could represent an increase in the load resistance between the two time frames, e.g. due to a non connected or blown bulb in a light source, the monitoring unit generates a first alert message. Subsequently, the monitoring unit sends or transmits e.g. by means of a SMS the first alert message through means of the communication unit to the alert receiving unit.

For example if the difference exceeds a specific threshold, it may indicate an increased load resistance, it may be due to an open circuit and / or circuit parts leading to that too small current runs. If the difference exceeds a specific threshold it may additionally be due to a poor connection to or among light sources, or due to that one, too, three, etc light sources do/does not draw current since it or they are burned off and/or has/have malfunction(s).

[0274] In response to the reception of the first alert message the alert receiving unit acts, e.g. breaks a power line or more power lines and /or provides another alert message. The another alert message is e.g. provided by means of a pictogram indicating a malfunctioning light source or light sources, a text message or in the form of LEDS being powered, e.g. on a panel in which the LEDS are mounted close to a supporting text.

[0275] In general, when alert messages are discussed herein each may indicate one of following alert situations: one light source being defect or malfunctioning, two light sources being defect or malfunctioning, the plurality of light sources has a defect among some of them or being malfunctioning, the plurality of light sources is defect or is malfunctioning, or the supply line or even the return line is somehow defective, e.g. wrongly connected or misconnected.

[0276] Moreover, the monitoring unit may further determine the time difference between the first and second point of time. This is used to determine the relative load resistance change over time, and is expressed as a ratio of the load resistance change over time. It is computed as the difference between the first and second load resistance divided by the determined time difference between the first and second point of time.

[0277] The ratio of the load resistance change over time reveals as compared to difference between the first and second load resistance whether the load resistance changes rapidly up and down. Since the first and second load resistance in both cases expresses a steady state situation for the light sources a resistance change - in e.g. ohm/sec - for an increasing load resistance and a decreasing load resistance as well indicate a malfunction somehow among the light sources and/or in the circuitry and lines connecting the light sources.

[0278] For example, a rapidly decreasing load resistance may indicate a short circuit and / or that a current erroneously, e.g. due to moist, water, etc. runs to ground instead of running properly back in the return line from the supply line.

[0279] Conversely, a rapidly increasing load resistance could indicate that e.g. a circuit of the return line and the supply line somewhere has a burnt over connection, a burnt off igniter, poor or missing connection and / or that a filament of a bulb of a light source is off.

[0280] In all cases when the ratio of the load resistance over time exceeds a second specific level the monitoring unit then generates a second alert message.

[0281] Subsequently, the communication unit e.g. the modem embedded in the monitoring unit sends the second alert message to the alert receiving unit.

[0282] In response to the reception of the second alert message the alert receiving unit acts accordingly, i.e. it presents an alert or alarm or does something to avoid further errors, e.g. switches off a power line or power lines etc. The alert or alarm in the form of an alert message may e.g. be provided by means of a pictogram on a display or a screen, where the pictogram indicates a malfunctioning light source or light sources or a malfunctioning circuitry. Alternative the message is e.g. provided in the form of a text message or in the form of LEDS being powered.

[0283] In addition or as a substitute how to generate the first or second alert message, the method of controlling the lighting system or lighting monitoring system may perform the following steps:

- defining in the monitoring unit a third time frame and a third point of time during the third time frame, during the third time frame a third steady state situation for the light sources powered is achieved, in order to measure correctly it is a prerequisite during the third time frame that a steady state situation for the light sources being powered is achieved. This means the light sources with igniters and ballasts, etc have heated up and have a stable power consumption, i.e. they draw a stable current. Typically 30 minutes are sufficient time to reach the third steady state situation being comparable with the very first steady state situation discussed.

the method proceeds with the steps:

- measuring in the monitoring unit at the third point of time as defined a third voltage level by means of the voltage measuring circuit,
- measuring in the monitoring unit at the third point of time a third current level by means of the current measuring circuit, now the current and voltages levels again are available for the discussed steady state situation,

the method proceeds with the step:

determining in the monitoring unit a first power level representing the power for the plurality of light sources being active during the third time frame based on the third voltage level and the third current level, e.g. by the product of the third voltage level and the third current level to obtain the first power level,

the method proceeds with the step:

defining in the monitoring unit a fourth time frame and a fourth point of time during the fourth time frame, during the fourth time frame a fourth steady state situation for the plurality of light sources is achieved, the fourth time frame being defined to take place after the third time frame has expired, the fourth steady state situation represents a period of the lighting system being in a stable operating mode, e.g. after more than 30 minutes have gone since the powering of the light sources and this steady stable situation is comparable with the discussed second steady state situation,

the method proceeds with the steps:

measuring in the monitoring unit at the fourth point of time a fourth voltage level by means of the voltage measuring circuit already used for voltage measurements,

measuring in the monitoring unit at the same point of time, i.e. at the fourth point of time a fourth current level by means of the current measuring circuit as already used for current measurements,

determining in the monitoring unit a second power level representing the power for the plurality of light sources being active (i.e. powered) during the fourth time frame based on the fourth voltage level and the fourth current level, e.g. by the product of the fourth voltage level and the fourth current level to obtain the second power level,

generating in the monitoring unit a third alert message provided a second alert criterion is also met, i.e. if the difference between the first and second power levels exceeding a third specific threshold,

[0284] A set-up in the monitoring unit may be made to combine the computations which resulted in respective first, second and third alert messages, if e.g. all three are determined it may indicate severe faults in light sources powered.

[0285] In addition or as a substitute how to generate the first, second or third alert message, the method of controlling the lighting system or lighting monitoring system may further perform the following steps:

[0286] the monitoring unit further determines a time difference between the third and fourth points of time, and then determines the ratio of the power level change over time as the difference between the above computed first and second power levels divided by the time difference between the third and fourth points of time, and in case the computed ratio of the power levels over time exceeds a third specific level the monitoring unit in turn generates a fourth alert message which message subsequently the communication unit of the monitoring unit sends to the alert receiving unit, and the alert receiving unit then further acts or alerts in response to its the reception of the fourth alert message.

[0287] For example, a rapidly increasing power level may indicate a short circuit and / or that a current erroneously, e.g. due to moist, water, etc. runs to ground instead of running properly back in the return line from the supply line, moreover the rapidly increasing power consumption may indicate that an active ballast or other circuitry controlling lamps or bulbs, etc attempts to counter react an decreasing voltage - measured by active ballast or other circuitry - by providing or allowing excessive currents to flow with the inevitable result that the power consumption is increased over time and also a total measure.

[0288] The alert messages as discussed may each indicate one of following alert situations: one light source being defect or malfunctioning, two, three, four, etc light sources being defect or malfunctioning, said plurality of light sources has a defect among some of them or being malfunctioning, said plurality of light sources being defect or being malfunctioning, or said supply line being defective.

[0289] In principle, the measurements taking place prior to the generation of the first, second, third and fourth alert message may be applied to detect the same types of malfunctions and/or defects. However, it may be the case that one of the four ways (with corresponding resulting first, second, third and fourth alert messages) of interpreting current and voltage data - e.g. the load resistance change and the relative load resistance change (load resistance change over time) turns out to be the fastest or most reliable one to detect a certain malfunction or defect. However, when the applicant over time compiles current and voltage data these data may be subject to advanced analyses in order to spot certain malfunctions or defects rather early in the data gathering process

[0290] In general for the systems discussed and for the monitoring unit as well, the phase or supply line provides electrical power such as AC power, consequently the voltage levels being measured along with the current levels also being measured are substantially AC levels in terms of volt and amperes.

[0291] The plurality of light sources or just a single light source is to be selected among a incandescent lamp, a bulb, a fluorescent lamp, a neon light, a Hg lamp, a sodium street lamp, a light emitting diode or a light emitting diodes light source and other sources of light suitable for illumination of areas.

[0292] The monitoring unit in a street light application being, a street light station, alternatively a lighting controller or a client. The alert receiving unit may be a server or a cellular phone.

[0293] Moreover, the communication unit may transmit or send the discussed alert messages through means of the pair of power supply lines, e.g. by superimposing a communication signal in the sinus wave of 50 or 60 cycles per second.

[0294] The communication unit may alternatively or additionally send the alert messages through means of a wireless communication, e.g. via a GSM network for example by means of textual messages, e.g. SMS messages.

[0295] Conversely, the communication unit may receive commands from the alert receiving unit through means of the one or two of the pair of power supply lines or by means of a textual message, e.g. a SMS message.

[0296] Appropriately, the implemented way of communicating forth and back between the alert receiving unit and the monitoring unit is chosen to be identical.

[0297] The commands may be instructions to the monitoring unit to switch on or off one, two, three, etc or all of the light sources connected to the monitoring unit.

[0298] Alternatively, or additionally the commands may be instructions to the monitoring unit to switch completely on or off one, two, three of the phases connected to light sources powered via the monitoring unit.

[0299] In the following section the applicant provides the software implementation of the invention. When the term "Rimfaxe" or similar is applied it is equivalent with the monitoring unit. Correspondingly, when the terms "Loke", "Loke modem" or "modem" is applied it is equivalent with the communication unit.

Claims

1. A lighting system comprising:

a pair of power supply lines,
 a plurality of light sources connected to said pair of supply lines,
 a monitoring unit, and
 an alert receiving unit communicating with said monitoring unit,
 said pair of power supply lines constituting a supply line and a return line,
 said supply line and said return line being connected to said plurality of light sources and through said monitoring unit,
 said pair of power supply lines providing electrical power to said plurality of light sources,
 said monitoring unit comprising a voltage measuring circuit measuring the voltage across said pair of power supply lines,
 said monitoring unit comprising a current measuring circuit measuring the current flowing through said supply line or said return line in response to the electrical power provided to said plurality of light sources,
 said monitoring unit defining a first time frame and a first point of time during said first time frame, during said first time frame a first steady state situation for said plurality of light sources is achieved,
 said monitoring unit measuring at said first point of time a first voltage level by means of said voltage measuring circuit,
 said monitoring unit measuring at said first point of time a first current level by means of said current measuring circuit,
 said monitoring unit determining a first load resistance representing the active load resistance for said plurality of light sources being active during said first time frame based on said first voltage level and said first current level,
 said monitoring unit defining a second time frame and a second point of time during said second time frame, during said second time frame a second steady state situation for said plurality of light sources is achieved,

said second time frame being defined to take place after said first time frame has expired,
 said monitoring unit measuring at said second point of time a second voltage level by means of said voltage measuring circuit,
 said monitoring unit measuring at said second point of time a second current level by means of said current measuring circuit,
 said monitoring unit determining a second load resistance representing the active load resistance for said plurality of light sources being active during said second time frame based on said second voltage level and said second current level,
 said monitoring unit generating a first alert message provided the difference between said first and second load resistance exceeds a first specific threshold constituting a first alert criterion,
 said monitoring unit comprising a communication unit for sending said first alert message to said alert receiving unit, and
 said alert receiving unit acting or alerting in response to the reception of said first alert message.

2. The lighting system according to claim 1, said monitoring unit further determining a first time difference between said first and second points of time, and determining a ratio of the load resistance change over time as the difference between said first and second load resistance divided by said determined time difference between said first and second points of time, and provided said ratio of said load resistance over time exceeds a second specific level said monitoring unit generating a second alert message and said communication unit of said monitoring unit sending said second alert message to said alert receiving unit, and said alert receiving unit further acting or alerting in response to the reception of said second alert message.

3. The lighting system according to claim 1 or 2, further comprising:

said monitoring unit defining a third time frame and a third point of time during said third time frame, during said third time frame a third steady state situation for said plurality of light sources is achieved,
 said monitoring unit measuring at said third point of time a third voltage level by means of said voltage measuring circuit,
 said monitoring unit measuring at said third point of time a third current level by means of said current measuring circuit,
 said monitoring unit determining a first power level representing the power for said plurality of light sources being active during said third time frame based on said third voltage level and said third current level,
 said monitoring unit defining a fourth time frame and a fourth point of time during said fourth time frame, during said fourth time frame a fourth steady state situation for said plurality of light sources is achieved, said fourth time frame being defined to take place after said third time frame has expired,
 said monitoring unit measuring at said fourth point of time a fourth voltage level by means of said voltage measuring circuit,
 said monitoring unit measuring at said fourth point of time a fourth current level by means of said current measuring circuit,
 said monitoring unit determining a second power level representing the power for said plurality of light sources being active during said fourth time frame based on said fourth voltage level and said fourth current level,
 said monitoring unit generating a third alert message provided a second alert criterion is also met as the difference between said first and second power levels exceeding a third specific threshold.

4. The lighting system according to claim 3, said monitoring unit further determining a second time difference between said third and fourth points of time, and determining a ratio of the power level change over time as the difference between said first and second power levels divided by said determined time difference between said third and fourth points of time, and provided said ratio of said power levels over time exceeds a third specific level said monitoring unit generating a fourth alert message, said communication unit of said monitoring unit sending said fourth alert message to said alert receiving unit, and said alert receiving unit further acting or alerting in response to the reception of said fourth alert message.

5. The lighting system according to claims 1 or 2, said first and second alert message each indicates one of following alert situations: one light source being defect or malfunctioning, two light sources being defect or malfunctioning, said plurality of light sources has a defect among some of them or being malfunctioning, said plurality of light sources being defect or being malfunctioning, or said supply line being defective.

6. The lighting system according to claim 3 and 4, said third and fourth alert message each indicates one of following

alert situations: one light source being defect or malfunctioning, two light sources being defect or malfunctioning, said plurality of light sources has a defect among some of them or being malfunctioning, said plurality of light sources being defect or being malfunctioning, said supply line being defective, or current running to ground.

5 7. The lighting system according to any of the preceding claims, said first time frame being identical to said third time frame and said second point of time being identical to said fourth point of time.

10 8. The lighting system according to any of the preceding claims, said electrical power being an AC power, said first and second voltage level and said first and second current levels are substantially AC levels.

