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(54) FIRE SYSTEM WITH DEGRADED MODE OF OPERATION

(57) A fire system 10 for a building is described. The fire system 10 comprises a fire panel 12 for monitoring the building and activating an alarm, the fire panel 10 comprising a loop controller 24; and a plurality of remote units 14, 16, 18 electrically connected to the fire panel 12 in a circuit 20 having a loop configuration, at least one of the plurality of remote units 14, 16, 18 comprising an indicating device 14, 18 for determining conditions that are indicative of a possible emergency and modulating a current in the circuit when those conditions indicate a possible emergency. In normal use the plurality of remote units 14, 16, 18 are in communication with the fire panel 12 in a master-slave relationship. The fire system 10 is configured to enter a degraded mode of operation when failure of the master-slave communications occurs, with the fire panel 12 being configured to create a high output impedance in the circuit 20 and enable a degraded communications mode for the remote units 14, 16, 18 in the degraded mode. Each of the plurality of remote units 14, 16, 18 comprises a current sensor 26 for detecting current in the degraded mode.

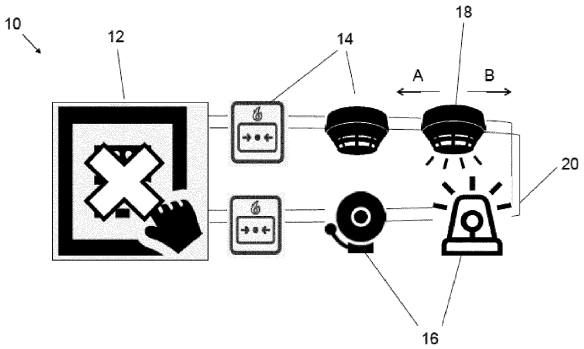

Fig. 3

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Description

[0001] The present invention relates to a fire system for a building, the fire system comprising: a fire panel for monitoring the building and activating an alarm; and a plurality of remote units electrically connected to the fire panel in a circuit having a loop configuration. The invention also relates to a method of operating such a fire system.

[0002] Typically, there is a regulatory requirement in buildings to have a fire system in place. These fire systems are used to identify possible fires in the building and alert authorities and/or occupants of the building of the possible fire. In some instances, fire systems can also identify other types of emergency, such as other emergencies that require evacuation of the building. Typical fire systems employ a fire panel and a number of remote units, with some of the remote units comprising indicating devices (e.g. smoke alarms, manual call points, heat detectors, etc.) and/or indicator devices (e.g. sirens, bells, lights, etc.). The remote units are typically distributed across the building and are connected to the fire panel through a communications network. There may be additional devices in the fire system, such as fire extinguishing devices that can be automatically triggered via the fire panel. In some fire alarm systems, the remote units are electrically connected to the fire panel in a loop configuration, and communication between the remote units and fire panel is achieved by modulating the current and voltage in the loop. The fire panel may determine specific actions for different zones of a building depending on the nature and location of the emergency. For example, the fire panel may raise an alarm across the whole building, but only trigger the fire extinguishing devices in the zone of the building where a fire has been detected. The fire panel may be connected to a further communication network, such as a WiFi network or telephone network, for the purposes of alerting authorities to the emergency.

[0003] In known systems, the fire panel and the remote units communicate through a master-slave communication system. This may involve the fire panel receiving an input from a remote unit in the form of a modulation in the current and, if the input is indicative of a possible emergency, communicating an alarm condition in the form of modulations in the voltage to other remote units. Such a configuration is often necessary due to regulatory requirements and/or to ensure compatibility with previously installed products that also employ a master-slave communication network. Thus, updated fire panels or remote units often must be able to carry out master-slave communications in order to operate correctly within pre-existing fire systems. However, known systems employing a master-slave communication system may be unable to function correctly if a fault occurs in in the master-slave communication system. This can lead to the fire system failing to properly trigger an alarm in emergency situations.

[0004] Viewed from a first aspect, the present invention provides a fire system for a building, the fire system comprising: a fire panel for monitoring the building and activating an alarm, the fire panel comprising a loop controller; and a plurality of remote units electrically connected to the fire panel in a circuit having a loop configuration, at least one of the plurality of remote units comprising an indicating device for determining conditions that are indicative of a possible emergency and modulating a current in the circuit when those conditions indicate a possible emergency; wherein the plurality of remote units are in communication with the fire panel in a master-slave relationship; wherein the system is configured to enter a degraded mode of operation when failure of the master-slave communications occurs, the fire panel being configured to create a high output impedance in the circuit and enable a degraded communications mode for the remote units in the degraded mode; and wherein each of the plurality of remote units comprises a current sensor for detecting current in the degraded mode.

[0005] The fire system of the first aspect allows the remote units to communicate with the fire panel during normal operation, and with one another during the degraded mode of operation. Advantageously, this allows an alarm condition to be triggered in the fire system even when communication between the remote units and the fire panel is lost. In prior art systems, if the fire panel can no longer operate correctly as the master within the master-slave system, then communication is lost and the alarm cannot be activated across the entire loop. By introducing a degraded mode wherein the remote units can communicate with one another without the fire panel, the alarm condition can be triggered across the whole loop even in the event that the fire panel cannot be used for master-slave communications.

[0006] In installations where the master-slave system also provides power to the remote units, the present fire system may be arranged so that the remote units are powered independently of the master-slave system. Thus, they may not rely on the fire panel for power, and can be fully operative without the fire panel.

[0007] The remote units are electrically connected in a loop configuration, and the circuit may comprise connecting wiring starting and finishing at the fire panel. The fire panel may be configured to monitor alarm conditions and possible emergencies in the building based on signals received from at least some of the remote units, and may be configured to trigger an alarm condition in at least some of the remote units in response to an indication of a possible emergency. The fire panel may be configured to monitor the voltage and/or current in the circuit in order to detect any signals from the remote units, and may comprise means for altering the voltage and/or current in the circuit in order to trigger an alarm condition throughout the loop. The fire panel may be further configured to monitor faults in the circuit, such as short circuits and/or line breaks.

[0008] The fire panel comprises a loop controller, which may be for controlling the operation of the loop.

The loop controller may be a part of a fire panel control system that also has overall control of the fire panel and its functions, or it may be a separate hardware or software element compared to such a control system. The loop controller may be a central processing unit (CPU). The loop controller may be configured to determine a response to the communications from the remote units. For example, in response to information from one of the remote units, the loop controller may be configured to determine that all or some of the remote units should enter an alarm condition. The loop controller may be configured to determine that only the remote units in the same zone as the emergency should enter an alarm condition, and/or that some remote units should enter an alarm condition at different times than others. This may aid efficient evacuation of the building in the event of an emergency.

[0009] The possible emergency may be related to a fire, for example, but it will be appreciated that the fire system may also be used for also other emergencies, such as non-fire emergencies requiring activation of an evacuation procedure.

[0010] The system is configured to enter a degraded mode of operation when failure of the master-slave communications occurs. The system may be arranged to determine that a failure of the master-slave communications occurs if the remote units are unable to detect communication from the master within a set time period. The time period can be set depending on the particular protocol that is being used and hence may vary depending, for example, on a normal polling time period for the protocol in question.

[0011] The fire panel may comprise a supervisor for supervising the loop controller. The supervisor may be configured to supervise correct operation of the loop controller. The supervisor may operate separately to the loop controller and therefore may be able to continue operating correctly even if the loop controller fails. The supervisor may be configured to detect any faults in the loop controller and/or determine that a failure in the master-slave communications has occurred. The supervisor may be a CPU supervisor. The supervisor may be added to the fire panel as a hardware modification or a software modification, or it may be added as a combination of the two.

[0012] The supervisor may be configured to detect the failure of the master-slave communications and trigger the degraded mode of operation. The supervisor may be configured to create the high output impedance in the loop in the degraded mode.

[0013] The supervisor may comprise an auxiliary controller for supervising the loop controller. The auxiliary controller may operate independently from the loop controller, such that it is configured to continue operating correctly even if the loop controller fails. The auxiliary controller may be an auxiliary CPU. The auxiliary controller may be configured to monitor how frequently the loop controller communicates with the loop. The auxiliary controller may be configured to trigger the degraded mode of operation if it determines that the frequency at which the loop controller communicates with the loop has fallen below a minimum threshold frequency, for example if there is no communication within a set period of time. The minimum threshold frequency may be considered as the frequency at which communications between the loop and the loop controller are considered to have failed and/or the frequency at which the master-slave communications are considered to have failed. The auxiliary controller may be added to the fire panel as a hardware modification and/or a software modification. The auxiliary controller may be configured to create the high output impedance in the degraded mode.

[0014] During normal operation of the fire system, the remote units communicate with the fire panel through a master-slave communication system. The master-slave communication system may be a wired network with wired connections between the fire panel and each of the remote units. In a standby condition, the remote units may be configured to draw a low current. The current in the standby condition may be less than 100μA. If a remote unit comprises an indicating device, the remote unit is configured to switch to an alarm condition when a condition indicative of a possible emergency is detected, and modulate the current in the loop accordingly. The fire panel may be configured to detect this modulation in the current and, in response, communicate a fire alarm condition to the remaining remote units by modulating the voltage throughout the loop.

