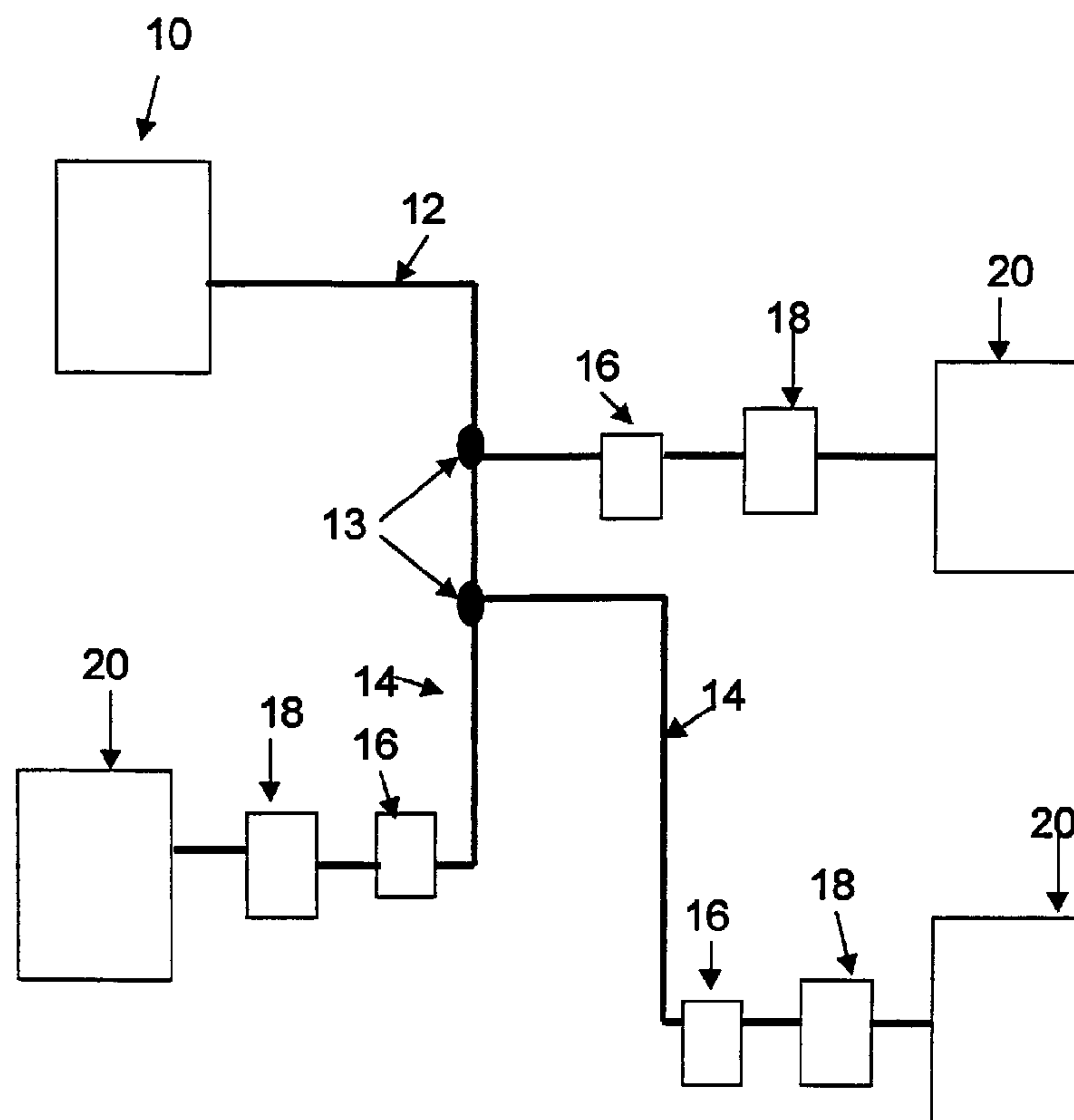




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A selective optical actuation system for a plurality of electrical devices (20) comprises a variable pulse frequency pulsed light source (10) and an optical fibre network (12, 13, 14) distributing the light pulses to an actuation gateway for each device, comprising a photovoltaic converter (16) whose correspondingly pulsed electrical output is applied to a ferroelectric transformer (18). Only if the pulse frequency is within the resonant band for a given transformer will the voltage be raised above a threshold value required to actuate that device. Choice of light pulse frequency thereby determines the device(s) to be actuated.



