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Emergency Lighting System

The present invention relates to an emergency lighting system and, in particular, to a test system for an
5 emergency lighting system operated over a LoRa wireless communication network.

Background

Emergency lighting systems including multiple emergency
10 luminaires are installed into buildings and activated in the event of a power outage or other emergency incident. Such emergency lighting systems are typically installed in both commercial and residential premises.

15 Emergency luminaires are powered separately from the main lighting systems of a building. Typically, emergency luminaires are backed up by batteries. The performance of emergency luminaires is tested periodically to check that the lights are in a suitable working condition in the
20 event that an emergency incident occurs.

Known testing systems for emergency lighting systems operate over radio networks. Figure 1 shows an
25 illustration of a prior art distributed emergency lighting system. In the example of Figure 1, Emergency luminaires 120, 121, 122 are connected to multiple emergency luminaires 120a-c, 121a 122a-f, etc. This is referred to as a branch network. Communications from area controller 110 are transmitted to emergency luminaires within the
30 emergency lighting system via defined communication pathways.

Emergency luminaires 120 121 122 are referred to as
primary luminaires in the example of figure 1. Primary
35 luminaires communicate directly with area controller 110 by receiving radio signals from area controller 110 and transmitting radio signals to area controller 110. Each

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of primary emergency luminaires 120 121 122 has a branch of further emergency luminaires extending from it. For example emergency luminaire 120 has emergency luminaires 120a 120b 120c on its branch. The further emergency
5 luminaires on the branch are referred to as secondary luminaires. The secondary luminaires communicate with area controller via the relevant primary luminaire. Secondary luminaires do not communicate directly with area controller 110. Any instruction signals from area
10 controller are received by primary luminaires 120 121 122 and forwarded to secondary luminaires on the branch. These communication paths are referred to as communication pathways.

15 The communication pathways for the emergency luminaires in the network are now described. In the case of primary luminaire 120, communication signals from area controller 110 are received at primary luminaire 120, transmitted from primary luminaire 120 to secondary luminaire 120a,
20 and further transmitted from secondary luminaire 120a to secondary luminaires 120b 120c. For primary luminaire 121, communication signals from area controller 121 are received at primary luminaire 121, transmitted from primary luminaire 121 to secondary luminaire 121a. In the
25 case of primary luminaire 122, communication signals from area controller 110 are received at primary luminaire 122, transmitted from primary luminaire 122 to secondary luminaires 122a 122b 122c, and further transmitted from secondary luminaire 120b to secondary luminaire 122d, and
30 further transmitted from secondary luminaire 122d to secondary luminaires 122e and 122f.

Communications from secondary luminaires to area controller 110 are transmitted in the reverse direction
35 along the same communication pathway. For example, signals from secondary luminaire 120c are transmitted to secondary luminaire 120a, and further transmitted from

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secondary luminaire 120a to primary luminaire 120, and then transmitted from primary luminaire 120 to area controller 110.

5 In the prior art example of Figure 1, the areas controller is typically connected to the primary emergency luminaires via a short range radio communication network, although other network connections, for example wired networks may be used. The connections between primary emergency
10 luminaires and secondary luminaires and between secondary luminaires may be across a fixed line network or a short range radio network.

When the emergency lighting system of Figure 1 executes a
15 test procedure for all emergency luminaires, an emergency luminaire test initiation signal is transmitted from area controller 110 to primary emergency luminaires 120 121 122.

20 On receipt of the test initiation signal, each of the primary emergency luminaires 120 121 122 transmits the test initiation signal on to secondary emergency luminaires on its branch, along the communication pathways discussed above. Each of the primary and secondary
25 emergency luminaires executes an emergency test procedure on receipt of the test initiation signal. Test results are transmitted from each emergency luminaire along the communication pathway of the branches to emergency luminaires 120 121 122. Primary emergency luminaires 120
30 121 122 then transmit the test results back to area controller 110 across the radio communication network. As discussed above, the distributed emergency luminaires are connected in a branch network.

