



(51) International Patent Classification:

G01S 11/06 (2006.01)

G01S 13/87 (2006.01)

G01S 13/56 (2006.01)

H05B 47/115 (2020.01)

(21) International Application Number:

PCT/EP2020/050692

(22) International Filing Date:

13 January 2020 (13.01.2020)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

PCT/CN2019/072186

17 January 2019 (17.01.2019) CN

19159254.2 26 February 2019 (26.02.2019) EP

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(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN,

HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

- as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))
- as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))

Published:

- with international search report (Art. 21(3))

(54) Title: PRESENCE DETECTION CIRCUIT AND METHOD

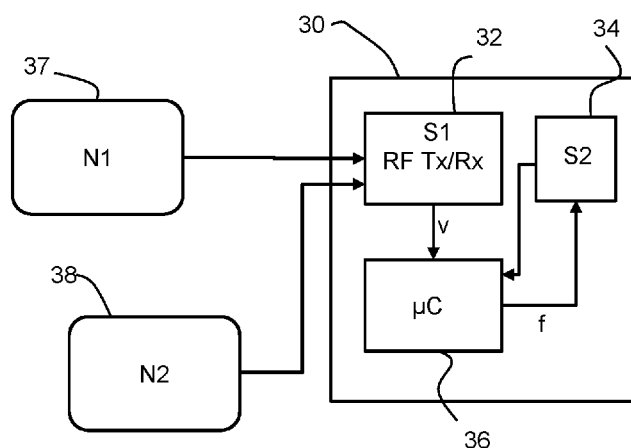


FIG. 3

(57) Abstract: A presence detection circuit comprises a first sensing module for sensing an object and determining information relating to a speed of movement of the sensed object, and a microwave sensor operated in an interrupted mode with a repetition frequency. The repetition frequency depends on the information relating to the speed of movement.

Presence detection circuit and method

FIELD OF THE INVENTION

This invention relates to presence detection circuits, for example to enable automated operation of a device in response to user presence. For example, automated control of lighting is well known based on detection of occupants with a space to be
5 illuminated.

BACKGROUND OF THE INVENTION

Presence detection is for example based on the use of motion sensors. Motion sensors have been widely used in lighting applications to realize occupancy-based lighting control to give energy savings. Furthermore, wireless intelligent lighting system (e.g., ZigBee
10 based) are also becoming more and more popular.

Traditionally, motion sensors are based on passive infrared (PIR) sensors, which measure IR light in a field of view.

There is an increasing interest in the use of microwave sensors. These may detect motion based on Doppler measurements. Unlike PIR sensors, they are able to penetrate non-metal materials. This gives advantages for integration into a lighting device, by eliminating the mandatory of line-of-sight. Therefore, microwave motion sensors have become the preferred choice for lamps such as TLED and LED bulbs.
15

Microwave sensors consume more power than PIR sensors during operation. The PIR sensor is a passive component, and only the associated electronics (e.g. amplifiers and filters) consume some power. Typically, this is of the order of tens of mW.
20

The microwave sensor is an active device (sending and receiving electromagnetic waves). A typical power consumption for lighting applications is of the order of 100mW. This brings a challenge with respect to compliance on standby power legislation, which is becoming stricter and stricter.
25

Low-cost microwave sensors that are affordable to integrate into lighting products operate using a continuous wave (CW) Doppler mode. One known method to reduce the power consumption of such microwave sensors is to work in an interrupted CW mode. This means that the sensor is switched on and off with a certain duty cycle and

frequency to reduce its average power consumption. The output of the microwave sensor then must be processed by sample and hold circuitry to enable representative readings from the sensor to be obtained.

The frequency of the pulsed operation needs to be sufficient to capture the frequency components resulting from the motion signal of interest. Each pulse also needs to have a certain duration to enable signal sampling. Thus, it is not possible to reduce the power consumption indefinitely. The higher the frequency, the higher the power consumption, but a minimum frequency is needed to capture the signal of interest.

There remains a need to reduce the power consumption of a microwave sensor, even when operated in an interrupted sensing mode.

US20170135180A1 discloses that detecting the density of objects, and a sensor of a second type can be turned on or off according to higher or lower density of objects occurs.

EP3276369A1 discloses detecting motion activity according to RSSI (Received Signal Strength Information).

SUMMARY OF THE INVENTION

It is a concept of the invention to use a first type of motion sensor to sense an object and determine information relating to a speed of movement of the sensed object. A microwave sensor is then used in an interrupted mode with a repetition frequency which depends on the information relating to the speed of movement. By taking speed information into account, power consumption can be reduced by selecting a repetition frequency which is suitable for the object being sensed, in particular its speed.

