(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
20 November 2014 (20.11.2014)

WIPO | PCT

(10) International Publication Number
WO 2014/184253 A2

(51) International Patent Classification: Not classified

(21) International Application Number:
PCT/EP2014/059866

(22) International Filing Date:
14 May 2014 (14.05.2014)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
1308696.2 15 May 2013 (15.05.2013) GB

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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, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, 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, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, 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, 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).

Published:

— *without international search report and to be republished upon receipt of that report (Rule 48.2(g))*

(54) Title: SENSING DEVICE METHOD AND SYSTEM

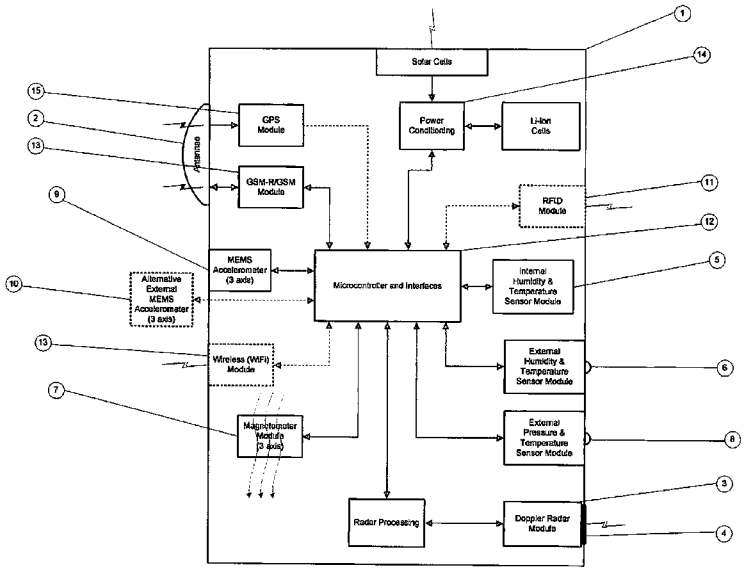

Figure 2

(57) Abstract: A device (1) for monitoring railway assets is described. The device (1) is positioned adjacent railway tracks in a rail network. The device (1) includes a radar transmit-receive module and a radar antenna together with an additional number of sensors capable of providing environmental and structural information on the track, the individual rails or the environment immediately adjacent the track. The device (1) further comprises wireless communications means thereby enabling the transfer of data collected from the device (1) to a central processing unit. The wireless communications means may also enable the device (1) to be updated remotely.

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Sensing Device, Method and System.

The invention relates to a sensing device and method. More specifically, but not exclusively it relates to a sensing device including a low power solid state Doppler radar and method for detecting trains and measuring their speed and direction using such a device.

Currently, railway network providers use 'track circuits' to indicate the presence of trains on the track. A 'track circuit' is an electrical circuit that includes an insulated section of track. A train occupying the track will complete the circuit by connecting the two rails together via its wheels and axles thus signalling the train's occupation of that section of track. Track circuits are designed to detect the presence or absence of a train only.

In modern rail networks there is a requirement to monitor the integrity of such track circuits. However, there is also a requirement to monitor the structural integrity of sections of track, not in the least to establish maintenance schedules but also to provide information as to potential problem areas of track or rail.

Track circuits cannot provide detailed information as to the state of the track or the environmental conditions in the vicinity of the track.

According to the invention there is provided a sensing device for mounting between a pair of rails in a track system, the device comprising radar transmitting and receiving means, the device further comprising a predetermined number of additional sensors, data processing means, and communication means, the sensors receiving data indicative of the condition and environment in the vicinity of the rails, the data processing means logging and storing said data, and the communication means enabling interrogation of the device and transmission of the data to a remote central data processing unit.