9. The lighting system according to any of the preceding claims, said plurality of light sources being selected among a incandescent lamp, a bulb, a fluorescent lamp, a neon light, a Hg lamp, a sodium street lamp, a light emitting diode or a light emitting diodes light source and other sources of light suitable for illumination of areas.

15 10. The lighting system according to any of the preceding claims, said first time frame representing a period of a learn session.

20 11. The lighting system according to any of the preceding claims, said second time frame representing a period of an operating system with the possibility that one or more of said light sources being defective.

12. The lighting system according to any of the preceding claims, said monitoring unit being a lighting controller, a street light station or a client.

25 13. The lighting system according to any of the preceding claims, said alert receiving unit being a server.

14. The lighting system according to any of the preceding claims, said alert receiving unit being cellular phone.

30 15. The lighting system according to any of the preceding claims comprising two pairs of power supply lines and two of said voltage and current measurement circuits.

16. The lighting system according to any of the preceding claims comprising three pairs of power supply lines and three of said voltage and current measurement circuits.

35 17. The lighting system according to any of the preceding claims further comprising a plurality of said monitoring unit.

18. The lighting system according to any of the preceding claims, the communication unit sending said alert messages through said pair of power supply lines.

40 19. The lighting system according to any of the preceding claims, the communication unit sending said alert messages through means of a wireless communication, e.g. via GSM.

20. The lighting system according to any of the preceding claims, said alert messages are textual messages, e.g. in the form of a SMS.

45 21. The lighting system according to any of the preceding claims, the communication unit receiving commands through said pair of power supply lines.

50 22. The lighting system according to any of the preceding claims, the commands being instruction to switch on or off said plurality of said light sources.

23. The lighting system according to any of the preceding claims, said return line being common for two of said pair of power supply lines.

55 24. The lighting system according to any of the preceding claims, said return line being common for three of said pair of power supply lines.

25. A lighting monitoring system comprising:

a monitoring unit and
 an alert receiving unit,
 said monitoring unit comprising a communication unit communicating with said alert receiving unit,
 said monitoring unit having two pairs of connectors constituting a pair of input connectors and a pair of output
 5 connectors,
 said pair of input connectors being connectable to a pair of power supply lines constituting a supply line and a
 return line,
 said pair of power supply lines providing electrical power,
 said pair of output connectors being connectable to a plurality of light sources,
 10 said pair of power supply lines providing an electrical power to said plurality of light sources through said
 monitoring unit,
 said monitoring unit comprising a voltage measuring circuit measuring the voltage across said pair of power
 supply lines across said pair of input connectors or across said pair of output connectors,
 said monitoring unit comprising a current measuring circuit measuring the current flowing through said supply
 15 line or said return line in response to the electrical power provided to said plurality of light sources, the current
 flowing between one of said pair of input connectors and one of said pair of output connectors,
 said monitoring unit defining a first time frame and a first point of time during said first time frame, during said
 first time frame a first steady state situation for said plurality of light sources is achieved,
 said monitoring unit measuring at said first point of time a first voltage level by means of said voltage measuring
 20 circuit,
 said monitoring unit measuring at said first point of time a first current level by means of said current measuring
 circuit,
 said monitoring unit determining a first load resistance representing the active load resistance for said plurality
 of light sources being active during said first time frame based on said first voltage level and said first current level,
 25 said monitoring unit defining a second time frame and a second point of time during said second time frame,
 during said second time frame a second steady state situation for said plurality of light sources is achieved,
 said second time frame being defined to take place after said first time frame has expired,
 said monitoring unit measuring at said second point of time a second voltage level by means of said voltage
 measuring circuit,
 30 said monitoring unit measuring at said second point of time a second current level by means of said current
 measuring circuit,
 said monitoring unit determining a second load resistance representing the active load resistance for said
 plurality of light sources being active during said second time frame based on said second voltage level and
 said second current level,
 35 said monitoring unit generating a first alert message provided the difference between said first and second load
 resistance exceeds a first specific threshold constituting a first alert criterion,
 said monitoring unit sending said first alert message through means of said communication unit to said alert
 receiving unit, and
 said alert receiving unit acting or alerting in response to the reception of said first alert message.

26. The lighting monitoring system according to claim 25, said monitoring unit further determining the time difference
 between said first and second points of time, and determining a ratio of the load resistance change over time as the
 difference between said first and second load resistance divided by said determined time difference between said
 first and second points of time, and provided said ratio of said load resistance over time exceeds a second specific
 45 level said monitoring unit generating a second alert message, said communication unit of said monitoring unit sending
 said second alert message to said alert receiving unit, and said alert receiving unit further acting or alerting in
 response to the reception of said second alert message.

27. The lighting monitoring system according to claim 25 or 26, further comprising:

said monitoring unit defining a third time frame and a third point of time during said third time frame, during said
 third time frame a third steady state situation for said plurality of light sources is achieved,
 said monitoring unit measuring at said third point of time a third voltage level by means of said voltage measuring
 circuit,
 55 said monitoring unit measuring at said third point of time a third current level by means of said current measuring
 circuit,
 said monitoring unit determining a first power level representing the power for said plurality of light sources
 being active during said third time frame based on said third voltage level and said third current level,

said monitoring unit defining a fourth time frame and a fourth point of time during said fourth time frame, during said fourth time frame a fourth steady state situation for said plurality of light sources is achieved, said fourth time frame being defined to take place after said third time frame has expired,
 said monitoring unit measuring at said fourth point of time a fourth voltage level by means of said voltage measuring circuit,
 said monitoring unit measuring at said fourth point of time a fourth current level by means of said current measuring circuit,
 said monitoring unit determining a second power level representing the power for said plurality of light sources being active during said fourth time frame based on said fourth voltage level and said fourth current level,
 said monitoring unit generating a third alert message provided a second alert criterion is also met as the difference between said first and second power levels exceeding a third specific threshold.

28. The lighting monitoring system according to claim 27, said monitoring unit further determining a second time difference between said third and fourth points of time, and determining a ratio of the power level change over time as the difference between said first and second power levels divided by said determined time difference between said third and fourth points of time, and provided said ratio of said power levels over time exceeds a third specific level said monitoring unit generating a fourth alert message, said communication unit of said monitoring unit sending said fourth alert message to said alert receiving unit, and said alert receiving unit further acting or alerting in response to the reception of said fourth alert message.

29. The lighting monitoring system according to claims 25 or 26, said first and second alert message each indicates one of following alert situations: one light source being defect or malfunctioning, two light sources being defect or malfunctioning, said plurality of light sources has a defect among some of them or being malfunctioning, said plurality of light sources being defect or being malfunctioning, or said supply line being defective.

30. The lighting monitoring system according to claims 27 and 28, said third and fourth alert message each indicates one of following alert situations: one light source being defect or malfunctioning, two light sources being defect or malfunctioning, said plurality of light sources has a defect among some of them or being malfunctioning, said plurality of light sources being defect or being malfunctioning, said supply line being defective, or current running to ground.

31. The lighting monitoring system according to any of the preceding claims, said first time frame being identical to said third time frame and said second point of time being identical to said fourth point of time.

32. The lighting monitoring system according to any of the preceding claims, said electrical power being an AC power, said first and second voltage level and said first and second current levels being substantially AC levels.

33. The lighting monitoring system according to any of the preceding claims, said plurality of light sources being selected among a incandescent lamp, a bulb, a fluorescent lamp, a neon light, a Hg lamp, a sodium street lamp, a light emitting diode or a light emitting diodes light source and other sources of light suitable for illumination of areas.

34. The lighting monitoring system according to any of the preceding claims, said first time frame representing a period of a learn session.

35. The lighting monitoring system according to any of the preceding claims, said second time frame representing a period of an operating system with the possibility that one or more of said light sources being defective.

36. The lighting monitoring system according to any of the preceding claims, said monitoring unit being a lighting controller, a street light station or a client.

37. The lighting monitoring system according to any of the preceding claims, said alert receiving unit being a server.

38. The lighting monitoring system according to any of the preceding claims, said alert receiving unit being a cellular phone.

39. The lighting monitoring system according to any of the preceding claims, said monitoring unit having two pairs of input connectors and two pairs of output connectors for connecting two pairs of power supply lines to respective two of said voltage and current measurement circuits.

40. The lighting monitoring system according to any of the preceding claims, said monitoring unit having three pairs of input connectors and three pairs of output connectors for interconnecting three pairs of power supply lines to respective three of said voltage and current measurement circuits.

41. The lighting monitoring system according to any of the preceding claims, the communication unit sending said alert messages through said pair of power supply lines.

42. The lighting monitoring system according to any of the preceding claims, the communication unit sending said alert messages through means of a wireless communication, e.g. via GSM.

43. The lighting monitoring system according to any of the preceding claims, said alert messages being textual messages, e.g. in the form of a SMS.

44. The lighting monitoring system according to any of the preceding claims, the communication unit receiving commands through said pair of power supply lines.

45. The lighting monitoring system according to claim 44, said received commands being instructions to switch on or off said plurality of said light sources.

46. A method of controlling a lighting system comprising:

a pair of power supply lines,
a plurality of light sources,
a monitoring unit, and

an alert receiving unit communicating with said monitoring unit, said method comprising the steps of:

providing said pair of power supply lines constituting a supply line and a return line, connecting said supply line and said return line to said plurality of light sources through said monitoring unit,
providing electrical power to said plurality of light sources by means of said pair of power supply lines,
providing a voltage measuring circuit measuring the voltage across said pair of power supply lines in said monitoring unit,
providing a current measuring circuit measuring the current flowing through said supply line or said return line in response to the electrical power provided to said plurality of light sources in said monitoring unit,
defining in said monitoring unit a first time frame and a first point of time during said first time frame and achieving during said first time frame a first steady state situation for said plurality of light sources,
measuring in said monitoring unit at said first point of time a first voltage level by means of said voltage measuring circuit,
measuring in said monitoring unit at said first point of time a first current level by means of said current measuring circuit,
determining in said monitoring unit a first load resistance representing the active load resistance for said plurality of light sources being active during said first time frame based on said measured first voltage level and said measured first current level,
defining in said monitoring unit a second time frame and a second point of time during said second time frame, achieving during said second time frame a second steady state situation for said plurality of light sources, defining said second time frame being to take place after said first time frame has expired,
measuring in said monitoring unit at said second point of time a second voltage level by means of said voltage measuring circuit,
measuring in said monitoring unit at said second point of time a second current level by means of said current measuring circuit,
determining in said monitoring unit a second load resistance representing the active load resistance for said plurality of light sources being active during said second time frame based on said measured second voltage level and said measured second current level,
generating in said monitoring unit a first alert message provided the difference between said first and second load resistance exceeds a first specific threshold constituting a first alert criterion,
providing in said monitoring unit a communication unit, and sending by means of said communication unit said first alert message to said alert receiving unit, and
receiving in said alert receiving unit said first alert message and said alert receiving unit acting or alerting

in response to the reception of said first alert message.

47. The method of controlling a lighting system according to claim 46, said method further comprising determining by said monitoring unit the time difference between said first and second points of time, and determining a ratio of the load resistance change over time as the difference between said first and second load resistance divided by said determined time difference between said first and second points of time, and provided said ratio of said load resistance over time exceeds a second specific level generating by said monitoring unit a second alert message, sending by said communication unit said second alert message to said alert receiving unit, and said alert receiving unit further acting or alerting in response to said received second alert message.

48. The method of controlling a lighting system according to claim 46 or 47, further comprising:

defining in said monitoring unit a third time frame and a third point of time during said third time frame, during said third time frame a third steady state situation for said plurality of light sources is achieved, measuring in said monitoring unit at said third point of time a third voltage level by means of said voltage measuring circuit, measuring in said monitoring unit at said third point of time a third current level by means of said current measuring circuit, determining in said monitoring unit a first power level representing the power for said plurality of light sources being active during said third time frame based on said third voltage level and said third current level, defining in said monitoring unit a fourth time frame and a fourth point of time during said fourth time frame, during said fourth time frame a fourth steady state situation for said plurality of light sources is achieved, said fourth time frame being defined to take place after said third time frame has expired, measuring in said monitoring unit at said fourth point of time a fourth voltage level by means of said voltage measuring circuit, measuring in said monitoring unit at said fourth point of time a fourth current level by means of said current measuring circuit, determining in said monitoring unit a second power level representing the power for said plurality of light sources being active during said fourth time frame based on said fourth voltage level and said fourth current level, generating in said monitoring unit a third alert message provided a second alert criterion is also met as the difference between said first and second power levels exceeding a third specific threshold.

49. The method of controlling a lighting system according to claim 48, said monitoring unit further determining a second time difference between said third and fourth points of time, and determining a ratio of the power level change over time as the difference between said first and second power levels divided by said determined time difference between said third and fourth points of time, and provided said ratio of said power levels over time exceeds a third specific level said monitoring unit generating a fourth alert message, said communication unit of said monitoring unit sending said fourth alert message to said alert receiving unit, and said alert receiving unit further acting or alerting in response to the reception of said fourth alert message.

50. The method of controlling a lighting system according to claims 46 or 47, said first and second alert message each indicates one of following alert situations: one light source being defect or malfunctioning, two light sources being defect or malfunctioning, said plurality of light sources has a defect among some of them or being malfunctioning, said plurality of light sources being defect or being malfunctioning, or said supply line being defective.

51. The method of controlling a lighting system according to claim 48 and 49, said third and fourth alert message each indicates one of following alert situations: one light source being defect or malfunctioning, two light sources being defect or malfunctioning, said plurality of light sources has a defect among some of them or being malfunctioning, said plurality of light sources being defect or being malfunctioning, said supply line being defective, or current running to ground.

52. The method of controlling a lighting system according to any of the preceding claims, said first time frame being identical to said third time frame and said second point of time being identical to said fourth point of time.

52. The method of controlling a lighting system according to claims 46 - 51, said electrical power being an AC power, said measured first and second voltage level and said measured first and second current levels being substantially AC levels.