The invention is defined by the claims.

In accordance with an example of the invention, there is provided a presence detection circuit, comprising:

a first sensing module adapted to sense an object and determine information relating to a speed of movement of the sensed object;

a second sensing module, of a different type to the first sensing module and comprising a microwave sensor, adapted to sense the object; and

a controller adapted to operate the second sensing module in an interrupted mode with a repetition frequency which depends on the information relating to the speed of movement.

This presence detection circuit makes use of two mechanisms for presence detection. The first sensing module is used to provide an initial indication of the presence and speed of a detected object. It is preferably a low power sensing approach, and indeed it may make use of sensing signals which are required in any case for other purposes.

5 The first sensing module does not need to have high accuracy. It may for example be operated in such a way as to give false positive rather than false negative results (i.e. it over-reports the presence of objects).

 In response to detection by the first sensing module, the mode of operation, in particular the repetition frequency, of the microwave sensor is selected. A lower repetition
10 frequency corresponds to low power consumption but is for example only suitable for signals from slow moving objects, where there may not be high frequency signal components needing to be detected.

 In this way, the first sensing module is used to enable operation of the microwave sensor in a most power efficient manner having regard to the signals that are to be
15 detected.

 By repetition frequency is meant the frequency with which samples of data are captured. The higher the frequency, the shorter the time between sampling instants so the greater the power consumption (assuming a fixed time required for obtaining a sample). The repetition frequency can be adjusted also taking into account information from the
20 microwave sensor itself, so that the repetition frequency can be adjusted while a sensed object continues to be sensed. When there is no sensed object, the microwave sensor can default to its lowest power mode, i.e. its lowest repetition frequency.

 At the limit, the microwave sensor may effectively be turned off, and only be reactivated when an object is first sensed by the first sensing module. The first sensing
25 module then activates and triggers the second sensing module as well as being used for setting the repetition frequency.

 The first sensing module may comprise an RF module adapted to receive RF signal transmissions, for example 2.4GHz RF transmissions.

 These RF signal transmissions may be part of a separate communication
30 system. Thus, the presence detection function, which does not need to be accurate, may be provided as an extra feature of existing RF communications. The presence detection is for example based on human body interference with radio wave signals, such as fading and shadowing effects which cause irregularities in the radio wave signature.

The presence detection circuit may comprise a component of one node of a network of nodes forming a communications network, and wherein the RF signal transmissions comprise communications between network nodes.

The nodes may all be at fixed locations (such as luminaires) so that the expected transmission and reception characteristics are known and expected to be largely constant over time. This makes it possible to identify irregularities caused by other objects. Furthermore, these communications between nodes may simply be existing network management messages so they do not need to be designed specifically for object detection.

The first sensing module may be adapted to analyze signal strength variations over time of received RF signal transmissions, thereby to determine the speed of movement of the sensed object.

This provides one way to analyze irregularities.

The first sensing module may be adapted to determine variations in the received signal strength indication, RSSI, associated with the received RF signal transmissions so as to determine the speed of movement of the sensed object.

The microwave sensor of the second sensor module preferably comprises a Doppler shift microwave sensor. Low cost microwave sensors operating in Doppler mode are known. This invention enables them to be operated in an interrupted mode in a power efficient manner.

The repetition frequency is for example selected to be higher than a Nyquist frequency associated with a Doppler shift frequency caused by the speed of movement.

This ensures that the frequency spectrum of the Doppler shift signals caused by the object movement are all sampled to enable reliable movement detection.

The controller may be adapted to categorize the speed of motion into a plurality of speed level categories, and to apply a predetermined repetition frequency for each speed level category.

This provides a simple processing approach, where accurate speed information is not needed. The speed may be categorized as slow, medium or fast. The presence detection is for example for detecting people in an indoor space, and they may for example be sitting, walking or running. The repetition frequency is then higher for higher speed level categories.

The second sensing module, after operating in the interrupted mode, for a certain duration, with the repetition frequency which depends on the information relating to the speed of movement sensed by the first sensing module, may be adapted to refine the information related to the speed of movement by itself. The controller is then adapted to

operate the second sensing module in the interrupted mode with a refined repetition frequency which depends on the refined information related to the speed of movement.