According to a further form of the invention there is provided a method of monitoring the loading on a section of track in a railway network, comprising the steps of monitoring the presence of rolling stock on the track using accelerometer and magnetometer means, monitoring other predetermined characteristics of the rails and the environmental conditions in the vicinity of the section of track using appropriate sensors, logging the data received from said sensors, transmitting the

data to a central processing unit and determining the condition of the section of track being monitored based on the combination of the data output by the radar and other sensors.

The invention further provides a rail network monitoring system comprising a series of sensing devices disposed between rails at predetermined locations around a railway network, each sensing device comprising a series of individual sensors and or radar transmitting-receiving means, the sensors collecting data relating to the loading of the tracks, the rolling stock and trains operational on the tracks and environmental conditions in the vicinity of each sensing device, each device including communication means for transmitting data collected by the individual sensors to at least one remote central data processing unit the data collected being processed so as to provide information relating to the rail network as a whole.

Preferably, the device includes wireless communications means thereby enabling remote interrogation of the device or periodic transmission of the data to a remote central data processing unit via a public wireless communications network.

The invention will now be described with reference to the following diagrammatic drawings in which:

Figure 1 is a schematic diagram showing a device in accordance with one form of the invention; and

Figure 2 is a schematic block diagram of the device of Figure 1, showing a selection of separate sensors that may be contained within the device together with a Doppler radar transmit and receive module.

As shown in Figure 1, the device 1 comprises a self-contained unit incorporating a wireless transmitter and antenna 2 enabling the device to transmit or receive data over a wireless network. The device 1 further comprises a Doppler radar transmit receive module 3 and an internal radar antenna 4 together with additional sensor means for monitoring predetermined characteristics of rails, track or environmental conditions in the vicinity of the device 1.

As shown in more detail in the block diagram of Figure 2, the sensors incorporated in the device 1 include, but are not limited to an internal temperature and humidity

sensor 5, an external temperature and humidity sensor 6, a magnetometer 7, an external pressure and temperature sensor 8, an internal accelerometer 9, an external accelerometer 10 and an RFID module 11.

The device further incudes interface and microcontroller means 12 for logging and processing data gathered by the radar module 3 and all the sensors. The device 1 further comprises communication means 13 enabling the device 1 to be interrogated remotely and further enabling the data logged and processed to be transmitted to a remotely located central processing device (not shown).

The device 1 further comprises power management means 14. The power management means 14 may include solar cells charging a battery, for example a Li-ion battery, thereby eliminating the need for connection of the device 1 to existing track side systems, railway power or signalling systems. In this way, the device 1 is autonomous. The power management means 14 also enables the device 1 to enter a sleep mode when not in use thereby preserving power. The device 1 becomes operational and is 'woken up' from sleep mode when a predetermined sensor is triggered.

The microcontroller means 12 may be a single interface and data processing card accommodating microcontroller and power conditioning/charging circuits.

In use, in a first embodiment of the invention, a series of devices 1 are located around the rail network and are used to monitor sections of rail or track. Each device 1 is positioned between the rails to be monitored. . The sensors in each device 1 monitor the environmental conditions in the vicinity of the track being monitored. The device should be positioned in such a way to ensure that the internal radar antenna 4 points along the track.

The device 1 is designed to work alongside existing track circuits in a railway network. A device 1 may be positioned in the vicinity of existing track circuits in order to provide information that verifies that obtained from the track circuits. Additionally, the presence of the additional sensors enables further information to be gathered over and above that provided by the track circuits. The device 1 detects and measures the speed of approaching trains using a low power solid state Doppler radar module 3. In the embodiment described, the sensors and their associated

electronics are housed in a hermetic polycarbonate case with full environmental protection. The device 1 may be fixed to a sleeper adjacent to every existing track circuit. Any data collected is logged within the device 1 and detections are processed and transmitted via GSM-R (or GSM as a fall back) prior to the train reaching the device. Both single (bi-directional) and multi-track configurations are handled by identical units (each track requires a separate unit). The device 1 is designed to be completely autonomous i.e. no external services required and is expected to have an operating life of at least ten years. Software updates and reconfiguration are achieved "over the air" with device 1 status reported as each train passes (and at user defined intervals).