35 Prior art systems encounter several operational challenges and problems. Branch networks are short range radio networks. Such networks have limited range and typically

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require the area controller to be in close proximity to the emergency luminaires. In large buildings this may require multiple area controllers and multiple branch networks. The area controllers are generally connected
5 together via physical cabling. The number of emergency luminaires associated with each branch network is also limited. Such prior art systems may also encounter issues with implementation in particular with the radio link between emergency luminaires within the branch network.
10 Fault diagnosis and identification of the location of faults in the system can also be challenging since communication failure between the area controller and the emergency luminaires could occur at a number of points in the system. If a single emergency luminaire in a branch
15 were to fail then all downstream emergency luminaires would also lose communication. For example, in figure 1 if emergency luminaire 122b were to fail then emergency luminaires 122d to 122f would all lose communication to primary emergency luminaire 122 and, hence, area
20 controller 110.

There are other network technologies to address some of these limitations such as mesh networks. In a mesh network any adjacent emergency luminaire can talk to any other
25 emergency luminaire. If a given emergency luminaire fails an alternative communication path can be tried. Such networks still have relatively short range connections and require sophisticated software to manage.

30 Embodiments of the present invention seek to address these challenges.

Summary of Invention

In a first aspect the invention provides an emergency
35 lighting system comprising a control node and plurality of emergency lights, wherein each of the plurality of emergency lights is directly connected to the control node

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across a wireless communications network, the control node being configured to transmit test initiation signals directly to each emergency light.

5 Preferably the wireless communications network is a LoRa network.

In a further aspect the invention provides an emergency luminaire for use in an emergency lighting system the
10 emergency luminaire being configured to receive a test signal across a wireless communications network directly from a control node and to activate a test procedure at the emergency luminaire on receiving the test signal.

15 In a further aspect the invention provides a control node for an emergency lighting system comprising a control node and a plurality of emergency lights:

the control node comprising:

transmitter configured to transmit a test initiation
20 signal across a wireless communication network to each of a plurality of emergency lights to initiate a test procedure at each emergency light;

receiver configured to receive results signals across
25 the wireless communication network directly from each of the emergency lights, the results signals comprising the results from the test procedure from the emergency lights.

In a further aspect the invention provides a test system for an emergency lighting system:

30 the emergency lighting system comprising a plurality of emergency lights, each of the plurality of emergency lights being configured to receive a radio test signal directly from a control node to activate a test procedure at the light.

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In further embodiments of the invention each of the plurality of emergency lights comprises a radio receiver

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for receiving the radio test signal directly from the control node.

In further embodiments of the invention each of the
5 plurality of emergency lights comprises:
processor for executing a test procedure at the emergency
light in response to receiving the radio test signal; and
radio transmitter for transmitting performance results
from the executed test procedure directly to the control
10 node.

In further embodiments of the invention radio test signals
are received at the emergency light and the performance
results are transmitted from the emergency light across a
15 LoRa network.

In further embodiments of the invention each emergency
light comprises an emergency lighting node, the emergency
lighting node comprising the radio receiver and radio
20 transmitter.

In further embodiments of the invention the control node
comprises a memory configured to store identification for
each of the plurality of emergency lights, the control
25 node configured to compare received performance results
with stored identification to identify whether performance
results have been received from each of the plurality of
emergency lights.

30 In a further aspect the invention provides a method for
testing the performance of an emergency lighting system,
the emergency lighting system comprising a plurality of
emergency lights, comprising the steps of:
transmitting a radio test signal from a control node
35 directly to each of the plurality of emergency lights;
receiving the radio test signal directly from the control
node to activate a test procedure at the emergency light.

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In further embodiments of the invention the step of receiving the radio test signal directly from the control node is performed at a receiver at the emergency light.

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Further embodiments of the invention comprise the steps of:

executing a test procedure at the emergency light in response to receiving the radio test signal.

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Further embodiments of the invention comprise the step of: transmitting performance results from the executed test procedure directly to the control node.

15 In further embodiments of the invention the steps of receiving the radio test signals at the emergency light and transmitting the performance results from the emergency light are performed across a LoRa network.

20 In further embodiments of the invention each emergency light comprises an emergency lighting node, the emergency lighting node comprising the radio receiver and radio transmitter.

25 Further embodiments of the invention comprise the further step of storing identification for each of the plurality of emergency lights at the control node.

Further embodiments of the invention comprise the step of
30 comparing received performance results with stored identification to identify whether performance results have been received from each of the plurality of emergency lights.