53. The method of controlling a lighting system according to claims 46 - 52, said plurality of light sources being selected among a incandescent lamp, a bulb, a fluorescent lamp, a neon light, a Hg lamp, a sodium street lamp, a light emitting diode or a light emitting diodes light source and other sources of light suitable for illumination of areas.

54. The method of controlling a lighting system according to claims 46 - 53, said first time frame representing a period of a learn session.

55. The method of controlling a lighting system according to claims 46 - 54, said second time frame representing a period of an operating system with the possibility that one or more of said light sources being defective.

56. The method of controlling a lighting system according to claims 46 - 55, said monitoring unit being a lighting controller, a street light station or a client.

57. The method of controlling a lighting system according to claims 46 - 56, said alert receiving unit being a server.

58. The method of controlling a lighting system according to claims 46 - 57, said alert receiving unit being a cellular phone.

59. The method of controlling a lighting system according to claims 46 - 58, applying two pairs of power supply lines and respective two of said voltage and current measurement circuits.

60. The method of controlling a lighting system according to claims 46 - 59, applying three pairs of power supply lines and respective three of said voltage and current measurement circuits.

61. The method of controlling a lighting system according to claims 46 - 60, applying a plurality of said monitoring unit.

62. The method of controlling a lighting system according to claims 46 - 61, sending by said communication unit said alert messages through said pair of power supply lines.

63. The method of controlling a lighting system according to claims 46 - 62, sending by said communication unit said alert messages through means of a wireless communication, e.g. via GSM.

64. The method of controlling a lighting system according to claims 46 - 63, said alert messages being textual messages, e.g. in the form of a SMS.

66. The method of controlling a lighting system according to claims 46 - 64, receiving by said communication unit commands through said pair of power supply lines.

67. The method of controlling a lighting system according to claim 66, said received commands being instructions to switch on or off said plurality of said light sources.