[0015] Typically, remote units in fire systems that employ master-slave communication do not comprise any means for detecting current as a means for allowing communications such as the degraded communications mode proposed herein. Hence, when a remote unit modulates the current in such a way that is indicative of a possible emergency, only the fire panel can sense this. The remaining remote units are therefore typically entirely reliant on communication from the fire panel in order to enter an alarm condition. By adding a current sensor to the remote units and with suitable configuration of the system to use those current sensors in context of the degraded communications mode, they are able to detect any modulation of the current themselves when the system is operating in the degraded mode, and hence are able to enter an alarm condition even when communication with the fire panel is lost. The degraded mode of operation may therefore be considered to provide redundancy to the system for safety purposes.

[0016] The plurality of remote units may be configured to enter an alarm condition when a detected current is indicative of a possible emergency. This may occur in the degraded mode of operation in reaction to communications between remote units using the degraded communications mode. The current sensor may be configured to determine if a detected current is indicative of a possible emergency. Alternatively, the remote units may comprise a unit controller, and the unit controller may be configured to use the measurements at the current sen-

sor to determine if a detected current is indicative of a possible emergency. Alternatively, the current sensor and the unit controller may work together to determine if a detected current is indicative of a possible emergency. The unit controller may be configured to determine a response to the detected current. For example, the unit controller may be configured to determine that the remote unit should enter an alarm condition if the detected current is indicative of a possible emergency. The unit controller may be configured to communicate with the current sensor only in the degraded mode of operation, but not in the normal mode of operation. Additionally or alternatively, the current sensor may be configured to operate in a 'sleep' mode during the normal mode of operation. The 'sleep' mode may be considered as a mode in which the current sensor is not active and does not measure the current in the loop. The unit controller may be configured to 'wake up' the current sensor when the remote unit enters the degraded mode, such that the current sensor is configured to measure the current in the loop only in the degraded mode of operation. The current sensor may be added to the remote units as an additional hardware element.

[0017] The fire panel may be configured to periodically poll at least some of the remote units to monitor their status during normal operation of the fire system. The fire panel may be configured to carry out this polling at regular time intervals. The fire panel may be configured to carry out this polling based on a predetermined communications protocol, and the frequency of polling may be determined based on the predetermined communications protocol. The fire panel may be configured to poll at least some of the remote units by transmitting one or more polling signals. The polling signal(s) may be encoded with an address of a remote unit, which may be used to communicate which remote unit the polling signal is intended for. The fire panel may be configured to poll each remote unit individually, and/or may be configured to poll groups of remote units at the same time. Polling groups of remote units at the same time may shorten the amount of time needed to poll the whole loop. The polled remote unit(s) may be configured to respond with a signal giving the status of the remote unit(s). The response signal may further comprise other information, such as the address or manufacturer code of the remote unit(s). As a result of this polling, the fire panel may be able to detect an approaching alarm condition and may take action accordingly.

[0018] As mentioned above, the remote units may comprise a unit controller. The unit controller may be a microcontroller. During the normal mode of operation, the unit controller may be configured to receive and analyse any signals from the fire panel, such as from the loop controller. The unit controller may be configured to decode any signals from the fire panel such that the encoded address can be determined. The unit controller may therefore be configured to determine whether it is the remote unit that the signal is intended for based on the decoded address. Alternatively, the remote units may comprise a unit transceiver for decoding signals received from the fire panel. The unit controller may be configured to determine how to respond to signals from the fire panel. For example, if a signal from the fire panel is a polling signal, the unit controller may be configured to determine the status of the remote unit and communicate this information back to the fire panel. Alternatively, if the signal from the fire panel indicates an alarm condition, the unit controller may be configured to trigger an alarm condition in the remote unit.

[0019] The unit controller may be configured to detect when master-slave communications have failed, and may be configured to trigger the remote unit to enter the degraded mode of operation in response. This may be done in addition to or instead of the use of a supervisor as discussed above. The unit controller may be configured to monitor how frequently the remote unit receives polling signals from the fire panel. The frequency at which the remote unit receives polling signals from the fire panel may be considered to be a polling frequency. The unit controller may compare the determined polling frequency to an expected polling frequency. The expected polling frequency may be the lowest frequency at which the master-slave communications are still considered to be functioning. The unit controller may be configured to determine that the master-slave communications have failed if the determined polling frequency falls below the expected polling frequency. If the unit controller determines that the master-slave communications have failed, the unit controller may be configured to trigger the remote unit to enter the degraded mode of operation. As explained above, the unit controller may be configured to communicate with the current sensor in the degraded mode of operation, and may be configured to determine a response to the current detected by the current sensor in the degraded mode.

[0020] The fire panel may comprise means for communicating a fire alarm condition or a fault status to an operator and/or occupant of the building. These means may comprise a display and/or LED lights. For example, the fire panel may display one form of visual feedback (e.g. lighting up one LED light) when a fire alarm condition is detected, and display one form of visual feedback (e.g. lighting up a different LED light) when a fault in the circuit is detected. Additionally or alternatively, the fire panel display may show information pertaining to the detected fire alarm condition or fault. This information may inform an operator and/or occupant of the building of the source of the alarm condition or fault, and may comprise the address of the relevant remote unit and the zone in which it is located.

[0021] The plurality of remote units may comprise a voltage sensor for detecting voltage in the loop, and may be configured to enter an alarm condition when the detected voltage indicates a possible emergency. The remote units may be configured to detect voltage in the loop in both the normal mode of operation and the de-

graded mode of operation.

[0022] The voltage sensor may be configured to detect modulations in voltage in the loop. The detected modulations in voltage may be encoded with alarm information. For example, the detected modulations in voltage may be encoded with a digital binary code that contains alarm information. In the normal mode of operation, the fire panel may be configured to transmit the modulations in voltage and encode the modulations in voltage with the alarm information. The voltage sensor may be configured to communicate the detected modulation in voltage to the unit controller and/or the unit transceiver. The unit transceiver and/or the unit controller may be configured to decode the detected modulation in voltage, such that the alarm information encoded in the modulation in voltage can be determined. If the decoded alarm condition is determined to be indicative of a possible emergency, the unit controller and/or the unit transceiver may trigger the remote unit to enter an alarm condition. Additionally or alternatively, the voltage sensor may comprise means for decoding the detected modulation in voltage, and may be configured to trigger an alarm condition in the remote unit if the decoded alarm information of the detected modulation in voltage is indicative of an alarm condition.

[0023] The detected modulations in voltage may be encoded with address information. The address information may comprise an individual address and/or a zone address of the indicating device that has detected the possible emergency. The address information may be encoded in the form of digital binary code. In the normal mode of operation, the fire panel may be configured to encode the modulations in voltage with the address information. The unit transceiver and/or the unit controller of the remote units may be configured to decode the detected modulation in voltage such that the address information encoded in the modulation in voltage can be determined. Additionally or alternatively, the voltage sensor may comprise means for decoding the address information in the detected modulation in voltage. The unit controller may be configured to determine a response based on the decoded alarm information and the decoded address information. For example, the unit controller may determine that the remote unit should only enter an alarm condition if it is in the same zone as the indicating device that has detected the possible emergency.

[0024] The voltage sensor and/or the unit controller may comprise means for determining whether a detected voltage passes a predetermined voltage threshold value. The voltage sensor may be configured to communicate the detected voltage to the unit controller and/or the unit transceiver only if the detected voltage passes the predetermined voltage threshold. Additionally or alternatively, the remote unit may be configured to decode a detected voltage only if the if the detected voltage passes the predetermined voltage threshold. Thus, modulations in voltage that are the result of noise in the loop, and are therefore small, may be ignored. Alternatively, the detected voltage may be considered to indicate a possible emergency when it passes the predetermined voltage threshold value, and thus the remote unit may be configured to enter an alarm condition if it determines that the detected voltage passes the predetermined voltage threshold value. The detected voltage may be considered to pass the predetermined voltage threshold value if the detected voltage falls below the predetermined voltage threshold value, or rises above the predetermined voltage threshold value.

[0025] The at least one indicating device may be configured to modulate the current through the loop when the indicating device detects conditions indicative of a possible emergency. The modulation of the current may be an increase or a decrease in current. The remote unit may further comprise a resistor, and the modulation of the current may be triggered by the resistor being switched.

[0026] In the degraded mode, the remote units located along the loop in a first direction may be able to detect the modulation of the current due to their current sensors. The first direction is a direction around the loop compared to the location of the indicating device that has detected the possible emergency, e.g. the current modulation may be detectable by other remote units that are forward of the indicating device. The indicating device may be configured to encode the modulation in current with alarm information. For example, the indicating device may be configured to encode the modulation in current with a digital binary code that contains the alarm information.

[0027] Hence, in the degraded mode the modulation of the current may cause other remote units located along the loop in the first direction to enter an alarm condition if the modulation of the current is indicative of an emergency condition. The modulation of the current may be considered to indicate a possible emergency if the encoded alarm information is indicative of a possible emergency. The current sensor of the remote units that have detected the modulation in current may be configured to communicate the detected modulation in current to the unit controller and/or the unit transceiver. The unit transceiver and/or the unit controller may be configured to decode the detected modulation in current, such that the alarm information encoded in the modulation in current can be determined. If the decoded alarm information is determined to be indicative of a possible emergency, the unit controller and/or the unit transceiver may trigger the remote unit to enter an alarm condition. Additionally or alternatively, the current sensor may comprise means for decoding the detected modulations in current itself, and may be configured to trigger an alarm condition in the remote unit if the decoded alarm information of the detected modulation in current is indicative of an alarm condition.