35 In a further aspect the invention provides a test system for an emergency lighting system comprising a radio control node and a plurality of emergency lighting nodes:

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the radio control node comprising:
transmitter configured to transmit a test initiation
signal across a wireless communication network to each of
a plurality of emergency lighting nodes to initiate a test
5 procedure at each emergency lighting node, each emergency
lighting node being associated with an emergency light;
receiver configured to receive results signals across the
wireless communication network directly from each of the
emergency lighting nodes, the results signals comprising
10 the results from the test procedure from the emergency
lighting nodes.

Further embodiments of the invention comprise a
transmitter configured to transmit a results transmission
15 signal across the wireless network directly to the
plurality of emergency lighting nodes, the results
transmission signal configured to initiate the emergency
lighting nodes to transmit the results signals.

20 In further embodiments of the invention the wireless
communication network is a LoRa network.

In further embodiments of the invention each of the
plurality of emergency lighting nodes has a node ID, the
25 node ID of the emergency lighting node being included in
the results signal from the emergency lighting node.

In further embodiments of the invention the radio control
node further comprising memory, the memory storing the
30 node ID of each of the plurality of emergency lighting
nodes.

In Further embodiments of the invention the radio control
node further comprises a processor, the processor
35 configured to compare the node ID of each of the plurality
of emergency lighting nodes stored in the memory with node
IDs of the received results signals.

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In embodiments the radio control node further comprising an alert system.

In further embodiments of the invention the processor
5 further comprising a clock, the processor being configured to activate the alert system if a results signal is not received from a node within a predefined time period.

In a further aspect the invention provides an emergency
10 lighting node of an emergency lighting system comprising:
receiver configured to receive a test initiation signal directly from a radio control node;
processor configured to initiate a test procedure at an emergency light associated with the emergency lighting
15 node on receipt of the test initiation signal and record results of the test procedure;
transmitter configured to transmit the results of the test procedure directly to the radio control node.

20 Further embodiments of the invention the emergency light comprises an activation means and a performance measurement system, the processor initiating the test procedure by activating the activation means to activate the emergency light for a predefined activation period,
25 the performance measurement system measuring the performance of the emergency light during the activation period.

Further embodiments of the invention the performance of
30 the emergency light is the current and voltage performance during the activation period.

In a further aspect the invention provides a method for measuring the performance of an emergency lighting system
35 comprising the steps of:
at a radio control node transmitting a test initiation signal across a wireless communication network directly to

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a plurality of emergency lighting nodes, each emergency lighting node being associated with an emergency light, to initiate a test procedure at the emergency lighting node; and,

5 receiving at the radio control node results signals across the wireless communications network, the results signals comprising the results from the test procedure from the emergency lighting nodes.

10 Further embodiments of the invention comprise the further step of transmitting a results transmission signal across the wireless network directly to the plurality of emergency lighting nodes, the results transmission signal configured to initiate the emergency lighting nodes to
15 transmit the results signals.

Further embodiments of the invention comprise the further step of determining the performance of emergency lights in dependence on the results signals.

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In further embodiments of the invention the wireless communication network is a LoRa network.

In further embodiments of the invention each of the
25 plurality of emergency lighting nodes has a node ID, the node ID of the emergency lighting node being included in the results signal from the emergency lighting node.

In further embodiments of the invention the radio control
30 node further comprises memory, the memory storing the node ID of each of the plurality of emergency lighting nodes.

In further embodiments of the invention the radio control node further comprises a processor, the processor
35 performing the step of comparing the node ID of each of the plurality of emergency lighting nodes stored in the memory with node IDs of the received results signals.

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In further embodiments of the invention the radio controller further comprises an alert system.

- 5 In further embodiments of the invention the processor further comprises a clock, the processor performing the step of activating the alert system if a results signal is not received from a node within a predefined time period.
- 10 In a further aspect the invention provides a method for measuring the performance of an emergency lighting system comprising the steps of:
- receiving at an emergency lighting node a test initiation signal directly from a radio control node;
- 15 initiating a test procedure at an emergency light associated with the emergency lighting node on receipt of the test initiation signal and recording results of the test procedure;
- transmitting the results of the test procedure directly to
- 20 the control node.