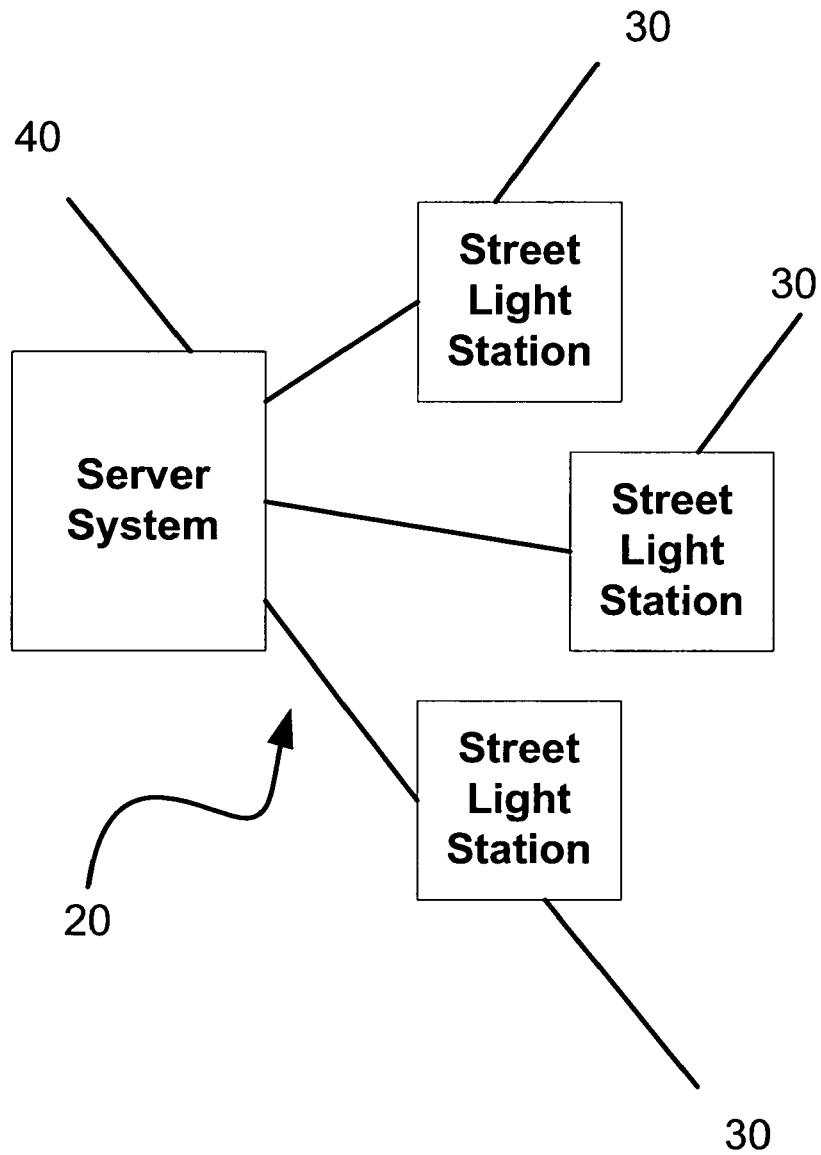


Fig. 1

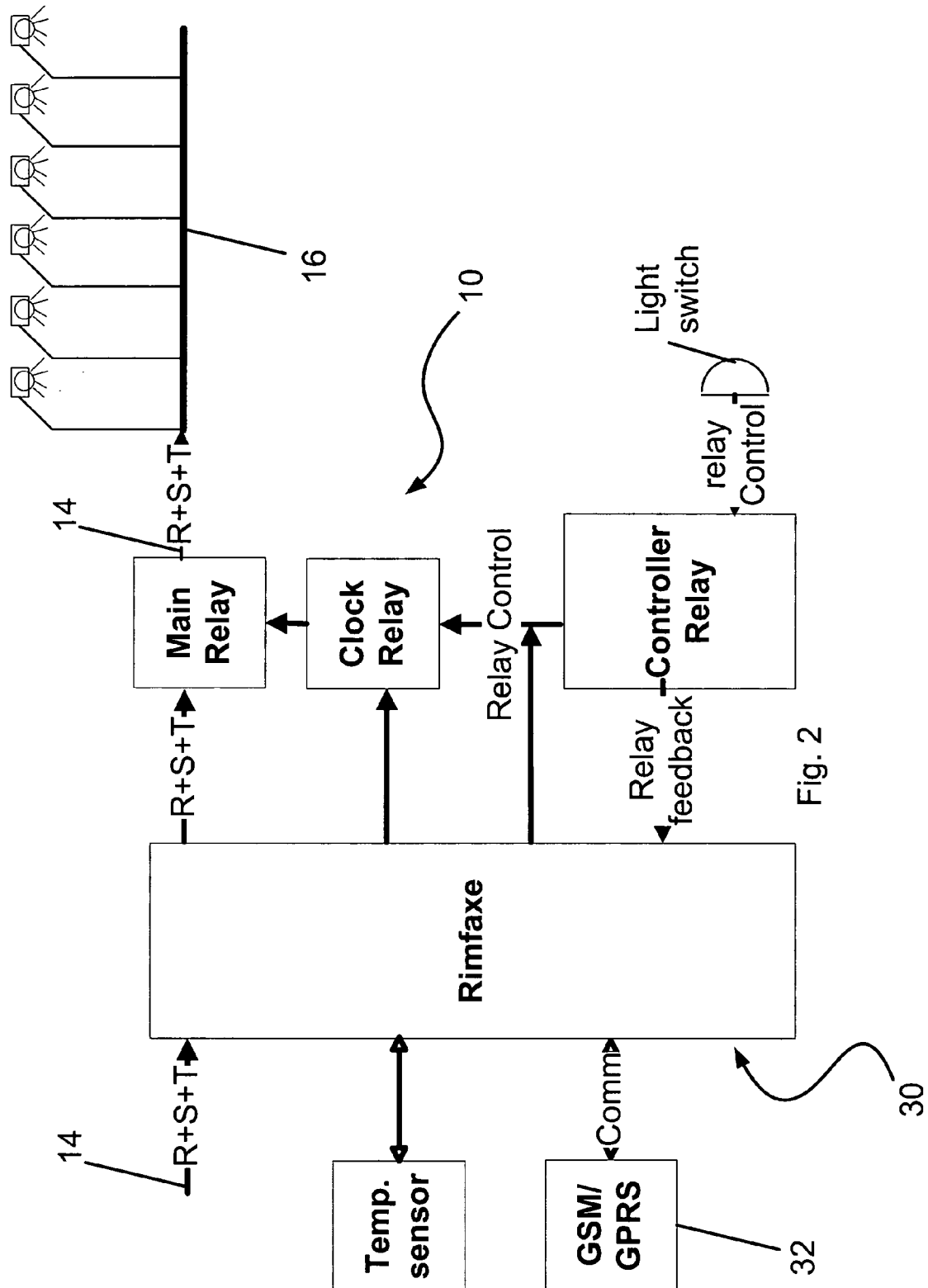


Fig. 2

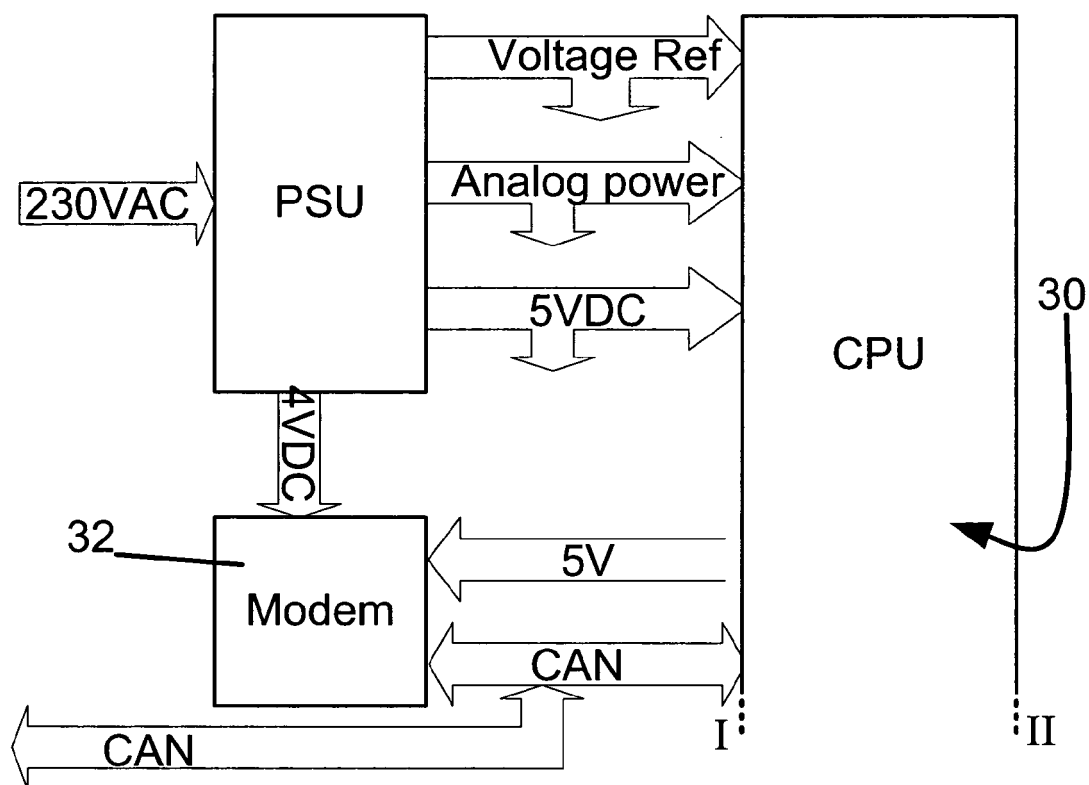


Fig. 3a

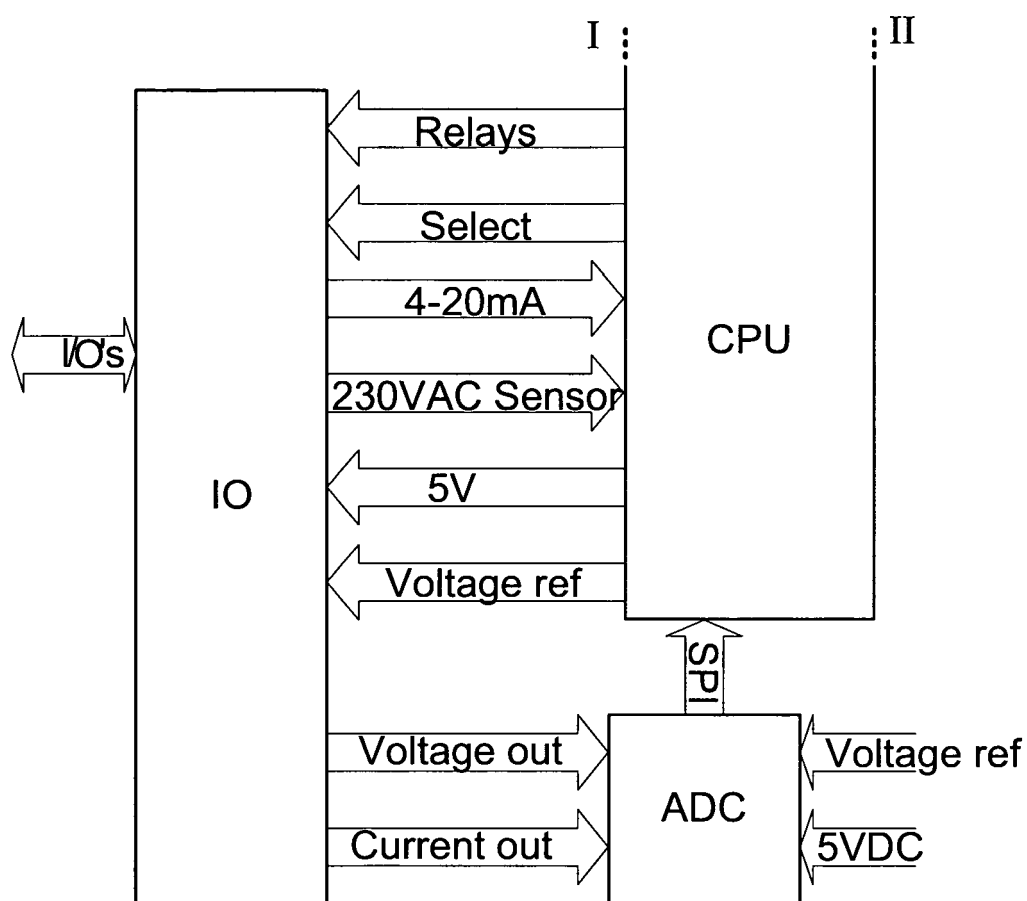


Fig. 3b

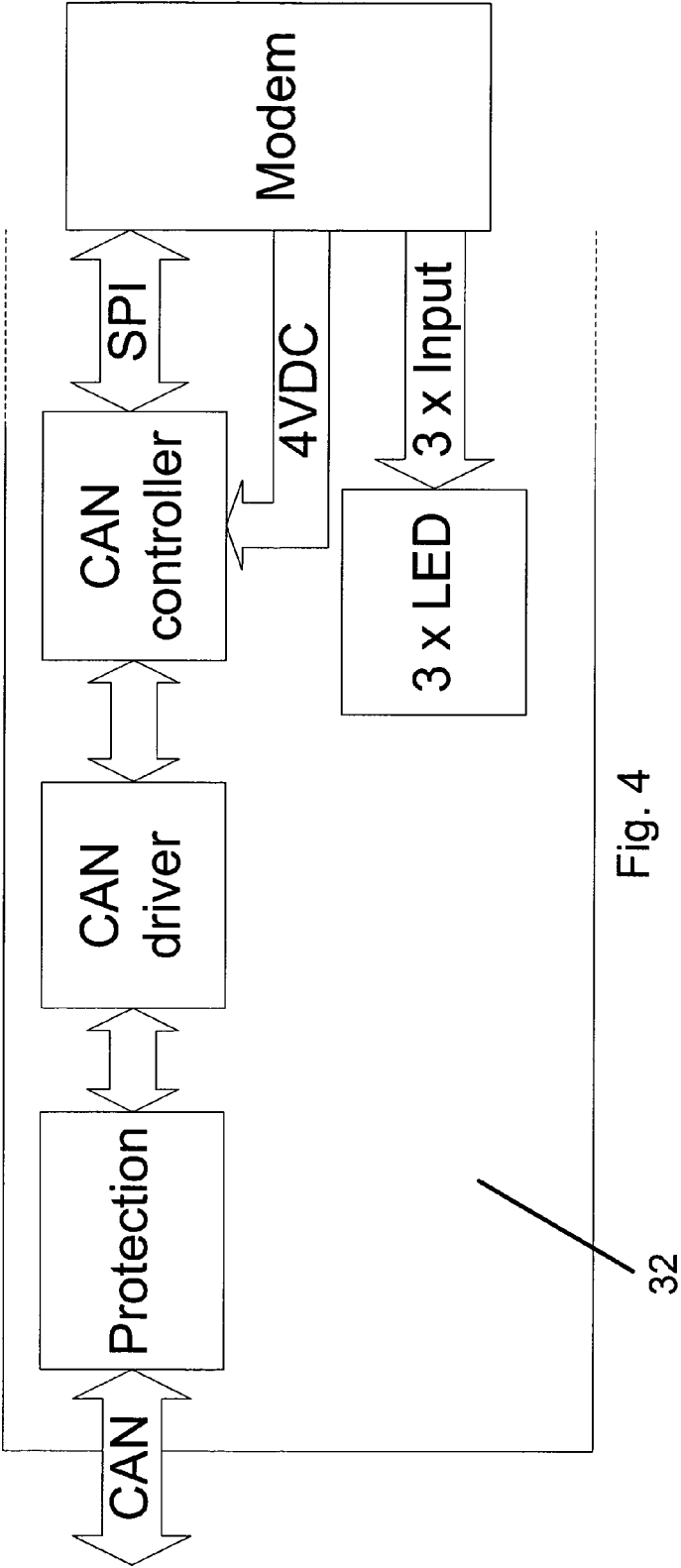


Fig. 4

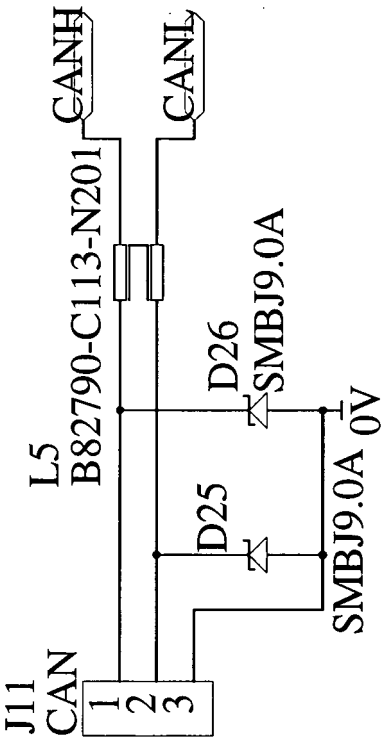
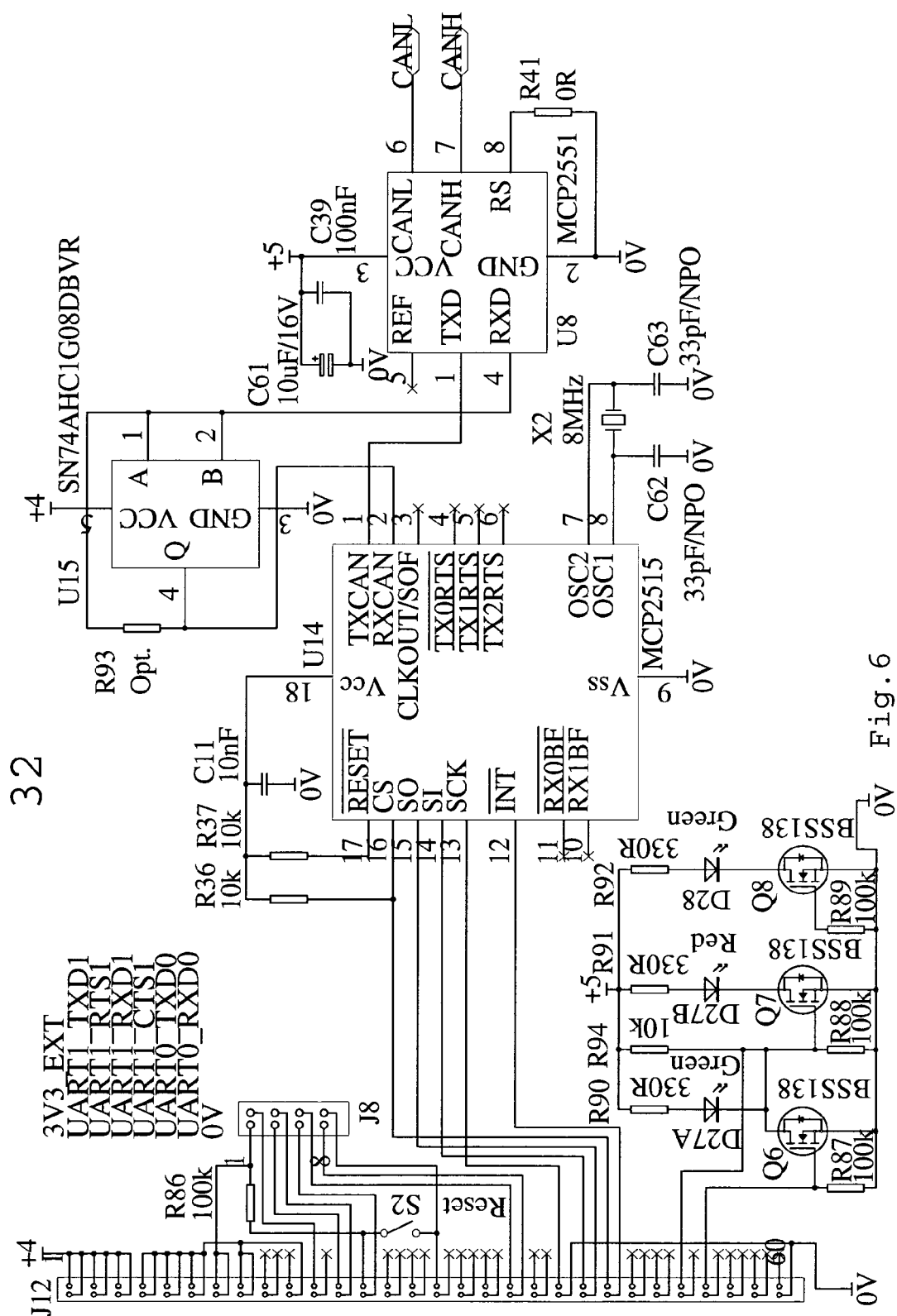