[0028] The at least one indicating device may be configured to encode the modulation in current with address information. The address information may comprise an individual address of the indicating device and/or a zone address. The zone address may indicate the zone in

which the indicating device is located. The address information may be encoded in the form of a digital binary code. The remote units in the first direction along the loop from the indicating device may be configured to decode the detected modulation in current such that the address information can be determined. As mentioned above, the current sensor, the unit controller, and/or the unit transceiver may be configured to decode the detected modulation in current. The unit controller may be configured to determine a response based on the decoded alarm information and the decoded address information. For example, the unit controller may determine that the remote unit should only enter an alarm condition if it is in the same zone as the indicating device that has detected the possible emergency.

[0029] The current sensor and/or the unit controller may comprise means for determining whether a detected modulation in current passes a predetermined current threshold value. The current sensor may be configured to communicate the detected modulation in current to the unit controller and/or the unit transceiver only if the detected modulation in current passes the predetermined voltage threshold. Additionally or alternatively, the remote unit may be configured to decode a detected modulation in current only if the if the detected modulation in current passes the predetermined current threshold. Thus, any modulations in current that are the result of noise in the loop, and are therefore small, may be ignored. Alternatively, the detected modulation in current may be considered to indicate a possible emergency if it passes the predetermined current threshold value, and thus the remote unit may be configured to enter an alarm condition if it determines that the detected modulation in current passes the predetermined current threshold value. The detected modulation in current may be considered to pass the predetermined current threshold value if the current falls below the predetermined current threshold value, or rises above the predetermined current threshold value.

[0030] The at least one indicating device may be configured to modulate the current in the loop such that the voltage in the loop is also modulated . The modulation of the current caused by the at least one indicating device may occur together with an opposite modulation of the voltage in the loop. The modulation of the voltage may be an increase or a decrease in voltage, depending on if the modulation of the current is an increase or decrease in current. For example, if the modulation of the current is an increase in current, then it may cause a drop in voltage, and vice versa. Consequently, the modulation in voltage may be encoded with information that corresponds to that of the modulation in current. This modulation of the voltage may be detectable by other remote units in a second direction along the loop, wherein the second direction is opposite to the first direction. In the degraded mode, this modulation of the voltage may be detected by the remote units located along the loop in the second direction. Voltage detection by the voltage sensor of the remote units can therefore form a part of the degraded communications between the remote units, with this voltage detection being used along with current detection to allow an alarm condition to be detected by other remote units both forward of and behind the indicating device that has detected the possible emergency. Hence, the alarm condition may be triggered in the devices located along the loop in the second direction by the modulation of the voltage, and detection thereof, rather than by the modulation of the current detected by the current sensor.

[0031] As mentioned above, in the degraded mode, the modulation in voltage may be encoded with information that corresponds to the information encoded in the corresponding modulation in current. Thus, the modulation in voltage in the degraded mode may be encoded with alarm information and address information that corresponds to that of the modulation in current, and the remote units located in the second direction along the loop from the indicating device may be configured to decode the detected modulations in voltage such that the alarm information and address information can be determined. The unit controller of these remote units may be configured to determine a response based on the decoded alarm information and the decoded address information of the detected modulation in voltage.

[0032] The at least one indicating device may be configured to modulate the current in the form of a current pulse. At least one of the remote units may be configured to replicate any detected current pulses such that the corresponding modulation in voltage is amplified through the loop. This may ensure that the amplitude of the modulation in voltage is prevented from falling too low to trigger an alarm condition as it travels along the loop. Hence, replicating the current pulses in this way may ensure that the modulation in voltage is sufficiently large to trigger an alarm condition across the whole loop. The remote units may be configured to replicate a detected current pulse only if they are within a certain proximity to the indicating device from which the current pulse originated. For example, the remote units that are configured to replicate a detected current pulse may be the four remote units that are immediately adjacent to the indicating device from which the detected current pulse originated in the first direction.

[0033] In the degraded mode, the fire panel is configured to create a high output impedance in the loop. As a result of this high output impedance, the modulation of the voltage in the loop is larger in the degraded mode of operation than it would be in the normal mode of operation. This enables the modulation of the voltage in the loop to be used in the degraded mode of operation to communicate an alarm condition to some of the remote units, as explained above.

[0034] At least one of the remote units comprises an indicating device, which may be a device for sensing conditions or for receiving inputs from users. For example the indicating device may include one or more of: manual

call points; smoke detectors; heat detectors; other building sensors used for fire or heat detection, such as room thermostats; sensors for supervised doors; sensors for supervised fire extinguishers; water flow sensors; and so on. Input-output modules may be provided for handling information from some types of sensors that may lie outside of the fire system, such as thermostats or water flow sensors. Such information from sensors may be used with master-slave communications via the loop, and thus can add extra information to enable the fire panel to determine a course of action to take. In some examples, the use of this information from sensors is not available in the degraded mode. Additionally or alternatively, input-output modules may be provided for activating fire extinguishers, fire sprinklers, automatic door opening and/or closure systems, or door locking systems. The indicating device may provide inputs for triggering an alarm condition of the fire system.

[0035] At least one of the remote units may comprise an indicator device, which may be a device for indicating an alarm condition of the fire system, such as audible or visible devices. The indicator device may include one or more of: sirens; bells; speech sounders; other types of sounders; lights; beacons or remote indicators. The indicator device may also include one or more transmitter devices for sending alarm notifications to users. Alarm notifications may be sent to local users, for example via wireless transmission of notifications to a mobile device, and/or may be sent to remote users such as building management authorities and/or emergency services.

[0036] At least one of the remote units may comprise a combined indicating and indicator device, for example a device including detection capabilities along with an alarm, such as smoke detectors also including an audible alarm. Such a remote unit may include combinations of any of the functions discussed above in relation to the indicating and indicator devices.

[0037] At least one of the remote units may comprise a connection module for enabling communication of an alarm condition to an external system. The connection module may be configured to connect to external hardware, and may be configured to communicate the alarm condition to the external hardware when the connection module enters an alarm condition. The external hardware may, for example, be configured to trigger an emergency call or some other form of alert to emergency services, and/or trigger an alarm condition in an external alarm system. The connection module may be configured to communicate the alarm condition to the external system in both the normal mode of operation and the degraded mode of operation. Alternatively, the fire panel may be configured to communicate the alarm condition to any external systems during the normal mode of operation, and the connection module may only be configured to take on this role in the degraded mode when the master-slave communications have failed.

[0038] The invention extends to a building incorporating the fire system, wherein the plurality of remote units may be distributed within the building.

[0039] Viewed from a second aspect, the invention provides a method of operating a fire system as in the first aspect, wherein the method comprises operating the fire system in the degraded mode when failure of the master-slave communications between the remote units and the fire panel occurs.

[0040] The method may include operating a fire system with any of the other features discussed above.

[0041] In installations where the master-slave system also provides power to the remote units, the method may include powering the remote units independently of the master-slave system. Thus, they may not rely on the fire panel for power, and can be fully operative without the fire panel.

[0042] The method may include monitoring alarm conditions and possible emergencies in the building based on signals received from at least some of the remote units, and triggering an alarm condition in at least some of the remote units in response to an indication of a possible emergency. During operation with master-slave communications, the method may include using the fire panel to monitor the voltage and/or current in the circuit in order to detect any signals from the remote units, and the fire panel may alter the voltage and/or current in the circuit in order to trigger an alarm condition throughout the loop. The method may include using the fire panel to monitor faults in the circuit, such as short circuits and/or line breaks.

[0043] The method may include using the loop controller for controlling the operation of the loop. The loop controller may be a part of a fire panel control system that also has overall control of the fire panel and its functions, or it may be a separate hardware or software element compared to such a control system. The loop controller may be a central processing unit (CPU). During the normal mode of operation, the method may include using the loop controller to determine a response to the communications from the remote units. For example, in response to information from one of the remote units, the loop controller may determine that all or some of the remote units should enter an alarm condition. The loop controller may determine that only the remote units in the same zone as the emergency should enter an alarm condition, and/or that some remote units should enter an alarm condition at different times than others. This may aid efficient evacuation of the building in the event of an emergency.

[0044] The method may include entering a degraded mode of operation when failure of the master-slave communications occurs. The method may include determining that a failure of the master-slave communications occurs if the remote units are unable to detect communication from the master within a set time period. The method may include using a particular protocol, and may include setting the time period depending on the particular protocol that is being used. Hence, the time period may vary depending, for example, on a normal polling time period

for the protocol in question.

[0045] The fire panel may comprise a supervisor for supervising the loop controller. The method may include using the supervisor to supervise correct operation of the loop controller. The supervisor may operate separately to the loop controller and therefore may be able to continue operating correctly even if the loop controller fails. The method may include using the supervisor to detect any faults in the loop controller and/or determine that a failure in the master-slave communications has occurred. The supervisor may be a CPU supervisor. The supervisor may be added to the fire panel as a hardware modification or a software modification, or it may be added as a combination of the two.

[0046] The method may include using the supervisor to detect the failure of the master-slave communications and trigger the degraded mode of operation. The method may include using the supervisor to create the high output impedance in the loop in the degraded mode.

[0047] The method may include using an auxiliary controller for supervising the loop controller. The method may include operating the auxiliary controller independently from the loop controller, such that it is configured to continue operating correctly even if the loop controller fails. The auxiliary controller may be an auxiliary CPU. The method may include using the auxiliary controller to monitor how frequently the loop controller communicates with the loop. The method may include using the auxiliary controller to trigger the degraded mode of operation if it determines that the frequency at which the loop controller communicates with the loop has fallen below a minimum threshold frequency, for example if there is no communication within a set period of time. The minimum threshold frequency may be considered as the frequency at which communications between the loop and the loop controller are considered to have failed and/or the frequency at which the master-slave communications are considered to have failed. The auxiliary controller may be added to the fire panel as a hardware modification and/or a software modification. The method may include using the auxiliary controller to create the high output impedance in the degraded mode.