In further embodiments of the invention the emergency light comprises an activation means and a performance measurement system, the processor performing the step of

25 initiating the test procedure by activating the activation means to activate the emergency light for a predefined activation period, the performance measurement system measuring the performance of the emergency light during the activation period.

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In further embodiments of the invention the performance of the emergency light is the current and voltage performance during the activation period.

35 **Description of the Drawings**

The present invention will now be described, by way of example only, with reference to the accompanying drawings,

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in which:

Figure 1 illustrates a prior art emergency lighting system; Figure 2 illustrates an emergency lighting system in accordance with an embodiment of the invention;

5 Figure 3A illustrates the components of a control node; Figure 3B illustrates the components of a control node; Figure 4 illustrates the components of emergency lighting node and emergency light;

10 Figure 5 is a flow diagram showing steps taken in an embodiment of the invention;

Figure 6 is a flow diagram showing steps taken in an embodiment of the invention; and

Figure 7 is a flow diagram showing steps taken in an embodiment of the invention.

15

Detailed Description

An embodiment of the present invention is shown in Figure 2 with some components illustrated in greater detail in Figures 3 and 4. Emergency lighting system 200 includes control node 210. Control node 210 activates an emergency test procedure for an emergency lighting system. The emergency lighting system includes emergency luminaires 1200 2200 3200 4200 5200. Each luminaire includes a light source 1222, 2222, 3222, 4222, 5222 and
25 each emergency light source has an associated emergency lighting node 1220, 2220, 3220, 4220, 5220. The emergency lighting node is typically the part of the emergency luminaire responsible for communication with the control node and can also control operation of the emergency
30 light. Typically the emergency lighting node is physically wired to the associated emergency light source. In some embodiments emergency lighting node may be contained in the same physical unit as the emergency light source. In other embodiments emergency lighting node and
35 emergency light source may be separate units. The emergency lighting node and emergency light may be connected via electrical wiring.

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Control node 210 communicates directly with emergency lighting nodes 1220, 2220b, 3220, 4220, 5220 over radio network 230. Preferred embodiments of the invention
5 communicate using LoRa technology. LoRa is a low power wide area radio network. Control node 210 includes a LoRa transmitter and LoRa receiver. Emergency lighting nodes are LoRa nodes and also include LoRa transmitter and receiver. A benefit of using LoRa technology in emergency
10 lighting systems is the long range of the LoRa communications network. LoRa networks have range of several kms. Therefore, a single LoRa control node is able to communicate with multiple emergency lighting nodes at large enough distances to cover large buildings or
15 areas. Additionally, the LoRa communication protocol is reliable over such long distances and can communicate with many nodes.

In the network architecture of Figure 2, every emergency
20 luminaire in the emergency lighting system communicates directly with the control node across a radio network. Control node 210 communicates with each emergency lighting node directly. All emergency lighting nodes receive radio signals from control node 210. In the architecture of
25 Figure 2, the radio signals are transmitted in a star configuration. The control node 210 is the hub which communicates with each emergency luminaire. Radio signals to and from the control node are not transmitted between emergency lighting nodes, instead signals are transmitted
30 directly between control node and each emergency lighting node. This communication architecture is sometimes referred to as point to point communication where there is direct communication between the control node and the emergency luminaires. The communication from the control
35 node to the emergency luminaires may be by a single broadcast communication or may be individual messages to each emergency luminaire.

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The components of control node 210 are illustrated in Figures 3A and 3B. The components of control node 210 may be contained in a single physical unit or in multiple
5 physical units which may be remote from one another.

Figure 3A illustrates a first example of control node 210A in which the components are distributed between two physical units. Control node 210A includes gateway 302A
10 and server 304A. Gateway 302A includes the radio components for the control node including LoRa antenna 310A and RF driver 360A. Server 304A includes the processing and control components. Server 304A typically makes the decisions and instructions, and includes memory
15 320A, processor 330A, clock 340A and input 350A.

Gateway 302A and server 304A are connected by communication channel 370A. In the example of Figure 3A the communication channel is an ethernet connection. In
20 further embodiments other wired connections may be used, for example electrical connection across an electrical wire, or wireless connections may be used.