In this way, the repetition frequency (for the second sensing module) is initially set by the first sensing module (while the first sensing module operates in continuous mode), but when the second sensing module is triggered, it may itself take over the calculation of the speed of movement, and thereby set its own (refined) repetition frequency.

The invention also provides a lamp, comprising:

a lighting unit; and

a presence detection circuit as defined above, wherein the the first sensing module of the presence detection circuit comprises an RF transceiver of the lamp which is used to communicate with other lamps which form a communications network with the lamp.

The invention also provides a presence detection method, comprising:

using a first sensor module to sense an object and determine information relating to a speed of movement of the sensed object;

setting a repetition frequency for a second sensing module for sensing the object, comprising a microwave sensor to be operated in an interrupted mode, according to the information relating to the speed of movement; and

operating the second sensing module with the set repetition frequency.

This is the method implemented by the circuit defined above.

Using the first sensing module may comprise receiving RF signal transmissions, for example 2.4GHz RF transmissions. The method may be implemented in one node of a network of nodes forming a communications network, and using the first sensor module may comprise receiving RF signal transmissions which are communications from other network nodes. Thus, the first sensor module is implemented with no additional overhead.

Determining information relating to a speed of movement may comprise analyzing signal strength variations over time of received RF signal transmissions.

Operating the second sensor module may comprise operating a Doppler shift microwave sensor and wherein the repetition frequency is selected to be higher than a Nyquist frequency associated with a Doppler shift frequency caused by the speed of movement.

These and other aspects of the invention will be apparent from and elucidated with reference to the embodiment(s) described hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of the invention, and to show more clearly how it may be carried into effect, reference will now be made, by way of example only, to the accompanying drawings, in which:

5 Fig. 1 shows a known microwave occupancy sensor system which is adapted for use in an interrupted CW mode;

 Fig. 2 shows waveforms to explain the timing of operation of the circuit of Fig. 1;

 Fig. 3 shows a presence detection circuit in accordance with an example of the
10 invention;

 Fig. 4 shows a lamp using presence detection circuit; and

 Fig. 5 shows a presence detection method.

DETAILED DESCRIPTION OF THE EMBODIMENTS

15 The invention will be described with reference to the Figures.

 It should be understood that the detailed description and specific examples, while indicating exemplary embodiments of the apparatus, systems and methods, are intended for purposes of illustration only and are not intended to limit the scope of the invention. These and other features, aspects, and advantages of the apparatus, systems and
20 methods of the present invention will become better understood from the following description, appended claims, and accompanying drawings. It should be understood that the Figures are merely schematic and are not drawn to scale. It should also be understood that the same reference numerals are used throughout the Figures to indicate the same or similar parts.

25 The invention provides a presence detection circuit which comprises a first sensing module for sensing an object and determining information relating to a speed of movement of the sensed object, and a microwave sensor operated in an interrupted mode with a repetition frequency. The repetition frequency depends on the information relating to the speed of movement.

30 Figure 1 shows a known microwave occupancy sensor system 10 which is adapted for use in an interrupted CW mode.

 The sensor system 10 comprises a microwave sensing unit 12 (having a microwave transmitter and receiver, and associated control electronics, not separately shown).

The power source 14 for the sensor system is coupled through a switch 16 so that power is intermittently provided to the microwave sensing unit 12. The sensing unit signal is provided to a sampling unit 18 which carries out sampling at a time instant set by a controller 20. The controller 20 also operates the switch 16, and sets the duty cycle DC and frequency f of operation of the switch 16. The sampled signal is applied to a delay and hold unit 22, and the delayed signal is read by the controller at a particular time instant.

The microwave sensing unit is itself well known and is not described in detail. In general, the microwave sensor comprises a microwave transmitter, a microwave receiver and a processor for analyzing the received signals.

One sensing approach is based on echo times, namely the length of time taken for the signals to return to the receiver. The echo time profile across the field of view enables the calculation of distances from any stationary object within the detection zone and establishes a baseline for a motion detector. A microwave sensor for example uses a baseline room analysis to detect the current distance from stationary objects within the detection range, after which it will return to motion sensing state. When a person enters the detection zone, this interrupts the microwave signal and therefore alters the echo time received by the motion detector. This will be perceived by the motion detector as a change in distance from a stationary object.

This invention is of particular interest for microwave sensors that use the Doppler effect. The transmitted microwave signal is compared against the received returned signal for frequency shifts, indicating movement. This Doppler analysis is suitable for intermittent operation in that frequency components of the returned signal are of interest.

The Doppler analysis also enables the speed of the sensed object to be determined.