Using the sensor configuration described above, the device 1 can detect trains and indicate their speed, direction, location and time/date of passage. In addition the device 1 can measure track cant and inclination, count axles, estimate axle loading, estimate gross daily tonnage, estimate rail pad wear, estimate track bed stability and identify train "make-up" (identify coaches/wagons). Since the device 1 uses the GSM-R and GSM mobile networks it can also routinely measure mobile radio signal strength. The data from multiple devices 1 in a system is transmitted to a secure server via wireless communications and can then be processed to provide a range of information services. For example, knowledge of train position and speed can be used to give independent early warning of approaching trains at level crossings or to track maintenance workers. Train detection data may also be transmitted to the appropriate signal control centre to enable comparison with existing track circuit outputs.

With the addition of a low cost Global Navigation Satellite System receiver, after post processing, the geographic position of the device 1 will be accurately known for example, within 20 cm of the actual position and can therefore be used by bespoke measurement trains to establish accurate positioning for their measurements. This facility makes it possible to introduce maintenance prognostics with relative ease.

The device 1 can also collect and transmit other types of information. For example, core functionality includes sensors for measuring ambient pressure, humidity, temperature and solar radiation. So, for example, rail temperature and humidity levels can routinely be reported.

It is possible to separate the data collected by the sensors in the device 1. This may be required if rail network operators require certain information but require other information to be logged and processed by third parties. For example, the track mounted device 1 detects and measures train parameters and transmits the collected data via GSM for railways (GSM-R) to trackside base-stations and then onward through the relevant rail network communications network to their control centres. Secondary data (and the train parameters) may then be transmitted via GSM to third party data centres.

For a given device 1, a typical sequence on the approach of a train would be as follows:

Firstly, a train is detected and the device 1 is powered up from sleep mode. The radar module 3 detects the approaching train and measures train speed and direction as the train approaches. The data generated by the radar module 3 is stored and transmitted as a data packet containing, for example, the following information to the relevant central processing centre: device 1 location and Unit ID; date and time; train speed; and train direction.

As each rail vehicle passes over the unit there is the additional potential to measure the following additional parameters (as alternatives or in combination): track vibration, characterised to provide an axle counting function; track cant and incline; magnetic field profile of the passing rail vehicles; and train identification by reading a passive RFID tag on each rail vehicle. Moreover, train weight, number of axles, track bed stability, rail temperature and rail pad wear may be monitored with the inclusion of appropriate sensors in the device 1 and additional data processing means.

Further measurement of environmental parameters at regular time intervals may also be provided and transmitted and may include but not be limited to external temperature, barometric pressure and humidity, to provide local metrological data.

It will be appreciated that whilst the device 1 described above may form part of a system of devices in a rail network, the information gathered may be of use to agencies other than the rail network operator. For example, environmental data such as temperature, pressure and humidity may be of relevance to meteorological

agencies. Moreover, a system of devices may be used to provide information to multiple agencies via separate communications means in the device 1.

It will further be appreciated that the device 1 may contain sensors other than those described above and that the invention is not limited to the sensors described. Any sensor capable of inclusion in the device may be considered.

Furthermore, the devices 1 need not be deployed as a whole system, individual devices 1 may be placed at crucial points on the rail network to provide additional condition monitoring information.

As the devices 1 may be used in conjunction with existing track circuits, the device will act to confirm the correct operation of the track circuits. Similarly, the track circuits provide confirmation of the correct operation of a device 1 in the same location.

CLAIMS

1. A sensing device for mounting between a pair of rails in a track system, the device comprising radar transmitting and receiving means, the device further comprising a predetermined number of additional sensors, data processing means, and communication means, the sensors receiving data indicative of the condition and environment in the vicinity of the rails, the data processing means logging and storing said data, and the communication means enabling interrogation of the device and transmission of the data to a remote central data processing centre.