Fig. 5



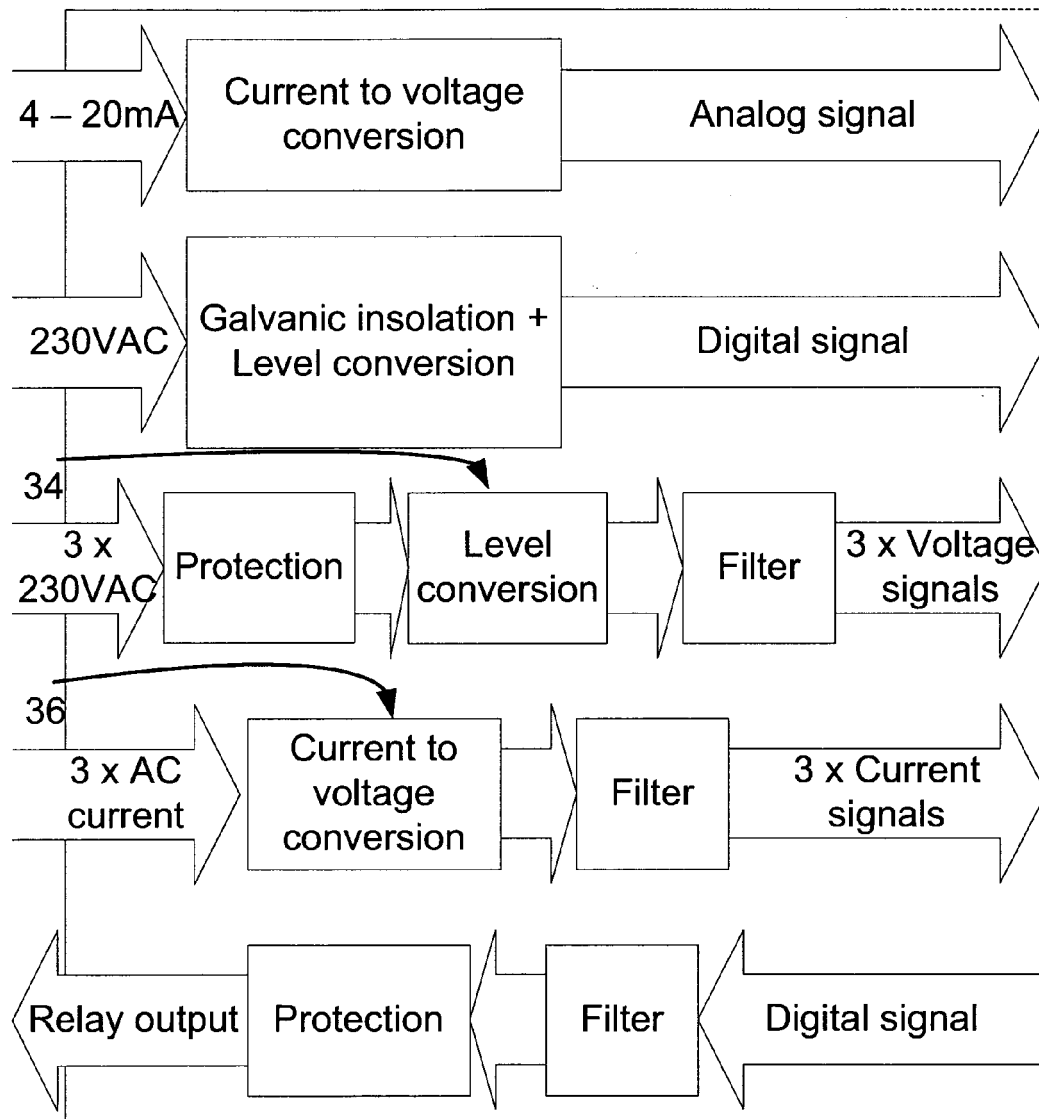


Fig. 7

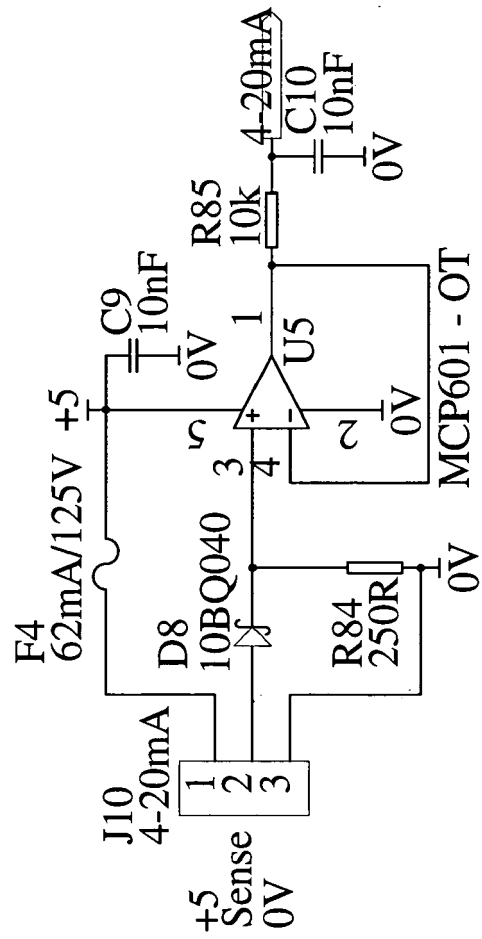


Fig. 8

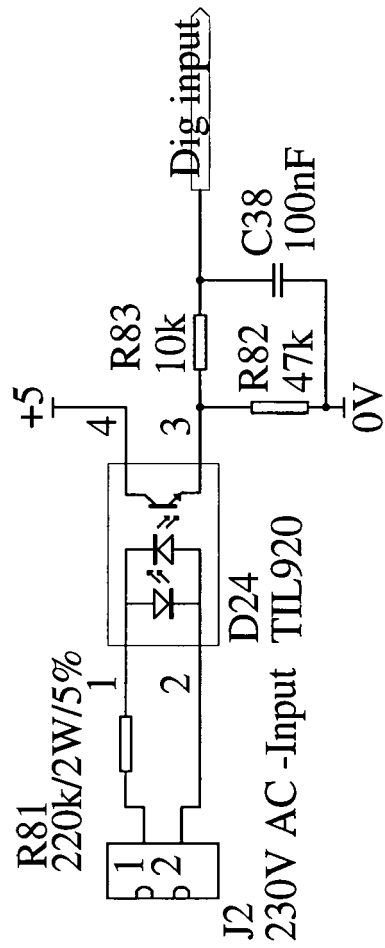


Fig. 9

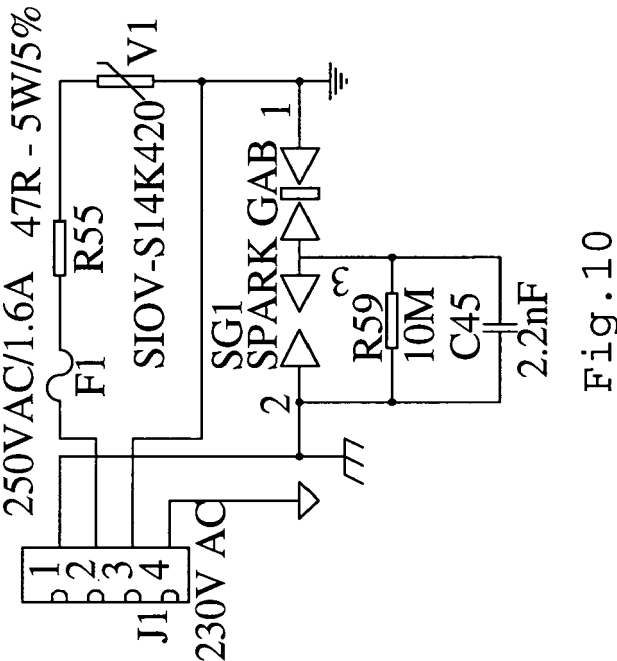
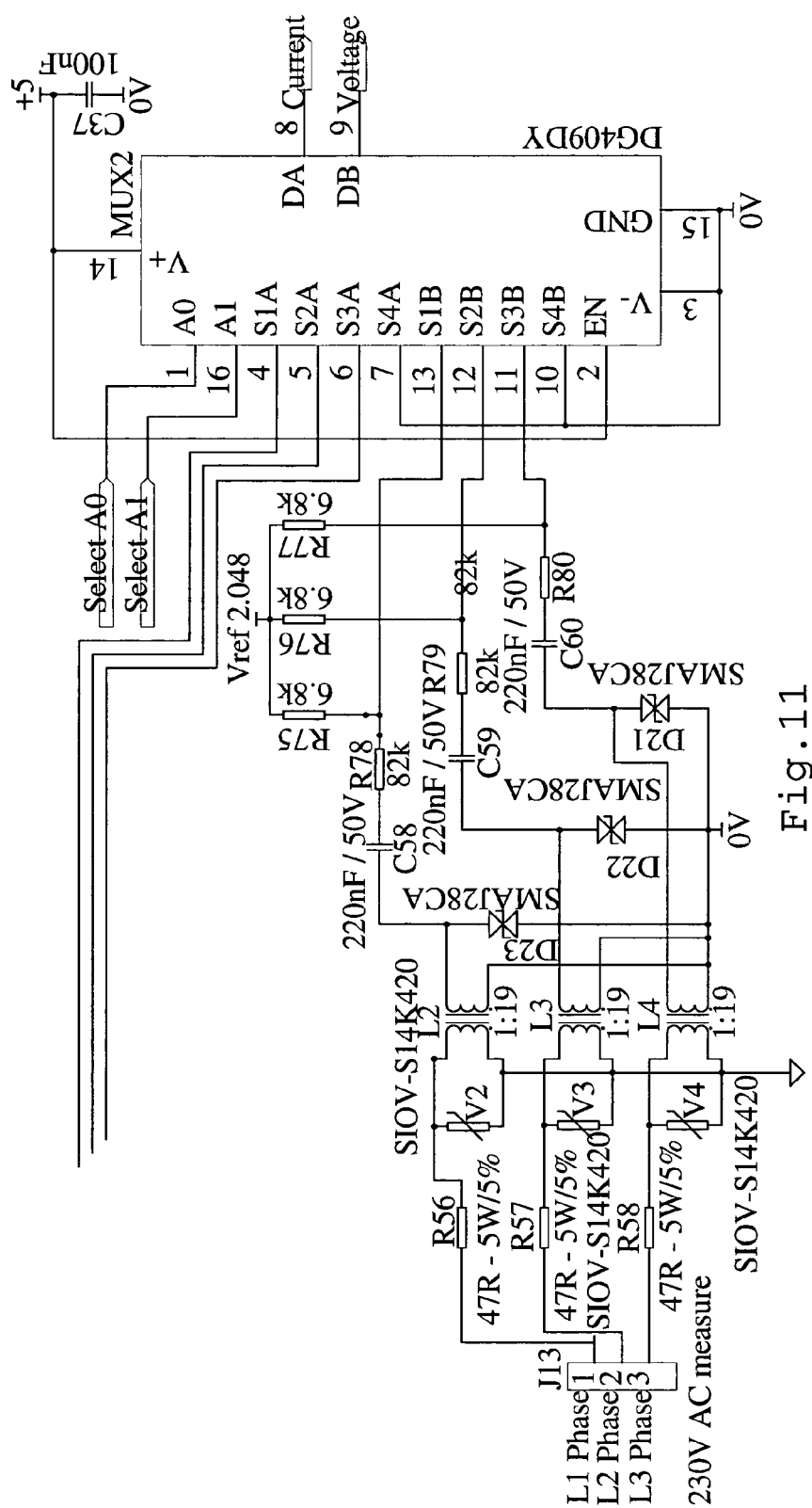


Fig. 10



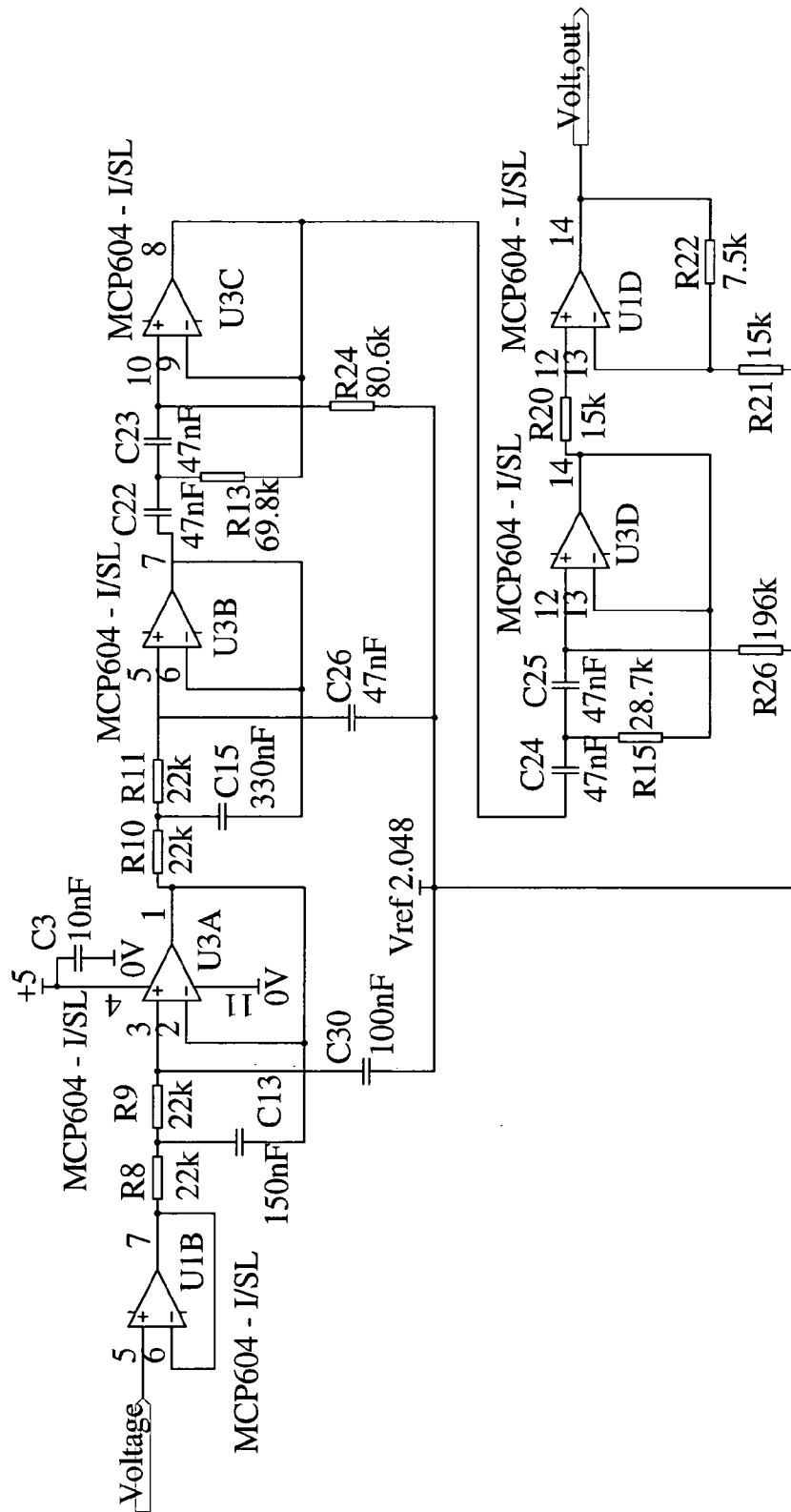
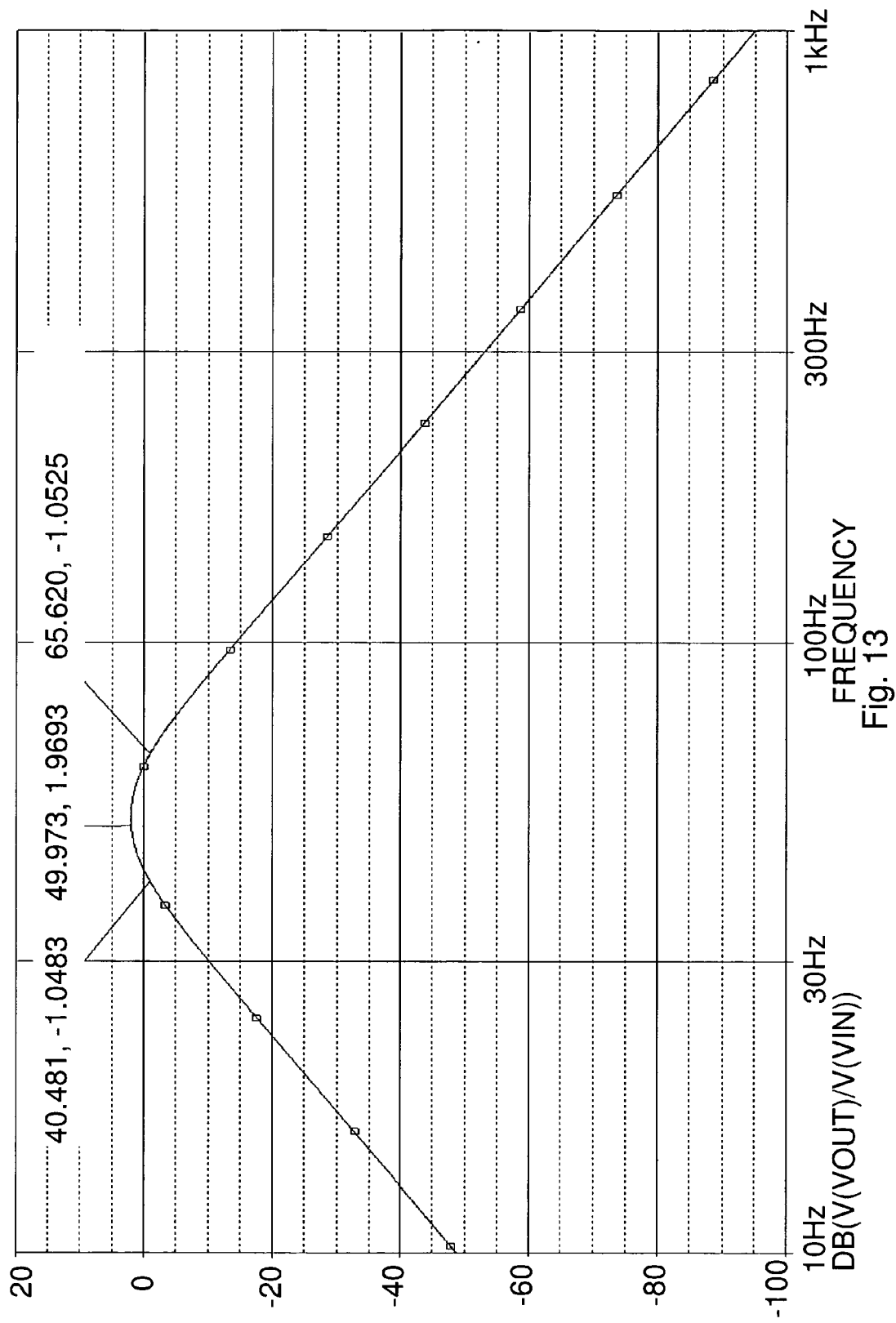