Microwave presence detectors are sensitive to movement and are ideal for large spaces and areas that have an awkward shape or where fine motion detection is required. They have a much greater coverage and higher sensitivity and can for example detect movement through glass or walls.

Figure 2 shows waveforms to explain the timing of operation of the circuit of Figure 1. The top plot 24 shows the activation times of the sensing unit 12 and hence shows the control signal for the switch 16. The time period t_{OFF} represents the time when power savings are obtained. The bottom plot 26 shows the sampling time periods of the sampling unit. The time period t_{HOLD} represents the time delay of the delay and hold unit 22.

The controller 20 determines the on and off times of the sensing unit with a certain frequency such as 100 Hz and duty cycle such as 2% or 200 μ s. For each on period, the controller 20 controls the sampling unit to sample within the on phase of the sensing unit and the delay and hold unit holds the signal during the whole off phase of the sensor.

5 Just before the next on phase of the sensor (in the next sampling period), the controller 20 reads the signal from the delay and hold circuit for further processing, e.g., motion detection.

To ensure a reasonable sensing performance, e.g., accurate detection of human motion, the frequency of the pulsed operation of the sensing unit needs to fulfill at least the
10 Nyquist theorem for sampling. Thus, the sampling frequency needs to be at least double the highest Doppler shift frequency of interest.

For example, for a microwave sensor with a carrier frequency of 5.8 GHz, each km/h of motion speed accounts for 10.6Hz of Doppler shift. For a motion speed of 10 km/h, frequencies up to 106 Hz can be expected. In this case, the sampling frequency should
15 be at least 212Hz.

The repetition frequency of the sensing unit should preferably be an integral multiple of the sampling frequency, so at least the same as the sampling frequency. In this way, the sampling instants in combination provide a train of pulses at least matching the desired sampling frequency (212 Hz in this example).

20 The on phase of each sampling period needs to have only the minimal value to ensure a proper stabilization of the microwave sensing unit (e.g., 200 μ s). This means that the on duration is frequency independent. Therefore, the power consumption of the microwave sensor is determined by the frequency of the pulsed operation, i.e., the higher the frequency, the higher its power consumption.

25 As will be clear from the above, the repetition frequency which is appropriate for sensing an object depends on the speed of that object. The invention thus makes use of initial speed sensing by another sensor, in order to set the repetition frequency of the interrupted operation of the microwave sensor.

Figure 3 shows a presence detection circuit 30 in accordance with an example
30 of the invention.

It comprises a first sensing module 32 for sensing an object and determining information relating to a speed of movement of the sensed object.

The first sensing module 32 does not need to have high accuracy. It may for example be operated in such a way as to give false positive rather than false negative results

(i.e. it over-reports the presence of objects). Thus, it provides an initial indication of the presence of an object and the approximate speed. The first sensing module is not a microwave sensor, and is preferably a sensor which can operate at a lower power consumption for long-term monitoring.

5 A second sensing module 34 is a microwave sensor of the type described with reference to Figure 1.

 A controller 36 is used for operating the second sensing module 34 in an interrupted mode with a repetition frequency which depends on the information relating to the speed of movement, shown as v in Figure 3. Essentially, the controller 36 is equivalent to
10 the controller 20 shown in Figure 1 but modified so that the frequency signal f is made dependent on speed information v provided by the first, lower power, sensing module 32.

 This presence detection circuit thus makes use of two mechanisms for presence detection. The first sensing module is used to provide an initial indication of the presence and speed of a detected object. It is a low power sensing approach, and indeed it
15 may make use of sensing which is required in any case for other purposes.

 For example, the first sensing module 32 may comprise an RF receiver for receiving RF signals from other nodes 37, 38 which, together with the presence detection circuit 30, form a communications network. The presence detection circuit 30 may be part of a lamp or luminaire, and the nodes 37 and 38 may comprise similar such lamps or luminaires.
20 The other nodes may also include other types of device which are part of the wireless network. The first sensing module for example comprises an RF transceiver, so that it also sends RF signals for reception by the other nodes.

 The nodes are typically at fixed locations (such as luminaires) so that the expected transmission and reception characteristics are known and expected to be largely
25 constant over time. The RF signals that are analyzed are for example routine communications between the RF nodes of the wireless network. The presence detection circuit thus continuously receives RF packages from the other RF nodes.