2. A sensing device according to claim 1 in which the radar module comprises a solid state low power Doppler radar and antenna.

3. A sensing device according to claim 1 or 2 in which the additional sensors comprise at least one of a temperature sensor, a humidity sensor, an accelerometer, a magnetometer, or a pressure sensor.

4. A sensing device according to any preceding claim in which the communications means comprises a GSM wireless communications module allowing data collected to be transmitted wirelessly to a remote central data processing centre.

5. A sensing device according to claim 4 in which the communications means further comprises a GSM-R wireless communications module allowing data collected to be transmitted wirelessly to a remote central data processing centre railway operators control centre

6. A sensing device according to any preceding claim in which the device further comprises power management means, enabling the device to hibernate when not in use and activate when triggered by a predetermined signal.

7. A sensing device according to any preceding claim in which the device comprises a series of solar cells and a battery charged by said solar cells, thereby eliminating the need for the device to be mains powered.

8. A sensing device according to any preceding claim in which the device further comprises a GNSS device providing information relating to the exact position of the device in the rail network.

9. A device according to any preceding claim in which the device further comprises identification means capable of identifying specific rolling stock in use on the track, the identification means sensing suitable ID tags mounted on the rolling stock.

10. A device according to claim 10 in which the ID tags are passive RFID tags.

11. A method of monitoring the loading on a section of track in a railway network, comprising the steps of monitoring the presence of rolling stock on the track using accelerometer and magnetometer means, monitoring other predetermined characteristics of the rails and the environmental conditions in the vicinity of the section of track using appropriate sensors, logging the data received from said sensors, transmitting the data to a central processing unit and determining the condition of the section of track being monitored based on the combination of the data output by the radar and other sensors.

12. A rail network monitoring system comprising a series of devices according to any one of claims 1 to 10 disposed at predetermined locations around a railway network.

13. A rail network monitoring system comprising a series of sensing devices disposed between rails at predetermined locations around a railway network, each sensing device comprising a series of individual sensors and or radar transmitting-receiving means, the sensors collecting data relating to the loading of the tracks, the rolling stock and trains operational on the tracks and environmental conditions in the vicinity of each sensing device, each device including communication means for transmitting data collected by the individual sensors to at least one remote central data processing unit the data collected being processed so as to provide information relating to the rail network as a whole.