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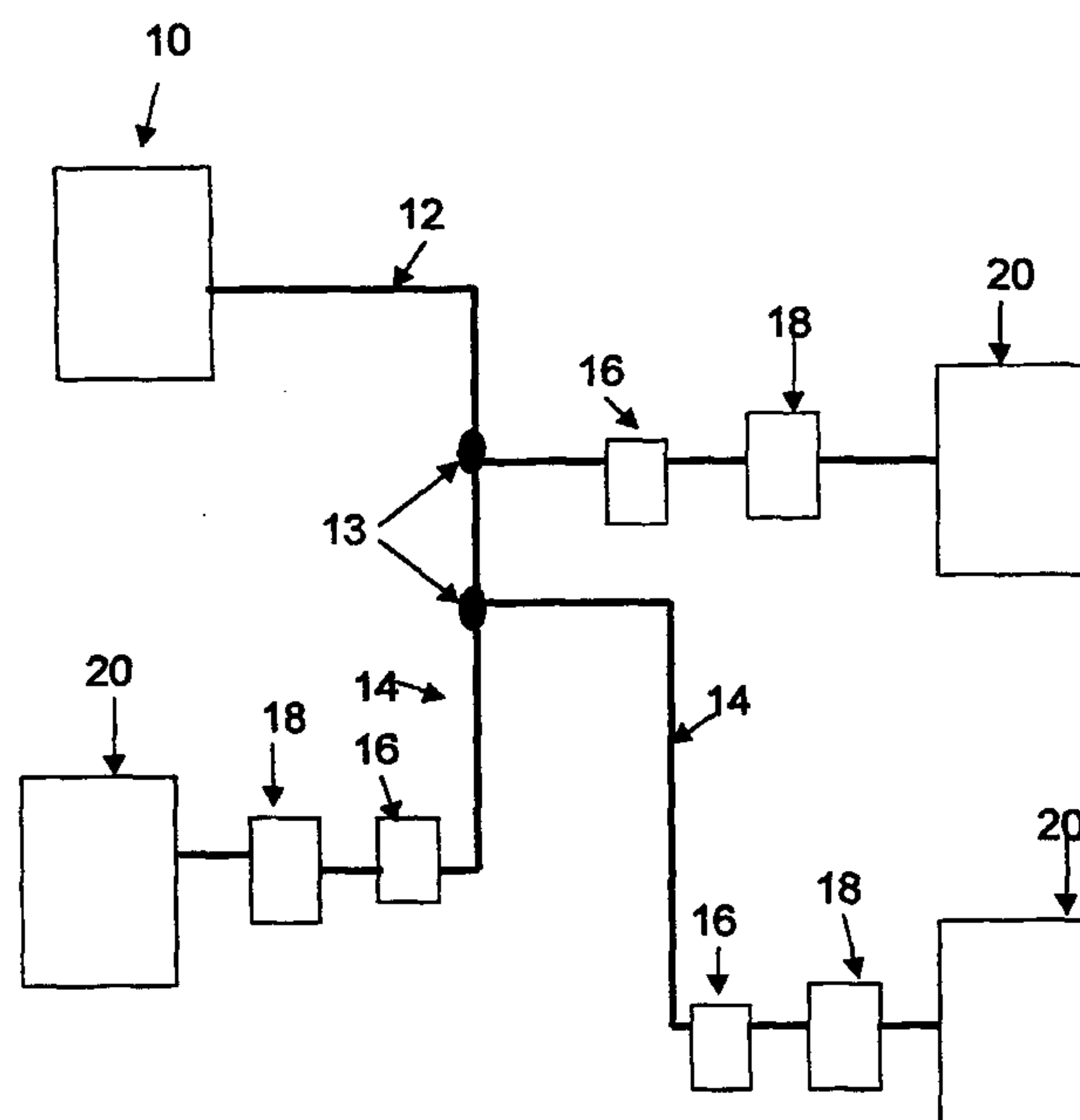
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(57) Abstract: A selective optical actuation system for a plurality of electrical devices (20) comprises a variable pulse frequency pulsed light source (10) and an optical fibre network (12, 13, 14) distributing the light pulses to an actuation gateway for each device, comprising a photovoltaic converter (16) whose correspondingly pulsed electrical output is applied to a ferroelectric transformer (18). Only if the pulse frequency is within the resonant band for a given transformer will the voltage be raised above a threshold value required to actuate that device. Choice of light pulse frequency thereby determines the device(s) to be actuated.