 In response to detection by the first sensing module, the repetition frequency of of the microwave sensor is selected. A lower repetition frequency corresponds to low
30 power consumption but is for example only suitable for signals from slow moving objects, where there may not be high frequency signal components needing to be detected. The first sensing module thus enables operation of the microwave sensor in a most power efficient manner having regard to the signals that are to be detected.

Once the microwave sensor 34 has been started and operated for a certain duration, it can also collect speed information, which is probably more accurate than the speed information obtained by the RF transceiver. Thus, the repetition frequency may also be adjusted over time, during the time period while there is a sensed object, based on speed information from the microwave sensor itself.

The second (microwave) sensing module in this way initially operates in the interrupted mode with a repetition frequency which depends on the information relating to the speed of movement sensed by the first sensing module. It then refines the information related to the speed of movement by itself. The second sensing module is then operated in the interrupted mode with this refined repetition frequency, so that the second sensing module takes over the calculation of the speed of movement.

The first sensing module for example comprise an RF module for receiving RF signal transmissions, for example 2.4GHz ZigBee RF transmissions. These RF signal transmissions may be communications signals between the nodes. The microwave sensor is for example a 5.8GHz or 24GHz sensor. Under normal conditions, before any presence or motion detection, or after completion of presence or motion detection, the microwave sensor may be off, or else operating in an interrupted CW mode at a relatively low frequency but with a fixed on phase, to achieve power saving.

Radio signal propagation characteristics are significantly versatile across different environments, especially indoors, where the signal can be absorbed, reflected, scattered or diffracted by many objects in its propagation path. At microwave frequencies such as 2.4 GHz, absorption by molecular resonance is a major factor affecting the radio propagation. Therefore, the presence of a human subject within the 2.4GHz RF network range results in signal strength (RSSI) variations at the receiver input, whereas the degree of variations is correlated with the level of human motion. This has become a feasible approach for human motion detection, as illustrated in Mrazovac, B., Bjelica, M. Z., Kukolj, D., Todorović, B. M., Vukosavljev, S.: "System Design for Passive Human Detection using Principal Components of the Signal Strength Space", Computer Science and Information Systems, Vol. 10, No. 1, 423-452. (2013).

The analysis is based on extracting principal components from the RSSI variations, to detect human presence and movement. A major issue of the approach is to achieve a reliable motion detection performance at an acceptable cost level to meet the critical requirement of certain applications such as lighting, requiring high detection accuracy and low false triggers.

As indicated in the article, approximately 75% detection accuracy is achieved for human presence (which includes walking and standing), By itself, this is below the desired performance for lighting control. However, the method can also distinguish between different speeds of motion. A human standing without movements (i.e., low speed motions) is less expressed on principal components, while the principal components are emphasized (to give peaks) when the human is walking (i.e., medium speed motion).

The RF detection by the first sensing module provides a balance between power saving and accuracy. A certain accuracy can still be provided by the RF detection, and the triggered microwave sensor is used to provide verification.

The object detection and speed sensing may thus be achieved by analyzing the RSSI (Received Signal Strength Indicator) of received packages and their variations at the input of the RF transceiver. From these variations, a level of the speed of the motion can be derived. The speed does not need to be accurate, but instead is generally a measure of the impact of motion (e.g. human motion) on the microwave sensor signal and the RSSI

variation. The minor motions of a person sitting and working at a work space may be categorized as low speed motions, leading to low Doppler shift frequency in the sensor signal and gentle RSSI variation. A person walking may be categorized as having a medium speed motion and a person walking fast or running is categorized as a having a high speed.

Based on the speed category (i.e., low, medium and high), the repetition frequency of the microwave sensor is adapted: the higher the speed category, the higher the repetition frequency so the higher the power consumption, and the vice versa. The presence detection of the first sensing module 32 is thus based on human body interference with radio wave signals, such as fading and shadowing effects which cause irregularities in the radio wave signature.

As explained above, the repetition frequency is preferably selected to be higher than a Nyquist frequency associated with a Doppler shift frequency caused by the speed of movement. This ensures that the frequency spectrum of the Doppler shift signals caused by the object movement are all sampled to enable reliable movement detection.

By way of example, settings for a 5.8GHz microwave sensor may be:

- Low speed motion (e.g., standing still or sitting & reading a book): 50Hz pulsed operation for the microwave sensor;

- Medium speed motion (e.g., walking below 5km/h): 200Hz pulsed operation for the microwave sensor; and

- High speed motion (e.g., running at 10km/h) : 500Hz pulsed operation for the microwave sensor.