Fig.12



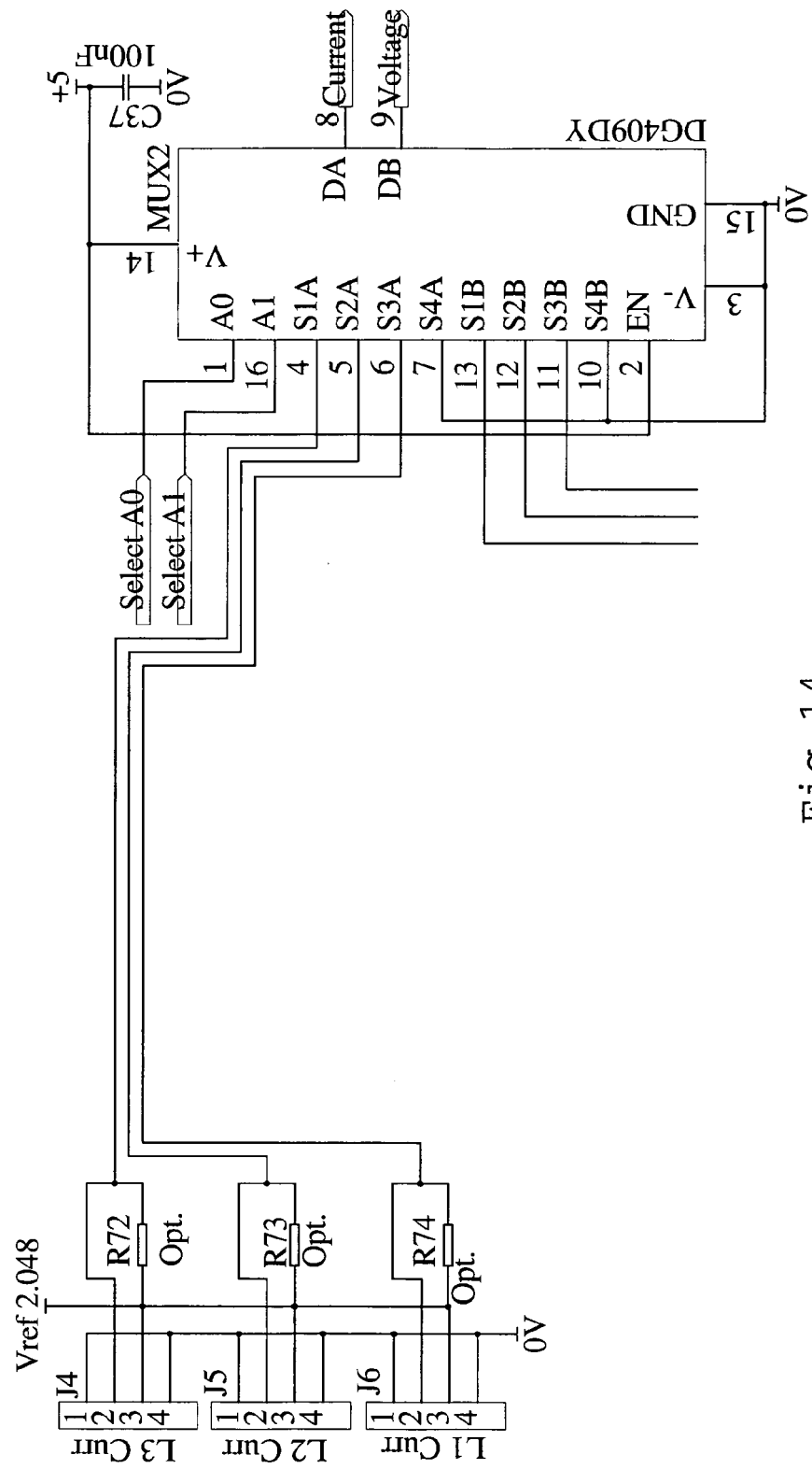


Fig. 14

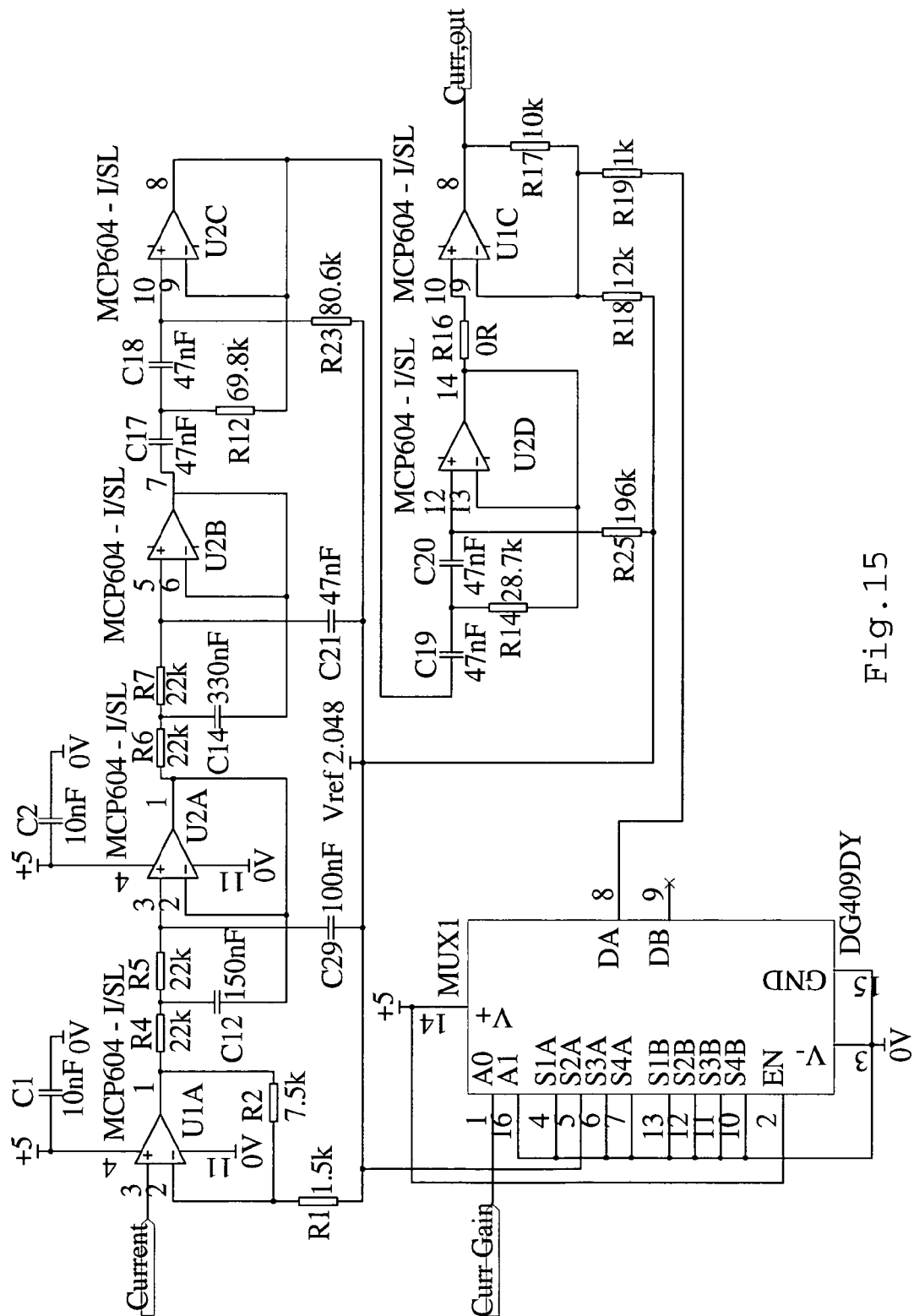
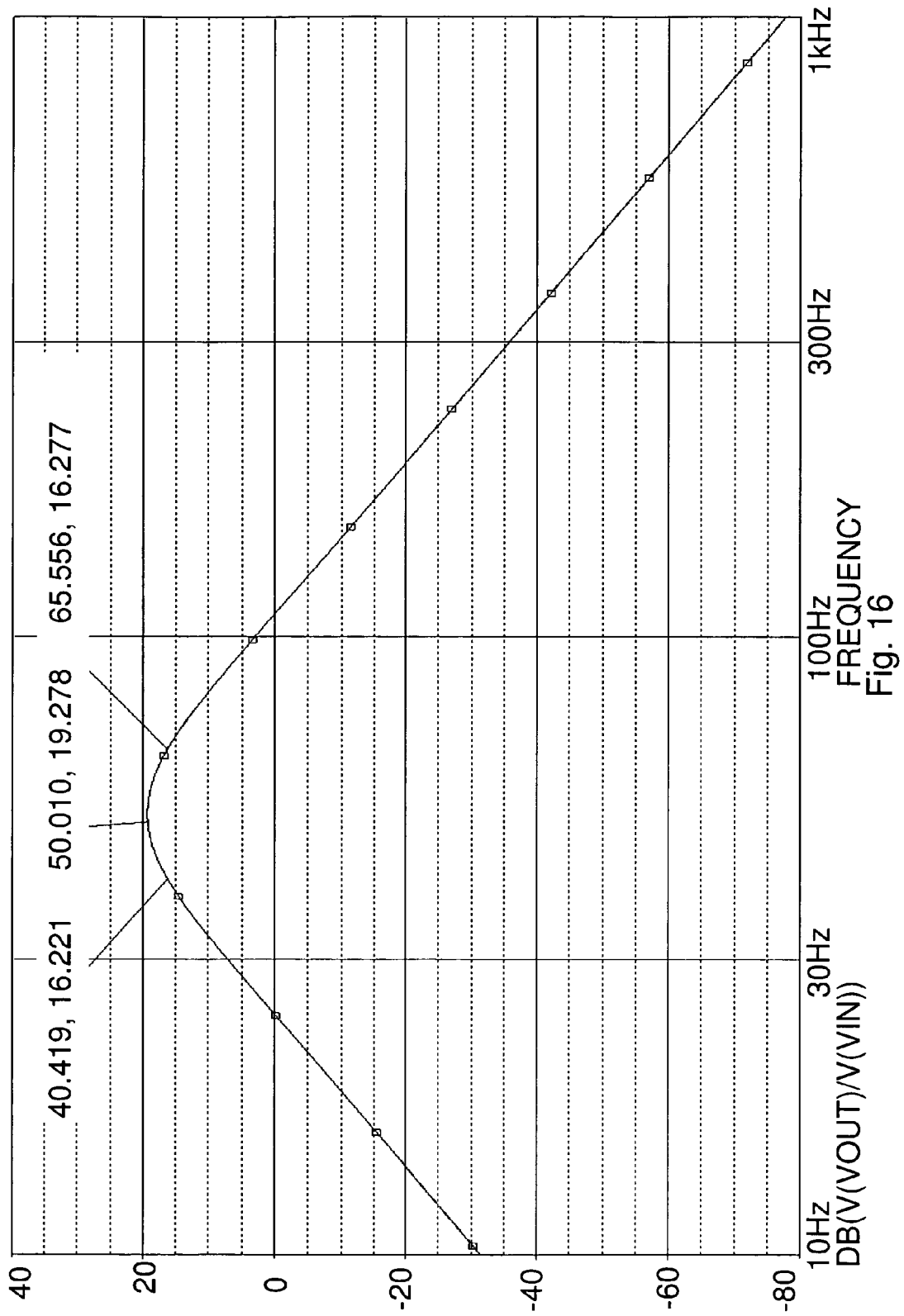