[0048] During normal operation of the fire system, the remote units communicate with the fire panel through a master-slave communication system. The master-slave communication system may be a wired network with wired connections between the fire panel and each of the remote units. In a standby condition, the remote units may draw a low current. The current in the standby condition may be less than 100μA. If a remote unit comprises an indicating device, the method may include switching that remote unit to an alarm condition when a condition indicative of a possible emergency is detected, and modulating the current in the loop accordingly. The method may include using the fire panel to detect this modulation in the current and, in response, communicate a fire alarm condition to the remaining remote units by modulating the voltage throughout the loop.

[0049] The method may include triggering an alarm condition in a remote unit when a current detected by the remote unit is indicative of a possible emergency. This may occur in the degraded mode of operation in reaction to communications between remote units using the degraded communications mode. The method may include using the current sensor to determine if a detected current is indicative of a possible emergency. Alternatively, the remote units may comprise a unit controller, and the method may include using the unit controller to determine if a detected current is indicative of a possible emergency based on the measurements at the current sensor. Alternatively, the method may include using the current sensor and the unit controller together to determine if a detected current is indicative of a possible emergency. The method may include using the unit controller to determine a response to the detected current. For example, the method may include using the unit controller to determine that the remote unit should enter an alarm condition if the detected current is indicative of a possible emergency. The method may include only using the unit controller to communicate with the current sensor in the degraded mode of operation, but not in the normal mode of operation. Additionally or alternatively, the method may include operating the current sensor in a 'sleep' mode during the normal mode of operation. The 'sleep' mode may be considered as a mode in which the current sensor is not active and does not measure the current in the loop. The method may include using the unit controller to 'wake up' the current sensor when the remote unit enters the degraded mode, such that the current sensor may measure the current in the loop only in the degraded mode of operation. The current sensor may be added to the remote units as an additional hardware element.

[0050] The method may include using the fire panel to periodically poll at least some of the remote units to monitor their status during normal operation of the fire system. The method may include using the fire panel to carry out this polling at regular time intervals. The method may include using the fire panel to carry out this polling based on a predetermined communications protocol, and the method may include determining the frequency of polling based on the predetermined communications protocol. The method may include using the fire panel to poll at least some of the remote units by transmitting one or more polling signals. The method may include encoding the polling signal(s) with an address of a remote unit, which may be used to communicate which remote unit the polling signal is intended for. The method may include using the fire panel to poll each remote unit individually, and/or poll groups of remote units at the same time. Polling groups of remote units at the same time may shorten the amount of time needed to poll the whole loop. The polled remote unit(s) may respond with a signal giving the status of the remote unit(s). The response signal may further comprise other information, such as the address or manufacturer code of the remote unit(s). As a result of this polling, the fire panel may be able to detect an

approaching alarm condition and may take action accordingly.

[0051] As mentioned above, the remote units may comprise a unit controller. The unit controller may be a microcontroller. During the normal mode of operation, the unit controller may receive any signals from the fire panel, such as from the loop controller, and the method may include using the unit controller to analyse these signals. The method may include using the unit controller to decode any signals from the fire panel such that the encoded address can be determined. The method may therefore include using the unit controller to determine whether it is the remote unit that the signal is intended for based on the decoded address. Alternatively, the remote units may comprise a unit transceiver and the method may include using the unit transceiver for decoding signals received from the fire panel. The method may include using the unit controller to determine how to respond to signals from the fire panel. For example, if a signal from the fire panel is a polling signal, the unit controller may determine the status of the remote unit and communicate this information back to the fire panel. Alternatively, if the signal from the fire panel indicates an alarm condition, the unit controller may trigger an alarm condition in the remote unit.

[0052] The method may include using the unit controller to detect when master-slave communications have failed, and to trigger the remote unit to enter the degraded mode of operation in response. This may be done in addition to or instead of the use of a supervisor as discussed above. The method may include using the unit controller to monitor how frequently the remote unit receives polling signals from the fire panel. The frequency at which the remote unit receives polling signals from the fire panel may be considered to be a polling frequency. The method may include using the unit controller to compare the determined polling frequency to an expected polling frequency. The expected polling frequency may be the lowest frequency at which the master-slave communications are still considered to be functioning. The unit controller may determine that the master-slave communications have failed if the determined polling frequency falls below the expected polling frequency. If the unit controller determines that the master-slave communications have failed, the method may include using the unit controller to trigger the remote unit to enter the degraded mode of operation. As explained above, the method may include allowing communications between the unit controller and the current sensor in the degraded mode of operation, and may include using the unit controller to determine a response to the current detected by the current sensor in the degraded mode.

[0053] The method may include using the fire panel to communicate a fire alarm condition or a fault status to an operator and/or occupant of the building. The method may include communicating this fire alarm condition through a display and/or LED lights on the fire panel. For example, the fire panel may display one form of visual feedback (e.g. lighting up one LED light) when a fire alarm condition is detected, and display one form of visual feedback (e.g. lighting up a different LED light) when a fault in the circuit is detected. Additionally or alternatively, the method may include displaying information pertaining to the detected fire alarm condition or fault on the fire panel display. This information may inform an operator and/or occupant of the building of the source of the alarm condition or fault, and may comprise the address of the relevant remote unit and the zone in which it is located.

[0054] The plurality of remote units may comprise a voltage sensor for detecting voltage in the loop, and the method may include triggering an alarm condition in a remote unit when the voltage detected by that unit indicates a possible emergency. The method may include using the remote units to detect voltage in the loop in both the normal mode of operation and the degraded mode of operation.

[0055] The method may include using the voltage sensor to detect modulations in voltage in the loop. The method may include encoding the modulations in voltage with alarm information. For example, the method may include encoding the detected modulations in voltage with a digital binary code that contains alarm information. In the normal mode of operation, the method may include using the fire panel to transmit the modulations in voltage and to encode the modulations in voltage with the alarm information. The method may include communicating the detected modulation in voltage from the voltage sensor to the unit controller and/or the unit transceiver. The method may include decoding the detected modulation in voltage using the unit transceiver and/or the unit controller, such that the alarm information encoded in the modulation in voltage can be determined. If the decoded alarm condition is determined to be indicative of a possible emergency, the unit controller and/or the unit transceiver may trigger the remote unit to enter an alarm condition. Additionally or alternatively, the voltage sensor may comprise means for decoding the detected modulation in voltage, and the method may include using the voltage sensor to decode the detected modulations in voltage, and to trigger an alarm condition in the remote unit if the decoded alarm information of the detected modulation in voltage is indicative of an alarm condition.

[0056] The method may include encoding the modulations in voltage with address information. The address information may comprise an individual address and/or a zone address of the indicating device that has detected the possible emergency. The method may include encoding the address information in the form of digital binary code. In the normal mode of operation, the method may include using the fire panel to encode the modulations in voltage with the address information. The method may using the unit transceiver and/or the unit controller of the remote units to decode the detected modulation in voltage such that the address information encoded in the modulation in voltage can be determined. Additionally or alternatively, the voltage sensor may comprise means

for decoding the address information in the detected modulation in voltage. The method may include using the unit controller to determine a response based on the decoded alarm information and the decoded address information. For example, the unit controller may determine that the remote unit should only enter an alarm condition if it is in the same zone as the indicating device that has detected the possible emergency.

[0057] The method may include using the voltage sensor and/or the unit controller may to determine whether a detected voltage passes a predetermined voltage threshold value. The method may include using the voltage sensor to communicate the detected voltage to the unit controller and/or the unit transceiver only if the detected voltage passes the predetermined voltage threshold. Additionally or alternatively, the method may include using the remote unit to decode a detected voltage only if the if the detected voltage passes the predetermined voltage threshold. Thus, modulations in voltage that are the result of noise in the loop, and are therefore small, may be ignored. Alternatively, the method may include determining that the detected voltage is considered to indicate a possible emergency when it passes the predetermined voltage threshold value, and thus the method may include causing the remote unit may to enter an alarm condition if the remote unit determines that the detected voltage passes the predetermined voltage threshold value. The method may include determining that the detected voltage has passed the predetermined threshold value if the voltage falls below the predetermined voltage threshold value, or rises above the predetermined voltage threshold value.

[0058] The method may include using the at least one indicating device to modulate the current through the loop when the indicating device detects conditions indicative of a possible emergency. The modulation of the current may be an increase or a decrease in current. The remote unit may further comprise a resistor, and the method may include using the resistor to trigger the modulation of the current.

[0059] In the degraded mode, the remote units located along the loop in a first direction may detect the modulation of the current due to their current sensors. The first direction is a direction around the loop compared to the location of the indicating device that has detected the possible emergency, e.g. the current modulation may be detectable by other remote units that are forward of the indicating device. The method may include using the at least one indicating device to encode the modulation in current with alarm information. For example, the method may include using the at least one indicating device to encode the modulation in current with a digital binary code that contains the alarm information.

[0060] Hence, in the degraded mode the modulation of the current may cause other remote units located along the loop in the first direction to enter an alarm condition if the modulation of the current is indicative of an emergency condition. The method may include determining that the modulation of the current indicates a possible emergency if the encoded alarm information is indicative of a possible emergency. The method may include using the current sensor of the remote units that have detected the modulation in current to communicate the detected modulation in current to the unit controller and/or the unit transceiver. The method may include using the unit transceiver and/or the unit controller to decode the detected modulation in current, such that the alarm information encoded in the modulation in current can be determined. If the decoded alarm information is determined to be indicative of a possible emergency, the method may include using the unit controller and/or the unit transceiver to trigger the remote unit to enter an alarm condition. Additionally or alternatively, the current sensor may comprise means for decoding the detected modulations in current itself, and the method may include using the current sensor to trigger an alarm condition in the remote unit if the decoded alarm information of the detected modulation in current is indicative of an alarm condition.