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OPTO-ELECTRICAL ACTUATION SYSTEM AND METHOD

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This invention relates to an opto-electrical actuation system and method.

Specifically, it relates to a system and method in which light is used to selectively actuate and control a plurality of electrical devices. References to

10 actuation herein are intended to include controlling and/or supplying operating power to the devices.

The system and method in accordance with the invention are intended to supply electrical power at an effective actuating voltage selectively to one or more of a

15 plurality of devices. The power may be used to switch the devices, or to supply running power to them, according to the demands of the devices and the availability of other electrical power sources.

The invention is particularly suitable for downhole use at oil and gas exploration

20 and production sites, in environments where temperatures can reach up to 300°C.

In accordance with one aspect of the invention, there is provided an actuation system for a plurality of electrically actuated devices, comprising a pulsed light

25 source of variable pulse frequency directed to a plurality of actuation gateways each adapted to supply an electrical actuation voltage above a threshold value to an associated device when illuminated by light pulsed at a trigger frequency for that device.

30 Each said gateway is suitably provided with an optical sensor such as photovoltaic converter means for converting pulsed incident light to a low voltage pulsed electrical current in the order of 3 to 5 volts, of corresponding

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frequency. Frequency sensitive ferroelectric DC-DC converter means may be provided for transforming the low voltage of the pulsed current to a higher voltage above the threshold value, typically 600-800 volts, for the associated device when the current frequency is at the trigger frequency. The DC-DC
5 converter means may be a ferroelectric transformer and the trigger frequency is then suitably a resonant frequency of the transformer selectably adjusted by variation in the component geometry. In some embodiments of the invention output voltages for the converter as low as 100 volts may be adequate to activate the associated device.

10

The trigger frequency may be in a band of not more than about 3kHz within the range 10kHz to 40kHz. The trigger frequencies of ferroelectric transformers to be operated independently are suitably separated to compensate for environmental effects, such as pressure and temperature, by a frequency
15 difference of about 3kHz or more.

20

The system desirably includes optical pathway means for directing light from the light source to the plurality of actuation gateways. The optical pathway means may comprise a branched network of optical fibres connected by optical
couplers. The coupler splitting ratios may be selected to provide optimum power to the devices to be actuated. Such ratios will depend upon the number of devices on the network and the available light source power. Typical optical coupling splitting ratios are in the order of 5:1 and are so selected as to provide optical power in the order of 40 to 50mW to the photovoltaic converter. The
25 optical couplers should also be selected from materials suitable for the elevated thermal conditions of the surrounding environment. A sufficient optical power budget should be provided to accommodate changes in splitting ratio and photovoltaic conversion efficiency under the changing environmental conditions.

30

The invention further provides a method of actuating a plurality of electrical devices which comprises providing an actuating system for the said devices as

set out above, and selectively actuating a device by illuminating the actuation gateways with light pulsed at a frequency that corresponds to the trigger frequency of the selected device.

- 5 One embodiment of the invention is illustrated by way of example in the accompanying drawing, which illustrates diagrammatically an actuation and control system in accordance with the invention.

10 As shown in the drawing, a single light source 10 is connected to an optical fibre backbone 12, along which a series of optical couplers 13 make optical connection between the backbone fibre and branch fibres 14. Light pulsed from the light source is conducted by the optical network (12, 13, 14) throughout the system.