In the example of Figure 3B the components are contained within one physical unit. Control node 210B includes LoRa
25 antenna 310B configured to transmit and receive radio signals over LoRa network. Signals from antenna 310B are driven by RF engine 360B. Control node 210B also includes memory 320B, processor 330B, clock 340B and input 350B.
30 Each control node is associated with one or more emergency lighting systems. Details of the emergency lighting systems are stored in memory 320B. Each emergency lighting system has a lighting system ID. Further details of each lighting system are stored in the memory including
35 at least some of the following information: number of emergency lights within the emergency lighting system, location of the emergency lighting system, location of

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emergency lights within the emergency lighting system, identification data for each emergency light. Memory 320B also includes performance history and performance requirements for each emergency lighting system. At least
5 some of the following information may be stored for each emergency lighting system: required frequency for testing emergency lighting system, date and time of previous emergency tests, test requirements for emergency lighting system for example duration of activation of emergency
10 lights during test, and any other specific performance requirements associated with that emergency lighting system. Memory may also include the time and date of the next scheduled test for the emergency lighting system.

15 Control nodes 210A/B include processors 330A/B. The processors 330A/B manage incoming and outgoing radio signals and accesses information to and from memory 320A/B relating to emergency lighting tests.

20 Processors 330A/B access clock 340A/B. Control nodes 210 A/B may include input 350A/B. 350A/B may be a manual input device, for example a keyboard, activation switch or other input device. Input relating to emergency lighting test activation and management may be received at input
25 device 350A/B.

An example of an emergency luminaire 4000 including an emergency lighting node and associated emergency light source is shown in Figure 4. In the example of Figure 4
30 the emergency lighting node 400 includes a transmitter and receiver antenna 420. As discussed previously, preferably the emergency lighting node operates within the LoRa communication framework and is configured to receive LoRa radio signals. Emergency lighting node 400 includes
35 memory 425. Memory 425 is configured to store performance data related to the emergency light during operation. Memory also stores node ID allocated to the emergency

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lighting node and/or the emergency light. Memory may also store previous performance data relating to the associated emergency light. Memory may store test procedure characteristics for example duration of test, measurements
5 required to be measured during test etc. The processor 430 receives and interprets signals received by antenna 420 and controls activation of emergency light 410. Clock 435 monitors activation periods for emergency light unit 410.

10

Emergency light unit 410 includes power supply 455. Typically power supply 455 is a battery unit dedicated to the emergency light. Emergency light 410 includes light source 445 and switch 440 to control the ON/OFF state of
15 light source 445. Switch 440 is controlled by processor 430. Switch 440 may include additional inputs not shown to trigger activation of the emergency light source, for example light sensors or other sensors or a manual input. Performance management system 450 monitors performance of
20 light source 445 during activation. Typically, the voltage across the light source and current through the light source are measured during the activation period. Performance measuring system 450 may monitor other performance criteria for the emergency light during the
25 test procedure. Results obtain by the performance measurement system during the test are provided to memory 425 for storage.

The arrangement of components within Figure 4 is for the
30 purposes of illustration only and is not restrictive. In further embodiments the components are distributed differently between physical units. For example light source 445 may be in a physically separate head unit and all other components may be contained within a head unit.
35 In further embodiments all components are positioned on a single physical unit.

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The mode of operation of an embodiment of the invention is now described with reference to the flow diagrams of Figures 5, 6 and 7.

5 At 510 a particular lighting system is identified for testing at control node 210. Typically, the lighting system is associated with a particular building or premises. Control node 210 retrieves information relating to the identified lighting system from memory 320.
10 Typically information may include lighting system ID, location of the lighting system, number of lights within the identified lighting system, etc. The test may be triggered by a manual input from input device 350 or triggered by a timing module using the timer from clock
15 340.

Processor 330 creates a test initiation signal. Typically, the test initiation signal includes the identification of the emergency lighting system. In a
20 situation where different configurations of test events might occur within a single system, the signal also includes identification of the relevant test procedure requirements. For example the system may include a first test procedure in which emergency lights are tested for a
25 120 minute period and a second test procedure when the lights are tested for a 90 minute period. At 520 the test initiation signal is transmitted from radio transmitter 310 of control node 210 across LoRa network 230. In some embodiments the time at which the test initiation signal
30 is transmitted from control node 210 is stored in memory 320 as Tstart. As discussed above control node 210 transmits test initiation signals directly to each emergency luminaire. This is performed in a star configuration with control node 201 being the hub.