[0061] The method may include using the at least one indicating to encode the modulation in current with address information. The address information may comprise an individual address of the indicating device and/or a zone address. The zone address may indicate the zone in which the indicating device is located. The method may include encoding the address information in the form of a digital binary code. The method may include using the remote units in the first direction along the loop from the indicating device to decode the detected modulation in current such that the address information can be determined. As mentioned above, the method may include decoding the detected modulation in current using the current sensor, the unit controller, and/or the unit transceiver. The method may include using the unit controller to determine a response based on the decoded alarm information and the decoded address information. For example, the unit controller may determine that the remote unit should only enter an alarm condition if it is in the same zone as the indicating device that has detected the possible emergency.

[0062] The method may include using the current sensor and/or the unit controller may to determine whether a detected modulation in current passes a predetermined current threshold value. The method may include communicating the detected modulation in current from the current sensor to the unit controller and/or the unit transceiver only if the detected modulation in current passes the predetermined voltage threshold. Additionally or alternatively, the method may include using the remote unit to decode a detected modulation in current only if the if the detected modulation in current passes the predetermined current threshold. Thus, any modulations in current that are the result of noise in the loop, and are therefore small, may be ignored. Alternatively, the method may include determining that the detected modulation in current indicates a possible emergency if it passes the predetermined current threshold value, and thus the method

may include causing the remote unit to enter an alarm condition if the remote unit determines that the detected modulation in current passes the predetermined current threshold value. The method may include determining that the detected modulation in current passes the predetermined current threshold value if the current falls below the predetermined current threshold value, or rises above the predetermined current threshold value.

[0063] The method may include using the at least one indicating device to modulate the current in the loop such that the voltage in the loop is also modulated. The modulation of the current caused by the at least one indicating device may occur together with an opposite modulation of the voltage in the loop. The modulation of the voltage may be an increase or a decrease in voltage, depending on if the modulation of the current is an increase or decrease in current. For example, if the modulation of the current is an increase in current, then it may cause a drop in voltage, and vice versa. Consequently, the modulation in voltage may be encoded with information that corresponds to that of the modulation in current. This modulation of the voltage may be detectable by other remote units in a second direction along the loop, wherein the second direction is opposite to the first direction. In the degraded mode, this modulation of the voltage may be detected by the remote units located along the loop in the second direction. Voltage detection by the voltage sensor of the remote units can therefore form a part of the degraded communications between the remote units, with this voltage detection being used along with current detection to allow an alarm condition to be detected by other remote units both forward of and behind the indicating device that has detected the possible emergency. Hence, the method may include triggering an alarm condition in the devices located along the loop in the second direction through the modulation of the voltage, and detection thereof, rather than through the modulation of the current detected by the current sensor.

[0064] As mentioned above, in the degraded mode, the modulation in voltage may be encoded with information that corresponds to the information encoded in the corresponding modulation in current. Thus, the modulation in voltage in the degraded mode may be encoded with alarm information and address information that corresponds to that of the modulation in current, and the method may include using the remote units located in the second direction along the loop from the indicating device to decode the detected modulations in voltage such that the alarm information and address information can be determined. The method may include using the unit controller of these remote units to determine a response based on the decoded alarm information and the decoded address information of the detected modulation in voltage.

[0065] The method may include using the at least one indicating device to modulate the current in the form of a current pulse. The method may include using at least one of the remote units to replicate any detected current pulses such that the corresponding modulation in voltage is amplified through the loop. This may ensure that the amplitude of the modulation in voltage is prevented from falling too low to trigger an alarm condition as it travels along the loop. Hence, replicating the current pulses in this way may ensure that the modulation in voltage is sufficiently large to trigger an alarm condition across the whole loop. The method may include using only the remote units that are within a certain proximity to the indicating device from which the current pulse originated to replicate a detected current pulse. For example, the method may include using the four remote units that are immediately adjacent to the indicating device from which the detected current pulse originated in the first direction to replicate a detected current pulse may be.

[0066] In the degraded mode, the method may include using the fire panel to create a high output impedance in the loop. As a result of this high output impedance, the modulation of the voltage in the loop is larger in the degraded mode of operation than it would be in the normal mode of operation. This enables the modulation of the voltage in the loop to be used in the degraded mode of operation to communicate an alarm condition to some of the remote units, as explained above.

[0067] At least one of the remote units comprises an indicating device. The method may include using the at least one indicating device for sensing conditions or for receiving inputs from users. For example the indicating device may include one or more of: manual call points; smoke detectors; heat detectors; other building sensors used for fire or heat detection, such as room thermostats; sensors for supervised doors; sensors for supervised fire extinguishers; water flow sensors; and so on. The method may include using input-output modules for handling information from some types of sensors that may lie outside of the fire system, such as thermostats or water flow sensors. The method may include using such information from sensors with master-slave communications via the loop, and thus may include adding extra information to the master-slave communications such that the fire panel can determine a course of action to take. In some examples, the use of this information from sensors is not available in the degraded mode. Additionally or alternatively, the method may include using input-output modules for activating fire extinguishers, fire sprinklers, automatic door opening and/or closure systems, or door locking systems. The indicating device may provide inputs for triggering an alarm condition of the fire system.

[0068] The method may include using the at least one indicator device to indicate an alarm condition of the fire system, such as through audible or visible devices. The indicator device may include one or more of: sirens; bells; speech sounders; other types of sounders; lights; beacons or remote indicators. The method may include using the indicator device for sending alarm notifications to users through one or more transmitter devices. The method may include sending notifications to local users, for example via wireless transmission of notifications to a mo-

bile device, and/or to remote users such as building management authorities and/or emergency services.

[0069] At least one of the remote units may comprise a combined indicating and indicator device, for example a device including detection capabilities along with an alarm, such as smoke detectors also including an audible alarm. The method may include carrying out combinations of any of the functions discussed above in relation to the indicating and indicator devices using such a remote unit.

[0070] At least one of the remote units may comprise a connection module for enabling communication of an alarm condition to an external system. The method may include using the connection module to connect to external hardware, and may include communicating the alarm condition from the communication module to the external hardware when the connection module enters an alarm condition. The method may include using the external hardware to, for example, trigger an emergency call or some other form of alert to emergency services, and/or trigger an alarm condition in an external alarm system. The method may include using the connection module to communicate the alarm condition to the external system in both the normal mode of operation and the degraded mode of operation. Alternatively, the method may include using the fire panel to communicate the alarm condition to any external systems during the normal mode of operation, and may only include using the connection module to fulfil this role in the degraded mode when the master-slave communications have failed.

[0071] Certain embodiments of the disclosure will now be described by way of example only and with reference to the accompanying drawings in which:

Figure 1 is a diagram of a fire system using a master-slave communication system;
Figure 2 is a diagram of a fire panel;
Figure 3 is a diagram of a fire system operating in a degraded mode; and
Figure 4 is a diagram of a combined indicator and indicating device.

[0072] As shown in Figure 1, a fire system 10 comprises a fire panel 12 and a number of remote units 14, 16, 18. The fire system 10 and remote units 14, 16, 18 are electrically connected in a loop configuration, joined by wire 20, with each remote unit positioned at a different location along the loop. This fire alarm 12 may be used to additionally provide power to the remote units 14, 16, 18. Alternatively, the remote units 14, 16, 18 may be powered independently of the fire alarm 12. The remote units of Figure 1 comprise indicating devices 14, indicator devices 16, and combined indicating and indicator device 18. Indicating devices 14 are used to detect conditions indicative of an emergency, and may include manual call points, smoke detectors, and/or heat detectors. Indicator devices 16 are used to alert users of an emergency condition and may include audible or visual devices, such as lights and/or bells. The combined indicating and indicator device 18 has a detection capability alongside an alarm, and may comprise a fire and/or smoke alarm. Although not shown in Figure 1, the fire system may further comprise fire suppression devices and/or a connection module for enabling communication with external devices.

[0073] The remote units 14, 16, 18 communicate with the fire panel 12 in a master-slave relationship. The remote units 14, 16, 18 send signals to the fire panel 12 through the wire 20 in the form of modulations in the current. These signals inform the fire panel 12 of the status of the remote units 14, 16, 18. The modulations in the current created by the remote units 14, 16, 18 may be increases or decreases in current, and may be encoded with information such as alarm, address, and/or fault information. For example, the modulations in current may be encoded with a digital binary code containing such information. In response, the fire panel 12 may issue a command to the remote units 14, 16, 18. For example, if indicating device 14 modulates the current in such a way that is indicative of a possible emergency, the fire panel 12 may send a command to the remaining remote units 14, 16, 18 instructing them to enter an alarm condition. Alternatively, the fire panel 12 may send this command to only some of the remote units 14, 16, 18, depending on the location and nature of the possible emergency. The command may be in the form of a modulation of the voltage, and may be encoded with information. For example, the command may be encoded with a digital binary code containing such information Typically, the current is modulated in one direction through the loop, whilst the voltage is modulated in the opposite direction. The remote units 14, 16, 18 therefore each comprise a voltage sensor, and are configured to enter an alarm condition when they detect a voltage that is indicative of a possible emergency.