Fig.15



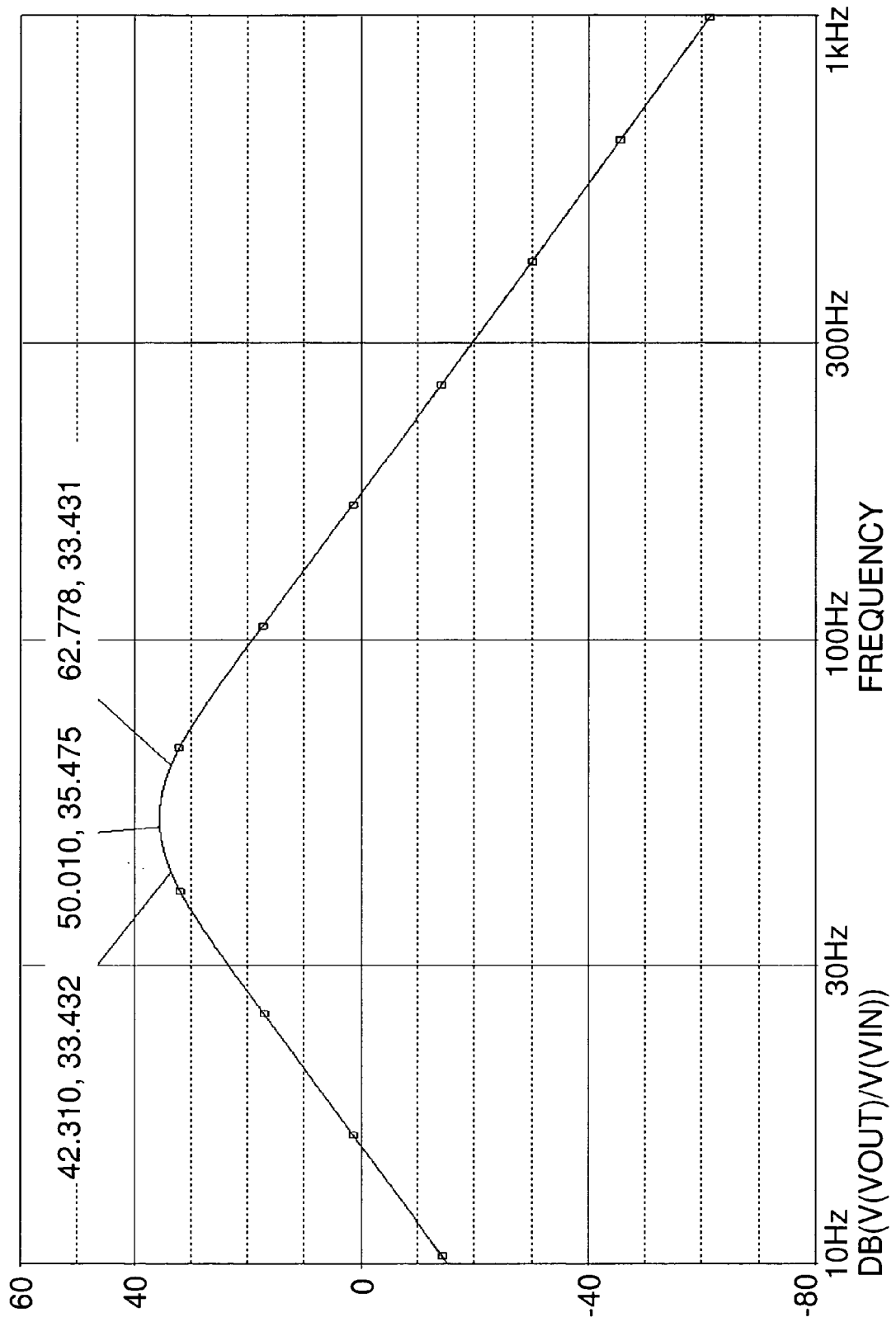
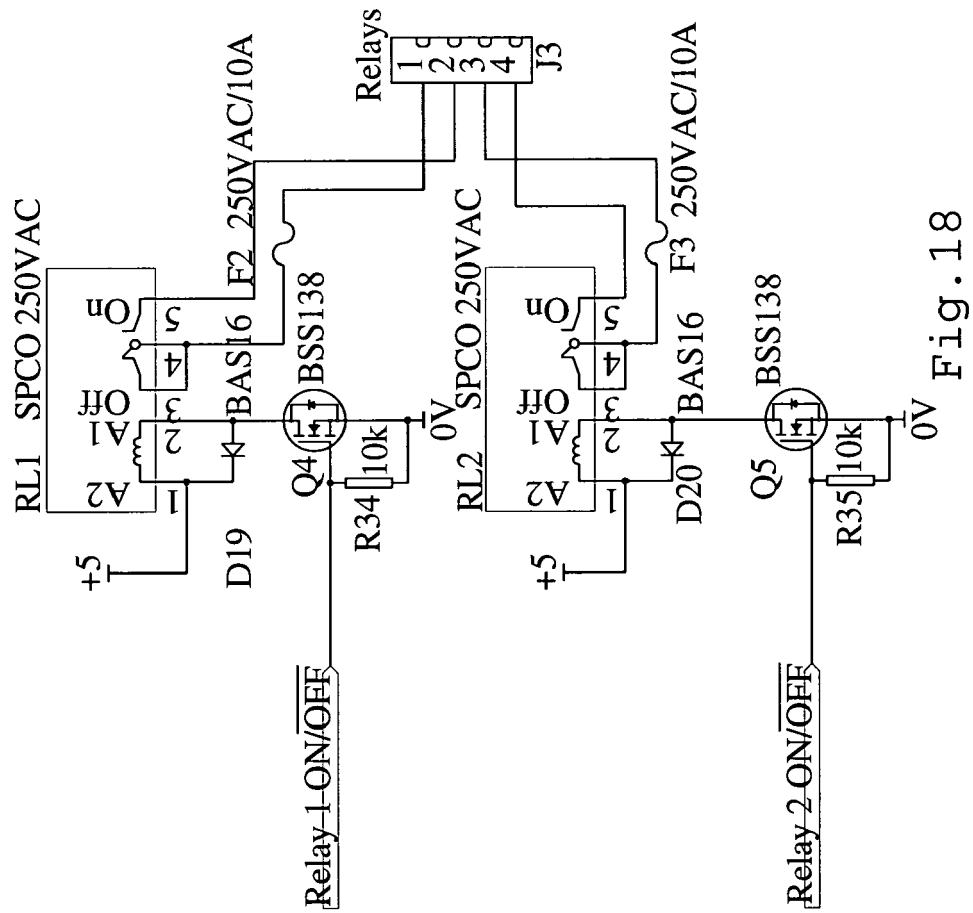