Figure 4 shows a lamp 40, comprising a lighting unit 42 (e.g. an LED array or string) and a presence detection circuit 30 as described above. The first sensing module 32 of the presence detection circuit is the RF transceiver of the lamp which is used to communicate with other lamps (and optionally other devices) which form a communications network with the lamp. The controller 36 also provides the lighting control signal to the lighting unit 42 so that the lighting is controlled as a function of the presence detection. Of course there may be separate controllers; a presence detection controller and a lighting controller.

Figure 5 shows a presence detection method, comprising:
in step 50, using the first sensor module to sense an object;
in step 52, using the first sensor module to determine information relating to a speed of movement of the sensed object;
in step 54, setting a repetition frequency for the second sensing module according to the information relating to the speed of movement; and
in step 56, operating the second sensing module with the set repetition frequency.

The presence detection circuit may be part of a smart lighting device as explained above, but it may instead be a standalone sensor device (e.g., battery powered).

Variations to the disclosed embodiments can be understood and effected by those skilled in the art in practicing the claimed invention, from a study of the drawings, the disclosure and the appended claims. In the claims, the word "comprising" does not exclude other elements or steps, and the indefinite article "a" or "an" does not exclude a plurality. A single processor or other unit may fulfill the functions of several items recited in the claims. The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measures cannot be used to advantage. If the term "adapted to" is used in the claims or description, it is noted the term "adapted to" is intended to be equivalent to the term "configured to". Any reference signs in the claims should not be construed as limiting the scope.

CLAIMS:

1. A presence detection circuit, comprising:
 - a first sensing module (32) adapted to sense an object and determine information relating to a speed of movement of the sensed object;
 - a second sensing module (34), of a different type to the first sensing module
 - 5 and comprising a microwave sensor, adapted to sense the object; and
 - a controller (36) adapted to operate the second sensing module (34) in an interrupted mode with a repetition frequency which depends on the information relating to the speed of movement.
- 10 2. A presence detection circuit as claimed in claim 1, wherein the first sensing module (32) comprises an RF module adapted to receive RF signal transmissions, for example 2.4GHz RF transmissions.
- 15 3. A presence detection circuit as claimed in claim 2, wherein the presence detection circuit comprises a component of one node of a network of nodes (37,38) forming a communications network, and wherein the RF signal transmissions comprise communications between network nodes.
- 20 4. A presence detection circuit as claimed in claims 3, wherein the first sensing module (32) is adapted to analyze signal strength variations over time of received RF signal transmissions, thereby to determine the speed of movement of the sensed object.
- 25 5. A presence detection circuit as claimed in claim 4, wherein the first sensing module (32) is adapted to determine variations in the received signal strength indication, RSSI, associated with the received RF signal transmissions so as to determine the speed of movement of the sensed object.

6. A presence detection circuit as claimed in any one of claims 1 to 5, wherein the microwave sensor of the second sensor module (34) comprises a Doppler shift microwave sensor.

7. A presence detection circuit as claimed in claim 6, wherein the repetition frequency is selected to be higher than a Nyquist frequency associated with a Doppler shift frequency caused by the speed of movement.

8. A presence detection circuit as claimed in any one of claims 1 to 7, wherein the second sensing module, after operating for a certain duration in the interrupted mode with the repetition frequency which depends on the information relating to the speed of movement sensed by the first sensing module, is adapted to refine the information related to the speed of movement by itself, and

the controller is then adapted to operate the second sensing module (34) in the interrupted mode with a refined repetition frequency which depends on the refined information related to the speed of movement.

9. A presence detection circuit as claimed in any one of claims 1 to 8, wherein the controller (36) is adapted to categorize the speed of motion into a plurality of speed level categories, and to apply a predetermined repetition frequency for each speed level category, and wherein the repetition frequency is higher for higher speed level categories.

10. A lamp (40), comprising:
a lighting unit (42); and

a presence detection circuit (30) as claimed in any one of claims 1 to 9, wherein the the first sensing module (32) of the presence detection circuit (30) comprises an RF transceiver of the lamp which is used to communicate with other lamps which form a communications network with the lamp.

11. A presence detection method, comprising:
using a first sensor module to (50) sense an object and (52) determine information relating to a speed of movement of the sensed object;

(54) setting a repetition frequency for a second sensing module for sensing the object, comprising a microwave sensor to be operated in an interrupted mode, according to the information relating to the speed of movement; and

(56) operating the second sensing module with the set repetition frequency.

5

12. A method as claimed in claim 11, wherein (50) using the first sensing module comprises receiving RF signal transmissions, for example 2.4GHz RF transmissions.