14. A system, method or device as hereinbefore described with reference to the accompanying diagrammatic drawings.

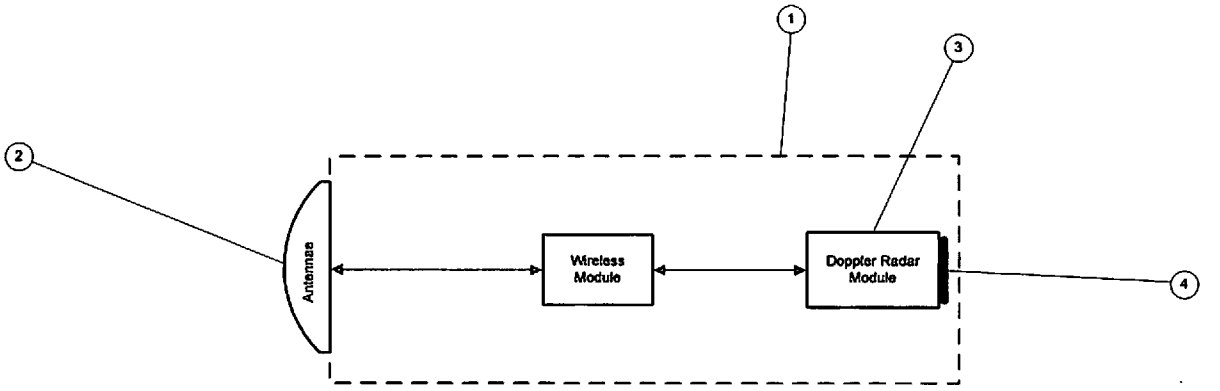

Figure 1

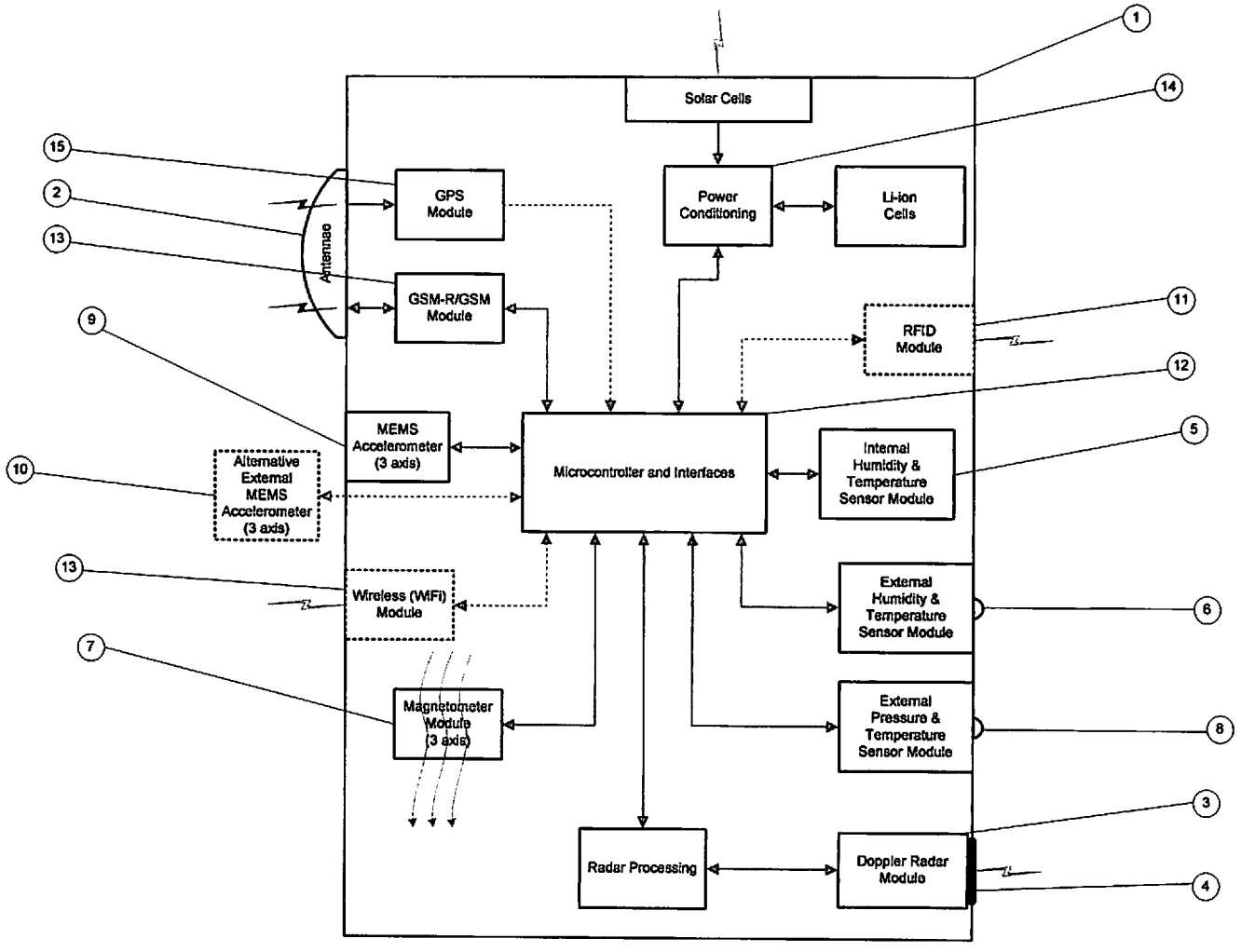

Figure 2