[0074] The fire panel 12 may also periodically send polling signals to the remote units 14, 16, 18, and the remote units 14, 16, 18 may respond with information regarding their status, their address, and/or their manufacturer code. The fire panel 12 may poll the remote units 14. 16, 18 at regular time intervals, which may be determined based on a communications protocol that the fire system 10 is employing. Thus, the frequency of polling may be determined by the communications protocol of the fire system 10. The fire panel 12 may poll the remote units 14, 16, 18 by transmitting one or more commands in the form of one or more polling signals. As mentioned above, these polling signals may be encoded with information, such as an address of a remote unit. This information may be used to communicate which remote unit 14, 16, 18 the polling signal is intended for. The fire panel 12 may comprise means for alerting a user of a possible emergency. These means can include, but are not limited to, lights and/or a display.

[0075] The fire panel 12 is shown in Figure 2. The operation of the fire panel 12 is controlled by a loop controller

24, which may be a central processing unit (CPU). The loop controller 24 may process the information received from the remote units 14, 16, 18 and decide how to respond. The loop controller 24 may decide whether it is necessary to communicate an alarm condition to some or all of the remaining remote units 14, 16, 18. The loop controller 24 may cause the remote units 14, 16, 18 to enter an alarm condition at different times, in order to aid and manage evacuation of a building. The fire panel 12 may also comprise a supervisor 22, which will be described in further detail later.

[0076] It will be appreciated that in a master-slave communications system, the remote units 14, 16, 18 are only alerted to the existence of a possible emergency through communications from the fire panel 12, unless they detect the emergency themselves. Hence, fire systems comprising only master-slave communication systems are entirely reliant of the correct operation of those systems to trigger an alarm across the whole loop. This can lead to safety issues when failure of the master-slave communications occurs.

[0077] Figure 3 shows a fire system 10 that is configured to address this problem. The fire system 10 of Figure 3 is operating in a degraded mode of operation, in which a degraded communications mode for the remote units 14, 16, 18 is established. In Figure 3, the fire panel 12 has detected a failure of the master-slave communication system and has triggered the degraded mode. This failure may be detected by the supervisor 22 (shown in Figure 2), which is configured to supervise the loop controller 24. The supervisor 22 may operate independently from the loop controller 24, and thus may continue to operate correctly even when there is a fault in the loop controller 24. The supervisor 22 may be added to the fire panel 12 as an additional software element, hardware element, or a combination of the two, and may be a CPU supervisor. In response to detecting that the master-slave communications have failed, the supervisor 22 may trigger the fire system 10 to enter the degraded mode of operation, and create a high output impedance in the loop.

[0078] The supervisor 22 may comprise an auxiliary controller, and the auxiliary controller may supervise the loop controller 24. The auxiliary controller may monitor how frequently the loop controller 24 communicates with the loop 20. The auxiliary controller may determine that the master-slave communications have failed if it detects that the frequency at which the loop controller 24 communicates with the loop 20 drops below a minimum threshold frequency. The minimum threshold frequency may be the frequency at which communications between the loop 20 and the loop controller 24, and/or the master-slave communications, are considered to have failed. In response to this detection, the auxiliary controller may trigger the fire system 10 to enter the degraded mode, and may create the high output impedance in the degraded mode.

[0079] In order to communicate with one another in the degraded mode, the remote units 14, 16, 18 comprise a current sensor 26 (as shown in Figure 4). Equipping the remote units 14, 16, 18 with a current sensor 26 in this way therefore provides these remote units with the ability to detect any modulations in the current passing by them in the loop in the degraded mode, and enter an alarm condition if the detected modulations in current are indicative of a possible emergency. Hence, the remote units 14, 16, 18 are able to communicate with one another in the degraded mode through these modulations in the current.

[0080] The remote units 14, 16, 18 may comprise a unit controller 28 (shown in Figure 4). The unit controller 28 may determine a response to any signals detected by the remote unit 14, 16, 18. For example, the unit controller 28 may determine a response to any detected signals from the fire panel 12, such as polling signals. The unit controller 28 may monitor the frequency at which the remote unit 14, 16, 18 receives polling signals, which may be known as a polling frequency. The unit controller 28 may compare this detected polling frequency with an expected polling frequency. The expected polling frequency may be the polling frequency at which the master-slave communications are considered to have failed, and may be based on the communications protocol of the fire system 10. The unit controller 28 may trigger the degraded mode in the remote unit 14, 16, 18 if it detects that the detected polling frequency has fallen below the expected polling frequency.

[0081] The current sensor 26 may be in a 'sleep' mode during normal operation of the fire system 10. In the 'sleep' mode, the current sensor 26 may not be active and may not measure any current in the loop. When the unit controller 28 triggers the degraded mode, the unit controller 28 may 'wake up' the current sensor 26 such that the current sensor 26 begins measuring the current in the loop and communicating with the unit controller 28. Alternatively, the current sensor 26 may always be in an active state, but the unit controller 28 may only begin communications with the current sensor when the degraded mode has been triggered.

[0082] As shown in Figure 3, a remote unit 18 may detect conditions indicative of a possible emergency. In response to this, the remote unit 18 may modulate the current in the loop in such a way that indicative of this emergency. The remote unit 18 may encode this modulation in current with information that is indicative of a possible emergency. The modulation in current may travel in a first direction A along the loop. In Figure 3, the first direction A is shown as being in an anti-clockwise direction along the loop; however, it will be appreciated that the modulation in current may be transmitted in either direction around the loop depending on the electrical configuration of the fire system 10. The current sensors 26 of other remote units located in the first direction along the loop will be able to detect this modulation of the current, and may trigger an alarm condition in the other remote units.

[0083] However, it will be appreciated that, since the

modulation in current is detectable only in a single direction along the loop, it cannot communicate the alarm condition to the remote units located in the opposite direction along the loop.

[0084] By modulating the current in the first direction A along the loop, a corresponding but inverse modulation of the voltage will be experienced in a second direction B along the loop, wherein the second direction B is opposite to the first direction A. For example, if the modulation in current is an increase in current detectable by remote units in the first direction A, then there will be a decrease in voltage detectable by remote units in the second direction B. Consequently, the modulation in voltage in the second direction B will be encoded with information that corresponds to the information encoded in the corresponding modulation in current. Hence, in Figure 3, the remote unit 18 will also modulate the voltage in the loop when it detects conditions indicative of an emergency.

[0085] This modulation of the voltage will be experienced when the current is modulated in both the normal mode of operation and the degraded mode of operation. In the normal mode of operation, the modulation of the voltage is typically too small to trigger an alarm condition in the remote units 14, 16, 18. However, these modulations of the voltage are larger in the degraded mode of operation due to the high output impedance in the loop. Therefore, in the degraded mode, when the current is modulated in the first direction A such that it is indicative of a possible emergency, the resultant modulation of the voltage in the second direction B will be sufficiently large to trigger an alarm condition in the remote units 14, 16, 18 located in that direction.

[0086] Hence, in the degraded mode, the alarm condition will be communicated to the other remote units located along the first direction A in the loop through the modulation of the current, and the alarm condition will be communicated to the other remote units located along the second direction B in the loop through the modulation of the voltage. The degraded mode therefore enables all the remote units 14, 16, 18 in the loop that have current and voltage sensors to be alerted to the alarm condition, even when the master-slave communications have failed.

[0087] The remote unit 18 may modulate the current in the form of a current pulse. Further, at least one of the remote units 14, 16, 18 may be configured to replicate any current pulses it detects. This aids the detection of the alarm condition by voltage sensing for the devices located along the direction B from the remote unit that has detected the alarm condition, since the amplification of the current pulses will create a corresponding amplification of the voltage drop in the loop.

[0088] The remote units 14, 16, 18 may only enter an alarm condition if they detect a modulation in the current or voltage that is indicative of a possible emergency. This may be determined by comparing the detected modulation in current or voltage to a predetermined current or voltage threshold value, respectively, or by decoding a binary code within the modulated signal, e.g. via pulses in the signal. The current sensors 26 of the remote units may determine whether the modulation in the current is indicative of a possible emergency. Alternatively, the unit controller 28 may determine if the modulation in the current is indicative of a possible emergency. Alternatively, the current sensor 26 and the unit controller 28 may work together to determine if the modulation in the current is indicative of a possible emergency.

[0089] In the case of a threshold value, if the detected current or voltage passes this predetermined current or voltage threshold, then it may be considered to be indicative of a possible emergency. If the remote units 14, 16, 18 are configured to modulate the current such that it increases in value, then the current may be determined to pass the predetermined current threshold value only when it exceeds the predetermined current threshold value, whilst the voltage may be determined to pass the predetermined voltage threshold value only when it falls below the predetermined voltage threshold value. Alternatively, if the remote units 14, 16, 18 are configured to modulate the current such that it decreases in value, then the current may be determined to pass the predetermined current threshold value only when it falls below the predetermined current threshold value, whilst the voltage may be determined pass the predetermined voltage threshold value only when it exceeds below the predetermined voltage threshold value. The predetermined current and voltage thresholds may be determined during installation of the fire system 10, and may be updated based on subsequent maintenance of the fire system 10 to account for any degradation of the system.