13. A method as claimed in claim 12, implemented in one node of a network of
10 nodes forming a communications network, and wherein (50) using the first sensor module comprises receiving RF signal transmissions which are communications from other network nodes.

14. A method as claimed in any one of claims 12 to 13, wherein (52) determining
15 information relating to a speed of movement comprises analyzing signal strength variations over time of received RF signal transmissions.

15. A method as claimed in any one of claims 11 to 14, wherein (56) operating the
second sensor module comprises operating a Doppler shift microwave sensor and wherein the
20 repetition frequency is selected to be higher than a Nyquist frequency associated with a Doppler shift frequency caused by the speed of movement.

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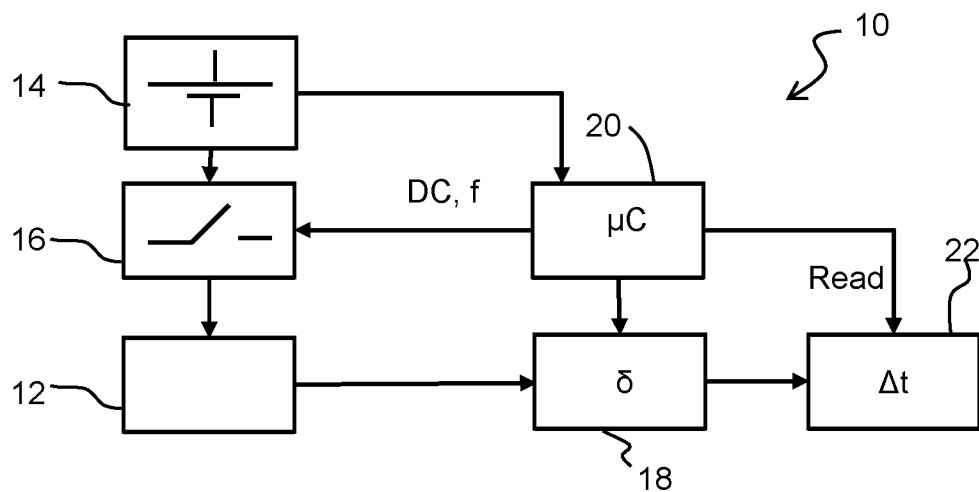