35 At 530 the test initiation signal is received at emergency lighting node 400 by antenna 420. Test initiation signal

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is decoded by processor 430. The parameters for the test are determined at 540. The test parameters may be included in the test initiation signal or, alternatively, the particular test may be identified within the test initiation signal by a particular code and the test parameters associated with the code are retrieved from memory 425. After the parameters are determined the test procedure is initiated at 550. In an embodiment the test procedure involves activating emergency light source for a particular time period associated with the test. At 550 the processor 430 activate switch 440 of the emergency light to activate light source 445. The time at which the light source is activated is provided by clock 435 and stored as test data against this test. During the emergency light test performance measurement systems 450 monitors the performance of the emergency light. As discussed above, the voltage and current of the lighting circuit may be measured and stored in memory 425 at 460. Clock 435 monitors the duration of the test procedure and upon completion of the test duration processor 430 terminates the test by switching off light source 445 by switch 440. Emergency light test is terminated at 570.

In some embodiments of the invention the test results are automatically transmitted back from transmitter 420 of each emergency lighting node to control node 210. In further embodiments control node 210 monitors the time period from Tstart. Upon completion of a predefined time period, for example the time period associated with the test or at a later predefined period, control node 310 transmits a result request signal to all emergency lighting nodes within emergency lighting system at 610. At 620 emergency lighting node 400 receives the results request signal at radio receiver 420. At 630 processor 430 retrieves results from the emergency test from memory 425. Typically, the test identification is included in the results request signal in order that results are

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retrieved from the appropriate test. The results signal is transmitted from each emergency lighting node 400 at 640 and received at control node 210 at 650.

5 Referring now to Figure 7, at 710 the results signals received from emergency lighting nodes within the emergency lighting system are analysed at control node 210. The performance of each emergency light is analysed against predetermined criteria. If an emergency luminaire
10 fails to meet the required performance standard an alert is raised at 730 by control node 210.

At 720 control node 210 determines whether results have been received from all emergency lighting nodes within the
15 emergency lighting system. The emergency lighting node IDs contained within the received signals are compared against the list of emergency lighting nodes within the emergency lighting system to identify whether any results have not been received. In the event that a results
20 signal is not received from an emergency lighting node, an alert is raised at 730.

The alert may be raised in many different forms, for example control node 210 may send an electronic
25 communication, for example a SMS or email, to predefined personnel responsible for the emergency lighting system to raise attention to the missing data. Alternatively, a visible alert may be raised to alert personnel. In some embodiments control node 210 creates an additional
30 interrogation signal and transmits this to those emergency lighting nodes which have not responded with results data.

Embodiments of the present invention provide a test system for an emergency lighting system which operates to
35 initiate tests at emergency luminaires within emergency lighting system over a radio communication network. Embodiments are configured to operate over a LoRa network.

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In embodiments a control node communicates directly with all emergency lighting nodes within an emergency lighting system. Each emergency lighting node is associated with an emergency luminaire. Each emergency lighting node
5 includes a receiver for receiving radio signals from the control node. The configuration allows all emergency luminaires to be controlled directly from the control node without signals needing to be transmitted between emergency lighting nodes.

10

Such embodiments provide a flexible system in which additional emergency luminaires can be added into an emergency lighting system without requiring any rewiring of existing infrastructure. Additionally, an entire
15 emergency lighting system even within large buildings or infrastructures can be tested by control node sending a single test initiation signal. Such systems provide control over the test environment and reduce the number of potential points of error in the case that a test result
20 is not received from an emergency light.

It will be clear to those skilled in the art that the advantages of using a one-to-many communication system between a control node and emergency light extend beyond
25 the test environment and could be used to interrogate any particular light at any time or could be used to control activation of the lights in any situation.

It is to be understood that, if any prior art publication
30 is referred to herein, such reference does not constitute an admission that the publication forms a part of the common general knowledge in the art, in Australia or any other country.

35 In the claims which follow and in the preceding description of the invention, except where the context requires otherwise due to express language or necessary

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implication, the word "comprise" or variations such as
"comprises" or "comprising" is used in an inclusive sense,
i.e. to specify the presence of the stated features but
not to preclude the presence or addition of further
5 features in various embodiments of the invention.