[0090] In the case of an encoded signal, the current sensor 26 and/or the voltage sensor of the remote units 14, 16, 18 may receive and decode any detected signals, and may communicate the decoded signal to the unit controller 28, which may then determine that the remote unit 14, 16, 18 should enter an alarm condition based on the decoded signal. Alternatively, the current sensor 26 and/or voltage sensor may communicate the detected signal directly to the unit controller 28, and the unit controller may decode the detected signals itself. Alternatively, the remote units 24, 26, 28 may comprise a unit transceiver, and the unit transceiver may decode the detected signals and communicate the decoded signals to the unit controller. The modulation in current, and corresponding modulation in voltage, may be determined to be indicative of a possible emergency if the alarm information encoded in the signal is indicative of a possible emergency.

[0091] In this case, the current sensor and/or the voltage sensor may use the predetermined current and/or voltage threshold value to determine whether the detected signal is large enough to warrant a response. For example, the current sensor 26 and/or voltage sensor may compare the detected signal with the corresponding threshold value. If the detected signal does not pass the

predetermined threshold value, the sensor may not communicate the detected signal to the unit controller 28. Alternatively, the unit controller 28 may compare the detected signal with the corresponding predetermined threshold value, and may only decode the signal if the detected signal is determined to pass the predetermined threshold value.

[0092] Indicating device 18 may encode the modulations in current, and hence the corresponding modulations in voltage, with address information. The address information may include individual address information (which describes the specific indicating device that has detected the alarm condition), and/or zone address information (which describes the zone in which the indicating device that has detected the alarm condition is located in). The remote units 14, 16, 18 may be able to decode the address information from the detected signals, for example through the current sensor 26, the voltage sensor, the unit transceiver, and/or the loop controller 28. The loop controller 28 may use the address information to determine whether the remote unit 14, 16, 18 should enter an alarm condition. For example, the unit controller 28 may determine that the remote unit 14, 16, 18 should only enter an alarm condition if it is in the same zone as the indicating device 18.

[0093] An exemplary combined indicating and indicator device 18 is shown in Figure 4, comprising a current sensor 26, a unit controller 28, an indicating component 30, indicator component 32, and an input-output module 34. As mentioned above, the remote units 14, 16, 18 may comprise indicating devices 14, indicator devices 16, or combined indicator and indicating devices 18. These can include manual call points; smoke detectors; heat detectors; other building sensors used for fire or heat detection, such as room thermostats; sensors for supervised doors; sensors for supervised fire extinguishers; water flow sensors; sirens; bells; lights; transmitter devices and so on. The fire system 10 may include input-output modules 34 for handling information from some types of indicating devices 14 that may lie outside of the fire system 10, such as thermostats or water flow sensors. Such information from the input-output modules 34 may be used in the master-slave communications to provide extra information to the fire panel 12, but in some examples may not be used in the degraded mode. Additionally or alternatively input-output modules 34 may be provided for activating automatic door opening and/or closure systems, or door locking systems.

[0094] The degraded mode of operation therefore provides redundancy to the fire system 10 for safety purposes. The degraded mode can be achieved by modifying a fire system 10 that would typically only employ master-slave communications such that the fire panel 12 comprises a supervisor 22, and the remote units 14, 16, 18 comprise a current sensor 26. The addition of the current sensor 26 allows communication between the remote units 14, 16, 18 to be established in the degraded mode, removing the reliance on the fire panel 12 to correctly activate an alarm when there is a possible emergency. The fire system 10 can therefore operate correctly even when the primary means of communication, i.e. the master-slave communication system, fails. A fire system with improved reliability and safety is provided by the use of such current sensors 26 for a degraded communication mode.

Claims

1. A fire system for a building, the fire system comprising:

   a fire panel for monitoring the building and activating an alarm, the fire panel comprising a loop controller; and
   a plurality of remote units electrically connected to the fire panel in a circuit having a loop configuration, at least one of the plurality of remote units comprising an indicating device for determining conditions that are indicative of a possible emergency and modulating a current in the circuit when those conditions indicate a possible emergency;
   wherein the plurality of remote units are in communication with the fire panel in a master-slave relationship;
   wherein the system is configured to enter a degraded mode of operation when failure of the master-slave communications occurs, the fire panel being configured to create a high output impedance in the circuit and enable a degraded communications mode for the remote units in the degraded mode; and
   wherein each of the plurality of remote units comprises a current sensor for detecting current in the degraded mode.

2. The fire system as claimed in claim 1, wherein the fire panel comprises a supervisor for supervising the loop controller.

3. The fire system as claimed in claim 2, wherein the supervisor is configured to detect the failure of the master-slave communications and trigger the degraded mode of operation.

4. The fire system as claimed in claim 2 or 3, wherein the supervisor is configured to create the high output impedance in the circuit in the degraded mode.

5. The fire system as claimed in any preceding claim, wherein the plurality of remote units are configured to enter an alarm condition when a detected current is indicative of a possible emergency.

6. The fire system as claimed in any preceding claim,

wherein the at least one indicating device is configured to encode the modulation in current with alarm information, and, in the degraded mode, the current sensors of at least some of the remote units are configured to decode any detected modulations in current such that the alarm information can be determined.

7. The fire system as claimed in any preceding claim, wherein the plurality of remote units comprise a voltage sensor for detecting voltage in the loop.

8. The fire system as claimed in claim 7, wherein the plurality of remote units are configured to enter an alarm condition when a detected voltage is indicative of a possible emergency.

9. The fire system as claimed in any preceding claim, wherein the at least one indicating device is configured to modulate the current in the loop such that the voltage in the loop is also modulated.

10. The first system as claimed in any preceding claim, wherein the at least one indicating device is configured to modulate the current in the form of a current pulse.

11. The fire system as claimed in claim 10, wherein at least one of the remote units is configured to replicate any detected current pulses.

12. The fire system as claimed in any preceding claim, wherein the at least one indicating device is configured to provide inputs for triggering an alarm condition of the fire system and includes components for sensing conditions and/or for receiving inputs from users.

13. The fire system as claimed in claim 12, wherein the at least one indicating device includes at least one of manual call points; smoke detectors; heat detectors; other building sensors used for fire or heat detection; sensors for supervised doors; sensors for supervised fire extinguishers; and water flow sensors; and/or wherein at least one of the remote units includes one more indicator device(s) for indicating an alarm condition of the fire system, optionally wherein the indicator device(s) include an audible or visible alert device and/or a transmitter device for sending alarm notifications to users.

14. The fire system as claimed in any preceding claim, wherein the remote units may include at least one fire suppression system(s), including fire suppression device(s) that can be triggered in an alarm condition.

15. A method of operating a fire system as claimed in any preceding claim, wherein the method comprises operating the fire system in the degraded mode when failure of the master-slave communications between the remote units and the fire panel occurs.