FIG. 1

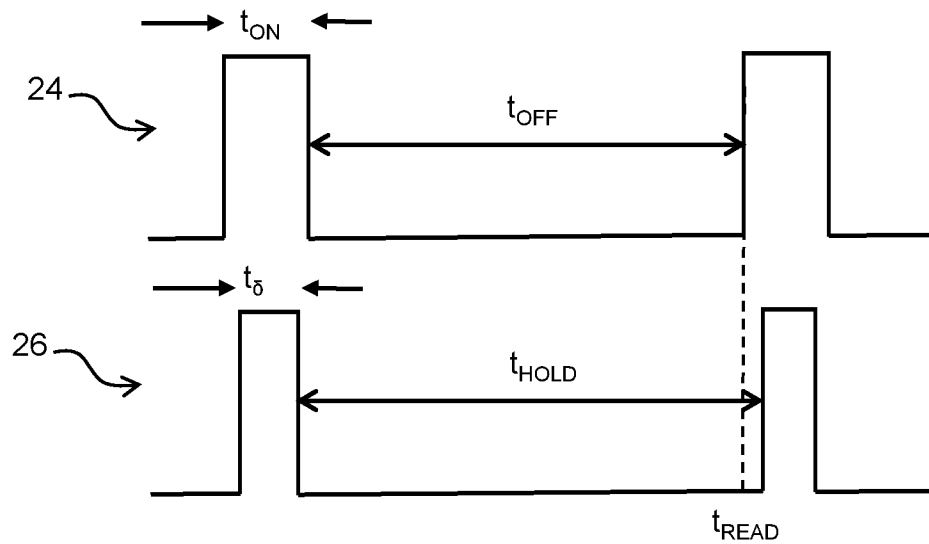


FIG. 2

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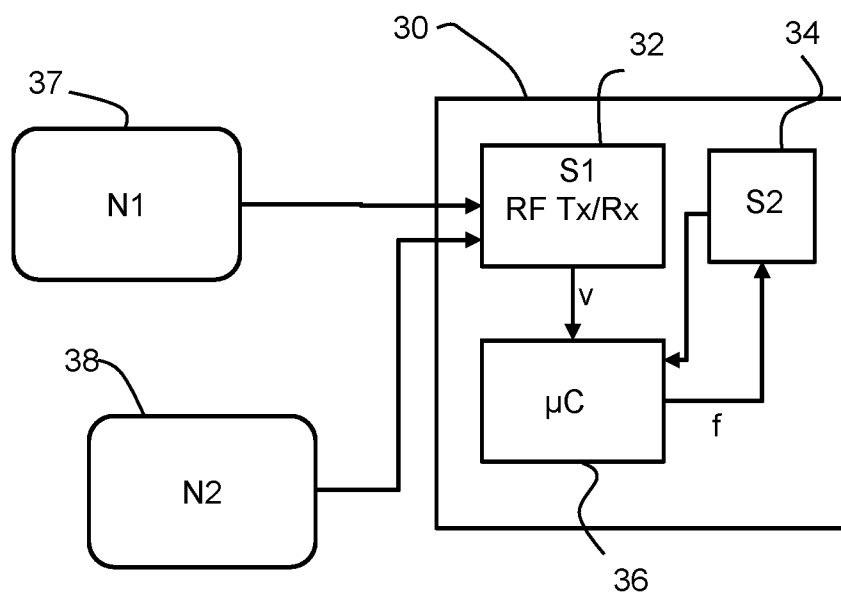


FIG. 3

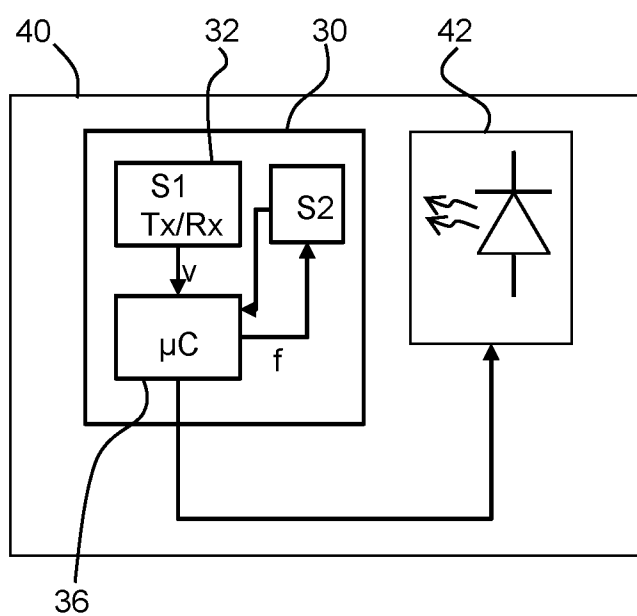


FIG. 4

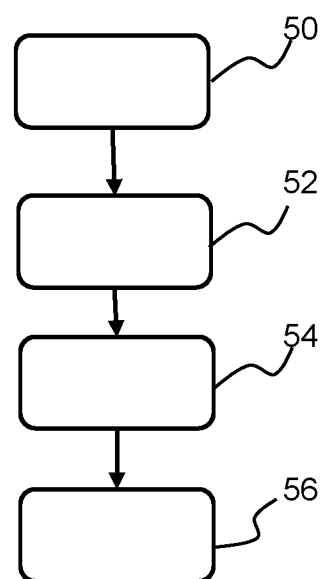


FIG. 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2020/050692

A. CLASSIFICATION OF SUBJECT MATTER INV. G01S11/06 G01S13/56 G01S13/87 H05B47/115 ADD.		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols) G01S H05B		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EPO-Internal, WPI Data		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US 2018/329049 A1 (AMIHOOD PATRICK M [US] ET AL) 15 November 2018 (2018-11-15) figure 1 claims 1,6,7 paragraph [0027] - paragraph [0031] paragraph [0046] - paragraph [0049] paragraph [0056] -----	1,6-11, 15 2-5, 12-14
Y	EP 3 276 369 A1 (THOMSON LICENSING [FR]) 31 January 2018 (2018-01-31) figure 1 paragraph [0021] - paragraph [0025] -----	2-5, 12-14
A	WO 2014/201574 A1 (HERSHKOVITZ SHMUEL [BS]; NINVE JR INC [BS]) 24 December 2014 (2014-12-24) figure 5 page 13, line 1 - page 14, line 8 ----- -/-	1-15
☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
* Special categories of cited documents : "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search 17 February 2020		Date of mailing of the international search report 25/02/2020
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016		Authorized officer Alberti, Carine

INTERNATIONAL SEARCH REPORT

International application No
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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
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