- 15 Branch fibres 14 deliver light to actuation gateways each associated with an electrical device 20. Each gateway comprises a photovoltaic converter 16 and a ferroelectric transformer 18. The devices 20 could be, for example, pilot valves, solenoid valves, motors and electrically powered instrumentation.

- 20 Each ferroelectric transformer 18 has a natural resonant frequency range of, typically, 3kHz or less. When provided with pulsed electrical current at a resonant frequency, the transformer increases the voltage to a value that is above a threshold value required to actuate the electrical device 20. If pulsed current is supplied to the transformer 18 at a frequency outside its resonant
25 trigger frequency range, the voltage increase is low, and does not reach the threshold value.

- The photovoltaic converter 16 at each gateway responds to incident light transmitted over the optical network from light source 10 and converts it into
30 electrical current of a corresponding pulse frequency. Accordingly, the pulse frequency of the light emitted by the light source determines the frequency of

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the electrical current applied to all the transformers 18 in the system at the same time.

In accordance with the invention, electrical devices 20 that are intended to
5 operate simultaneously are associated with actuation gateways in which the
transformers 18 have similar resonant trigger frequencies, and electrical devices
that are intended to operate independently are provided with actuation
gateways in which the transformers have distinctly different resonant
frequencies. In this way, the devices to be actuated can be selected by
10 appropriate selection of the pulse frequency at the light source.

Typical operating frequencies of a series of devices in accordance with the
invention are 13-16kHz for the first device, 19-22kHz for the second device, and
so on, with each device having a 3kHz trigger frequency band with a 3kHz
15 separation between bands.

As an example, the output voltage of the photovoltaic converters 16 may be
from 3 to 5 volts. If, and only if, the light pulse frequency is such as to produce
an electrical frequency in the resonant trigger band of the transformer 18, the
20 transformer output may be 600-800V, sufficient to actuate the associated
electrical device.

CLAIMS:

1. An actuation system for a plurality of electrically actuated devices, comprising a pulsed light source of variable pulse frequency directed in an optical path to a plurality of actuation gateways; each gateway being adapted to supply an actuation voltage above a threshold value to an associated device when illuminated by light pulsed at a trigger frequency for that device; each said gateway comprising photovoltaic converter means for converting pulsed incident light to a pulsed electric current of corresponding frequency; said system having at least a portion of the optical path from said pulsed light source being through optical fibres; and by each said gateway comprising frequency-sensitive transformer means for producing a voltage output above the threshold value for the associated device when the input current frequency is at a trigger frequency.
2. A system according to claim 1, wherein the transformer means comprises a ferroelectric transformer and the trigger frequency is a resonant frequency of that transformer.
3. A system according to either claim 1 or claim 2, wherein output voltage of the photovoltaic converter means is 3 to 5 volts.
4. A system according to any one of claims 1 to 3, wherein the voltage output of the transformer means is 600 to 800 volts.
5. A system according to any one of claims 1 to 4, in which the trigger frequency is a band of not more than about 3kHz within the range 10kHz-40kHz.

- 6 A system according to any one of claims 1 to 5, in which the trigger frequencies of devices to be operated independently are separated by at least 3kHz.
- 5 7. A system according to claim 1, wherein the optical pathway means comprises a branched network of optical fibres connected by optical couplers.
8. A system according to claim 7, wherein the optical couplers provide optical power of 40 to 50mW to each actuation gateway.
- 10 9 . A system according to claim 1, comprising one or more optical couplers coupled to distribute light from said pulsed light source among said gateways.
- 15 10. A system according to any one of claims 1 to 9, wherein said associated device comprises a pilot valve, a solenoid valve, a motor, or electrically powered instrumentation.
- 20 11. A method of actuating a plurality of electrical devices, comprising providing an actuation system for the said devices according to any one of claims 1 to 10, and selectively actuating a device by illuminating the actuation gateways with light pulsed at a frequency that corresponds to the trigger frequency of the selected device.