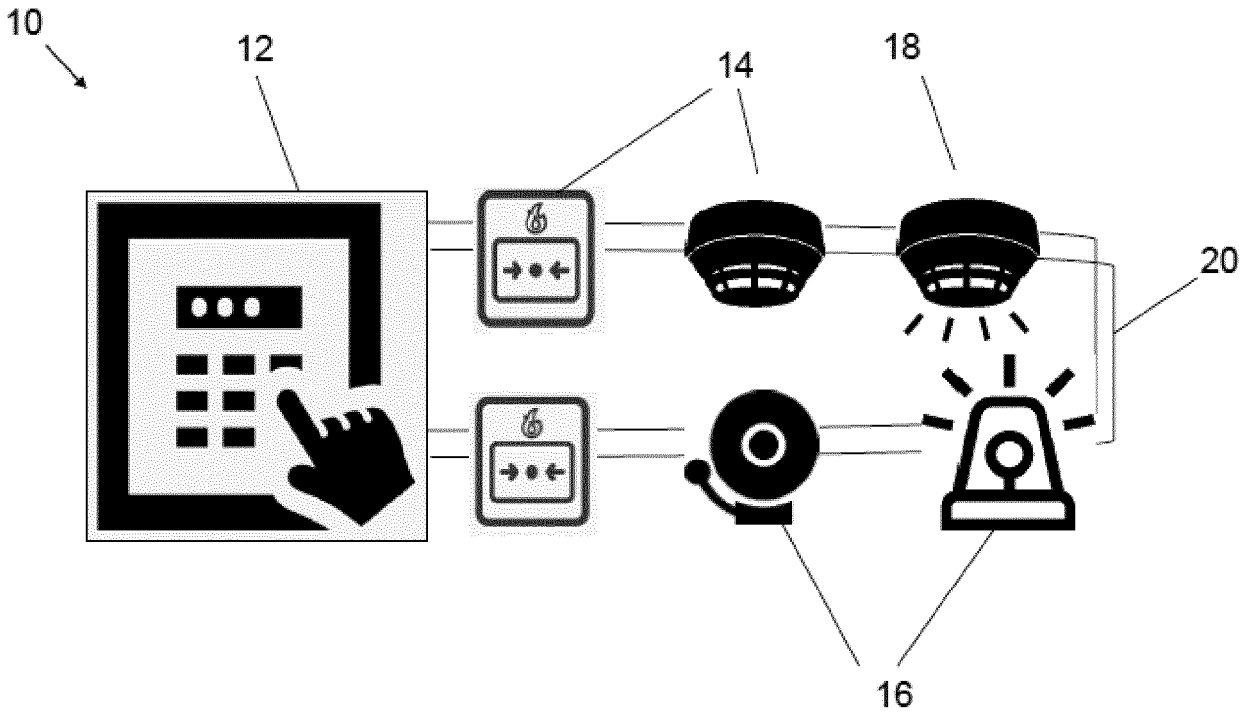

Fig. 1

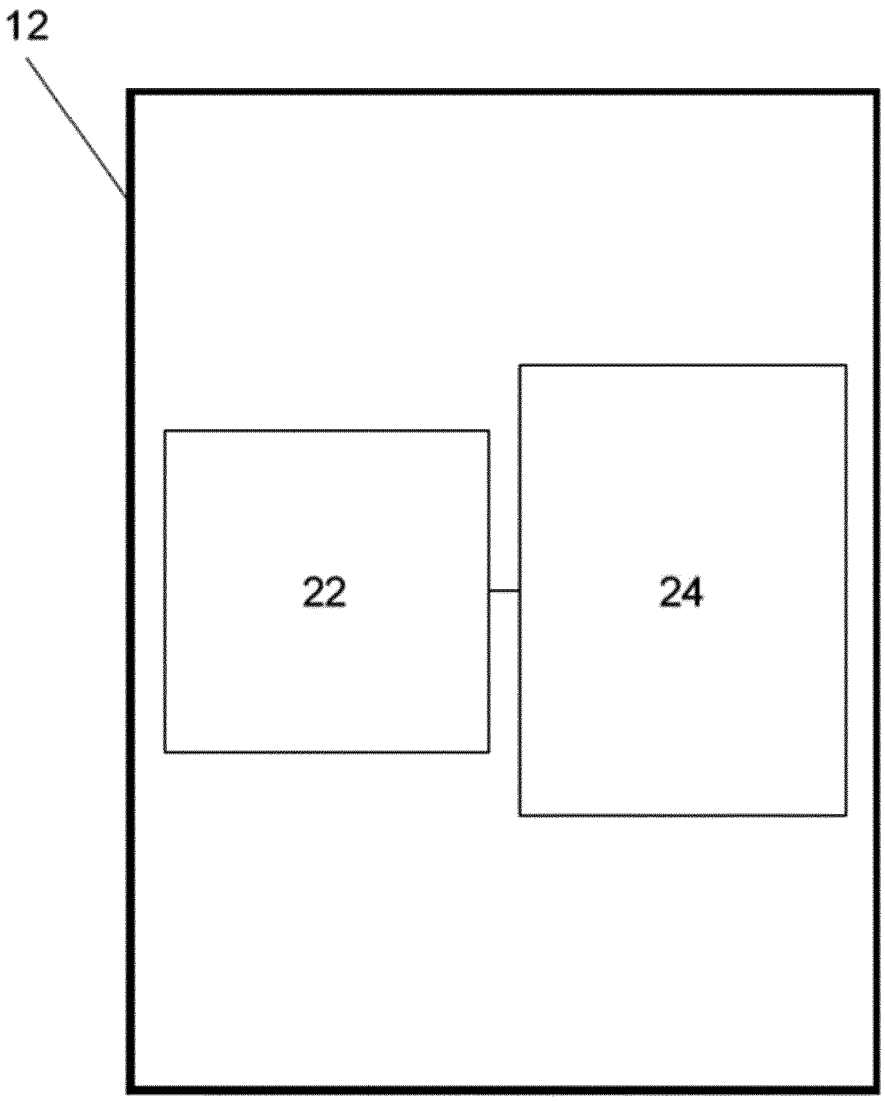

Fig. 2

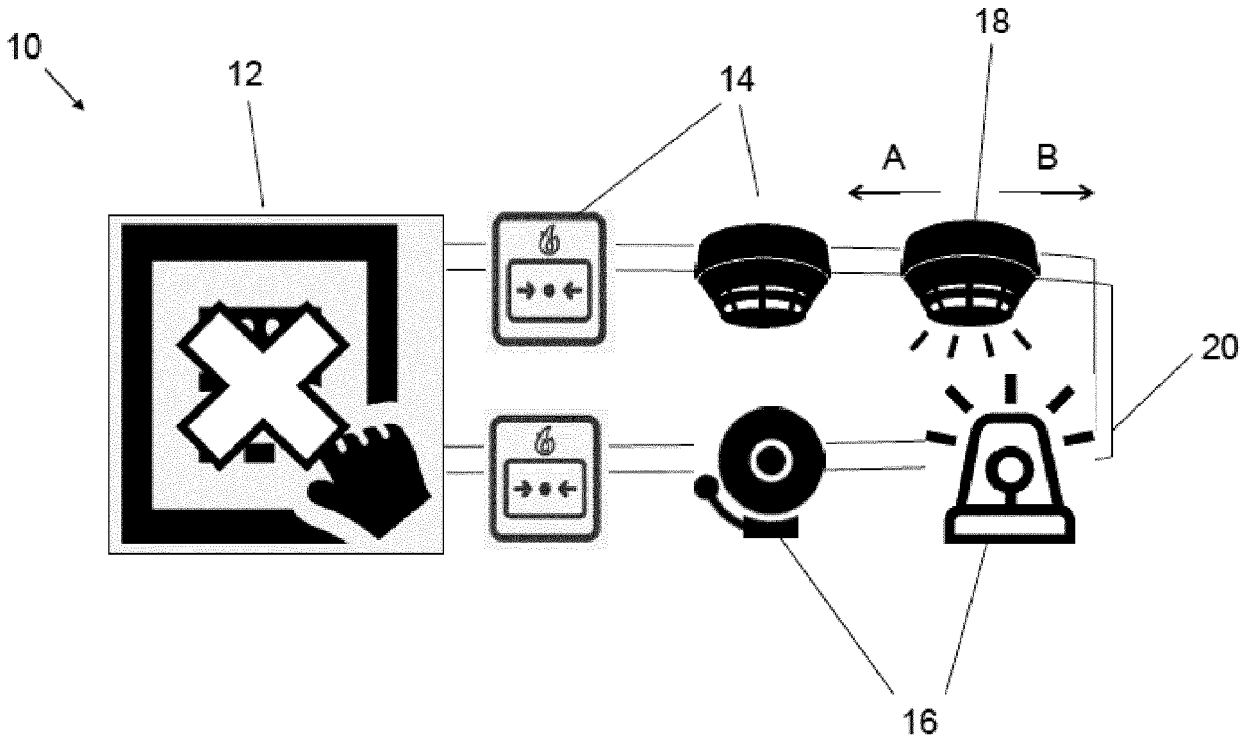

Fig. 3

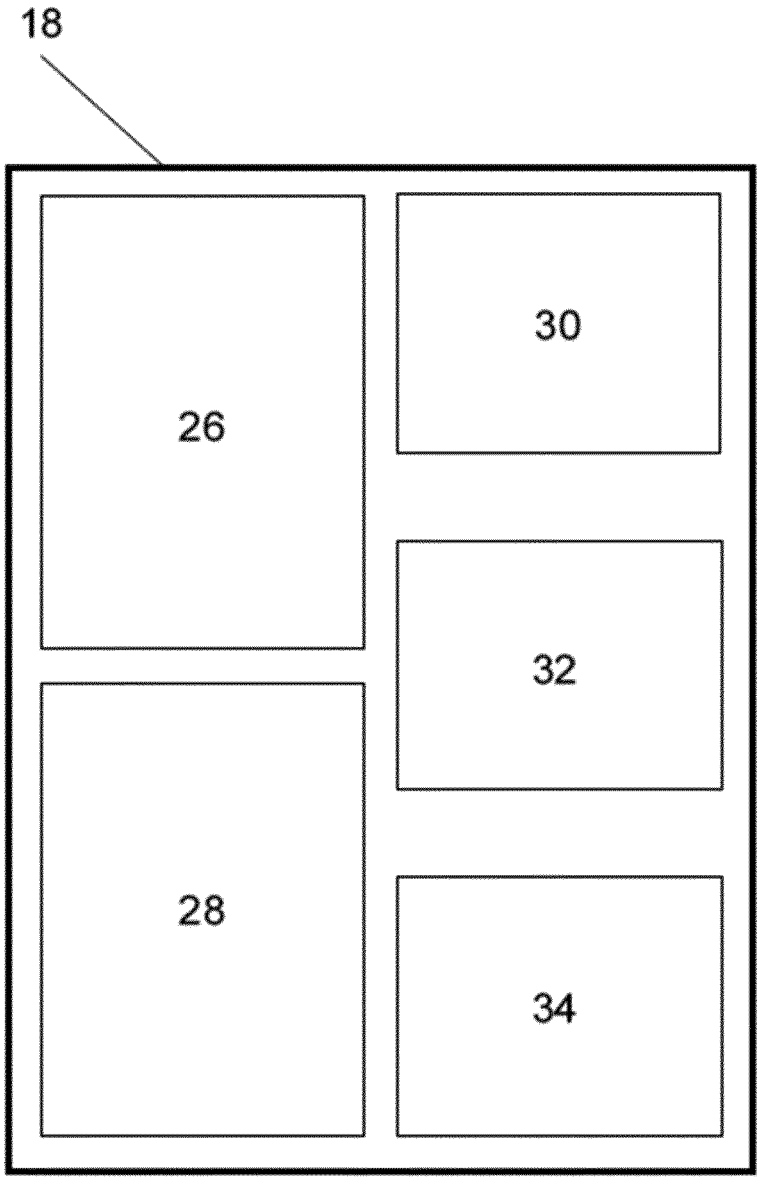

Fig. 4

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EUROPEAN SEARCH REPORT

Application Number
EP 21 38 2281

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2012/159237 A1 (SKRODZKI AXEL [DE] ET AL) 21 June 2012 (2012-06-21) * paragraph [0001] - paragraph [0004] * * paragraph [0009] - paragraph [0031] * * paragraph [0035] - paragraph [0038] * * paragraph [0042] - paragraph [0045] * * figures *	1-3,5, 7-15	INV. G08B25/04 G08B25/14
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	16 September 2021	Königer, Axel

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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