Fig. 17



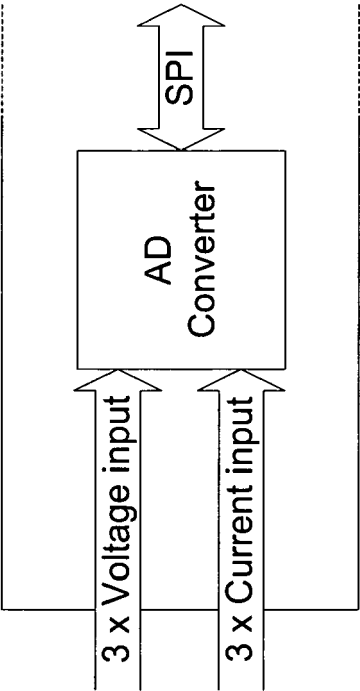


Fig. 19

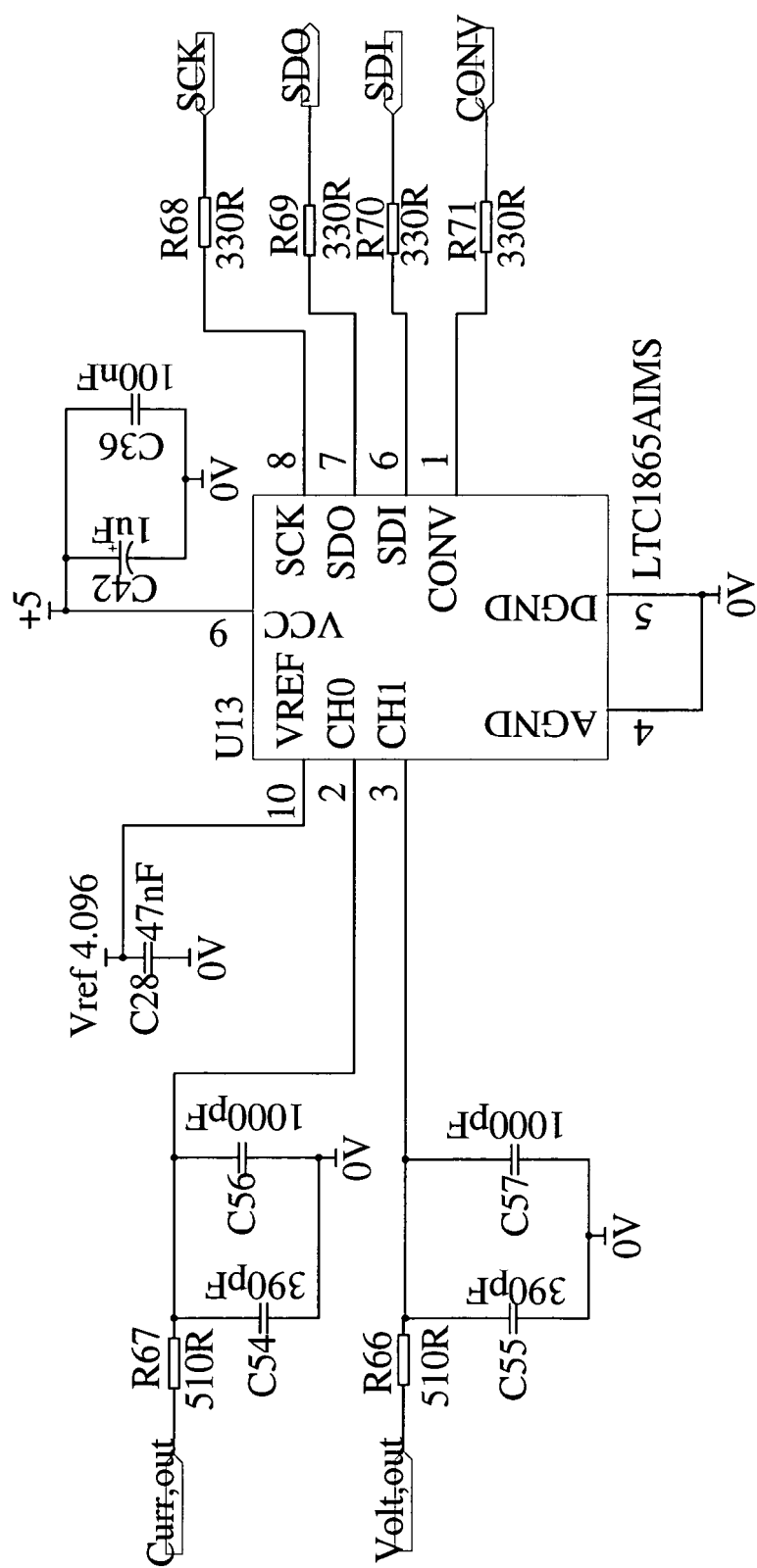


Fig. 20

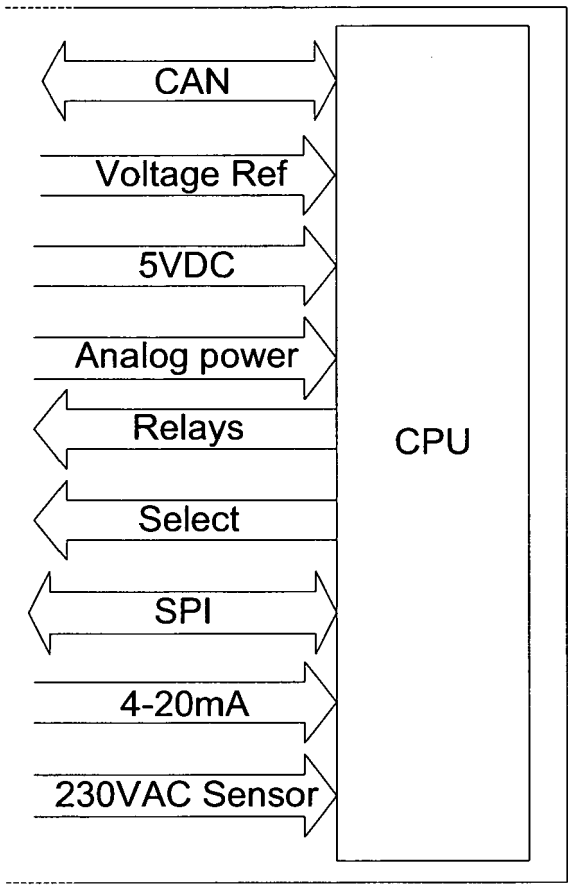


Fig. 21

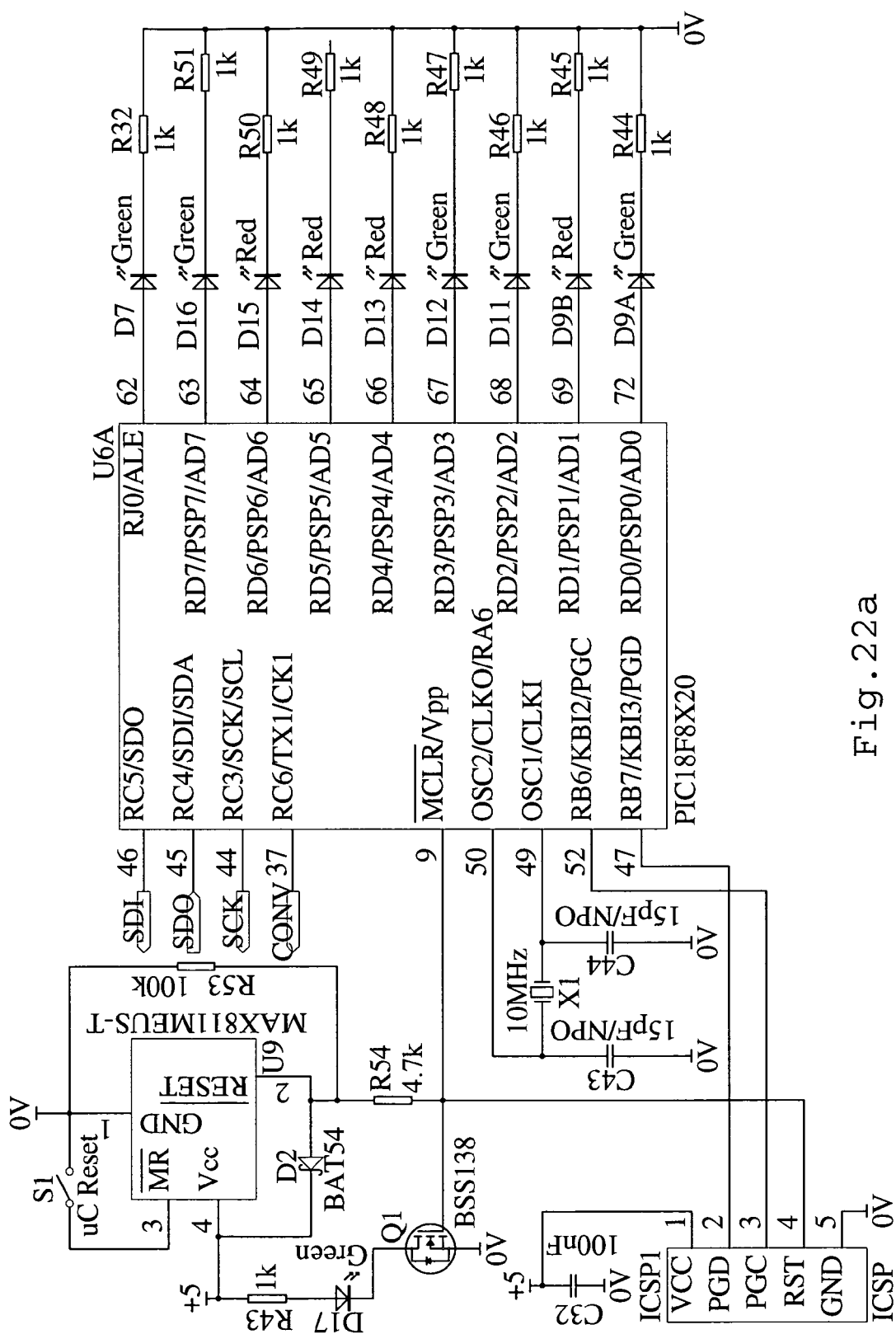


Fig. 22a

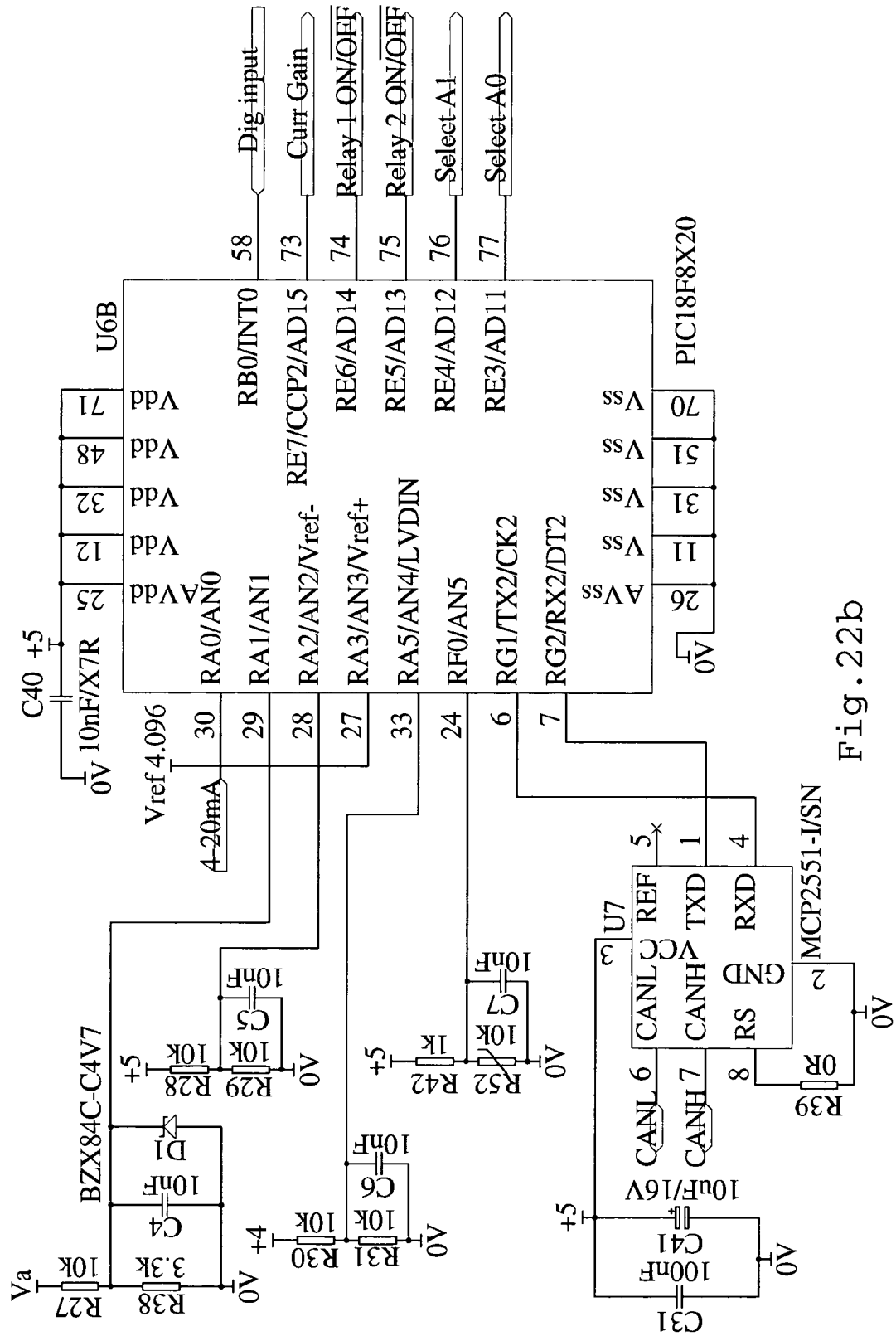


Fig. 22b

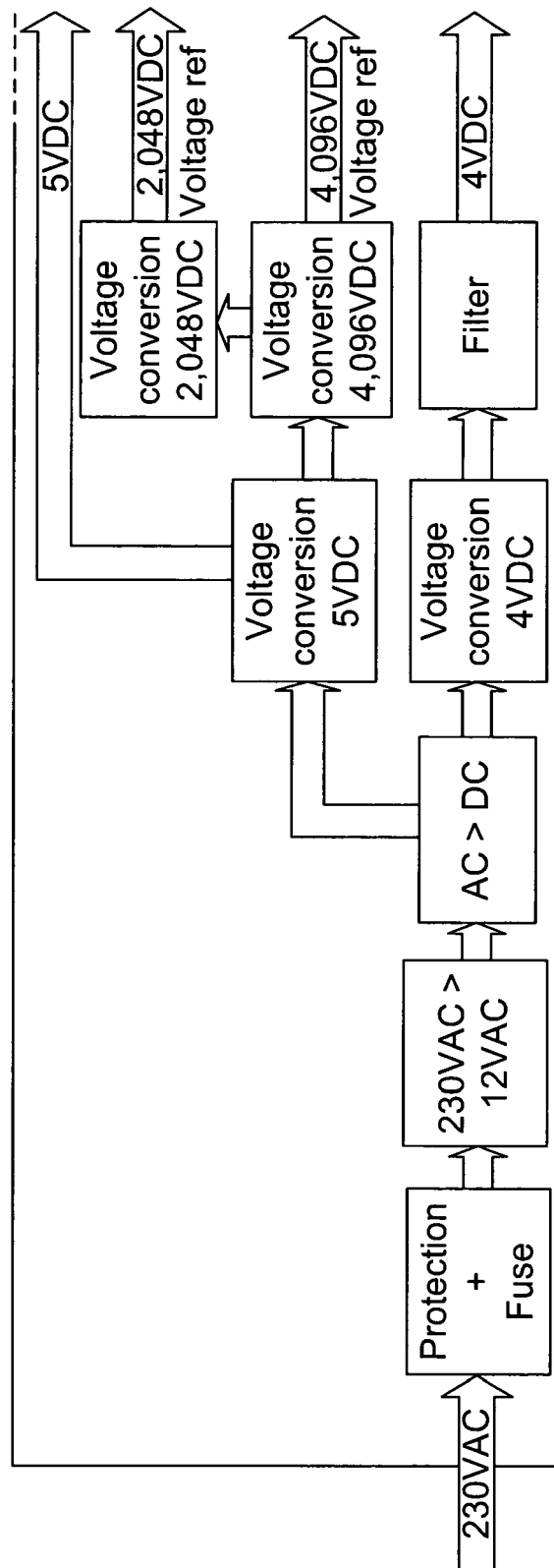


Fig. 23

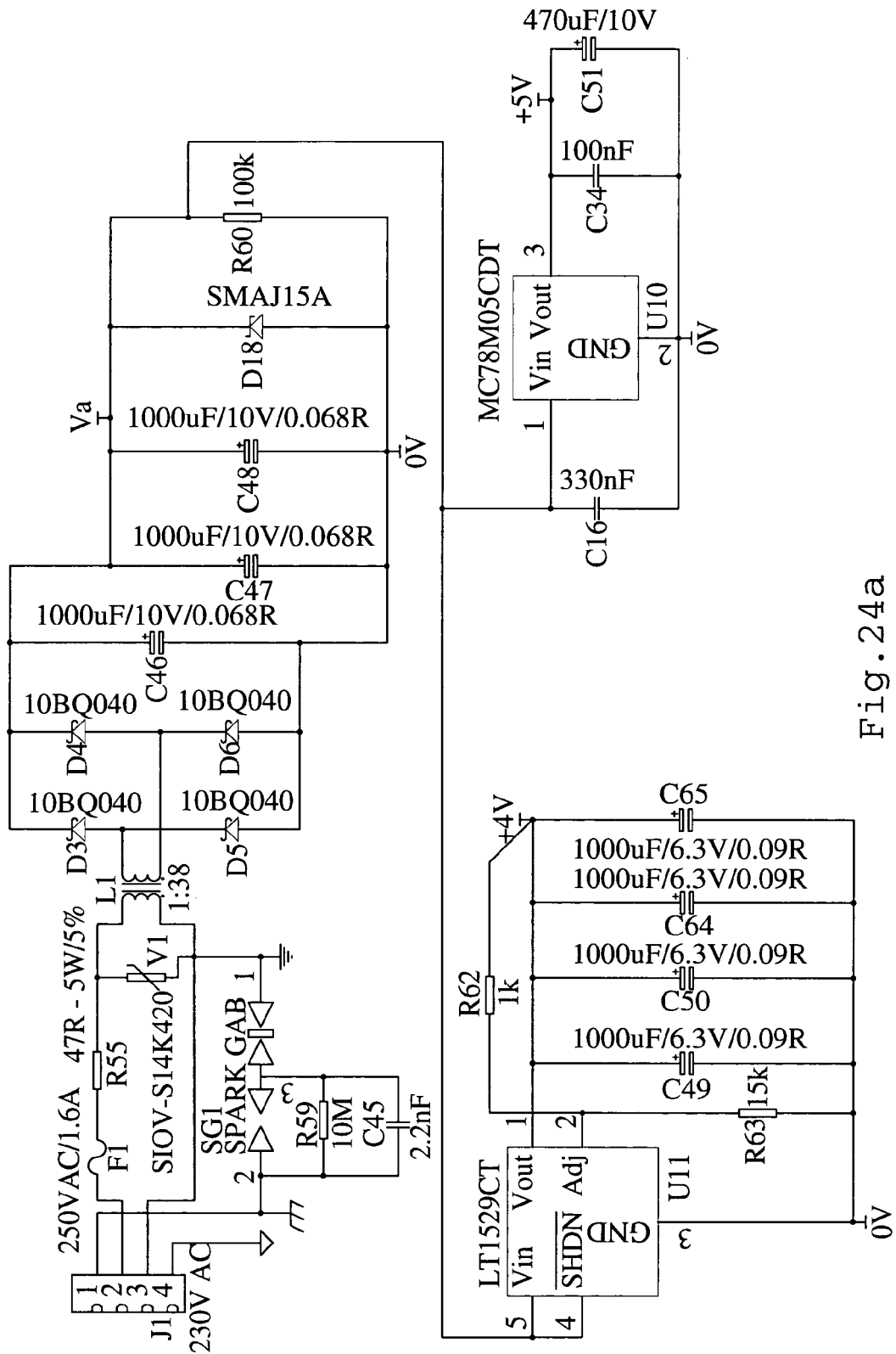
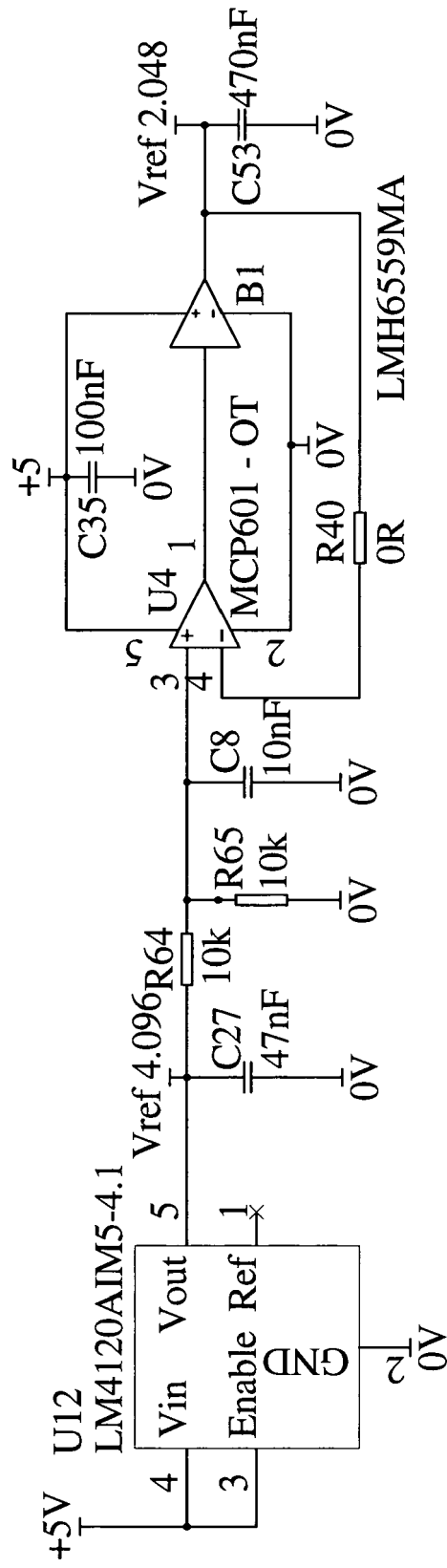


Fig. 24a





European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 06 38 8040

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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X	US 2004/204917 A1 (WILLIAMS LARRY [US] ET AL) 14 October 2004 (2004-10-14) * abstract * * paragraphs [02.5], [0001] - [0023], [0025], [0028], [0031], [0047] - [0051], [0069], [0070], [0075], [0080], [0089], [0095], [0106] * * paragraphs [0111], [0112] * * figures 2-7 *	1-67	TECHNICAL FIELDS SEARCHED (IPC) H05B
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The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 8 November 2006	Examiner Hagan, Colm
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

3
EPO FORM 1503 03.82 (P04C01)



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 06 38 8040

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	US 5 479 159 A (KELLY WILLIAM [GB] ET AL) 26 December 1995 (1995-12-26) * the whole document * -----	1,12,18, 19,25, 36,41, 42,46, 57,63,64	
			TECHNICAL FIELDS SEARCHED (IPC)
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 8 November 2006	Examiner Hagan, Colm
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

3

EPO FORM 1503 03/82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 06 38 8040

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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08-11-2006

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