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(51) INT CL:
H04B 7/00 (2006.01) ***G01R 31/02*** (2006.01)

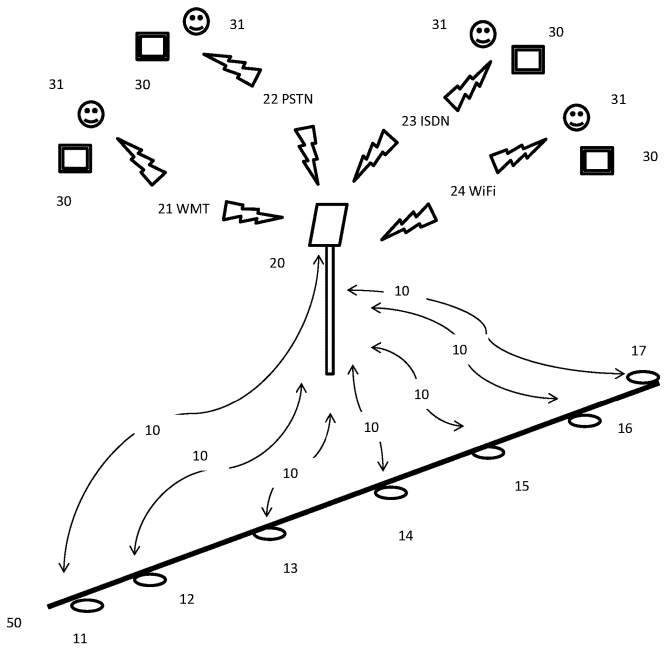
(56) Documents Cited:
CN 201820326 U **CN 101408581 A**
US 8860580 B1 **US 20140011222 A1**

(58) Field of Search:
INT CL **H04B**
Other: **EPODOC; WPI**

(54) Title of the Invention: **Integrated long range ISM sub gigahertz network for monitoring & controlling theft, damage and loss of supply to high voltage cables**
Abstract Title: **Network for monitoring of high voltage cables**

(57) A current/voltage sensing node 11-17 which includes a sensing circuit and a data interface which on detection of the voltage/current being removed from cabling 50, a data signal 10 is generated and sent via a sub-gigahertz transceiver to a remote station 20 and then to a recipient 31 or control room 30. The station may be part of a network including a repeater or a base station 20. A public address message may also be transmitted using the network to alert a warning of a fault. The non-intrusive monitoring of voltage carrying electric cables and in particular but without limitation to monitoring the theft, loss of power or damage to high voltage cables, but without limitation to, all electric cables capable of carrying an electric current.

Fig 2:



GB 2532999 A

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

Title: Integrated long range ISM sub gigahertz network for monitoring & controlling theft, damage and loss of supply to High Voltage cables

Fig 1

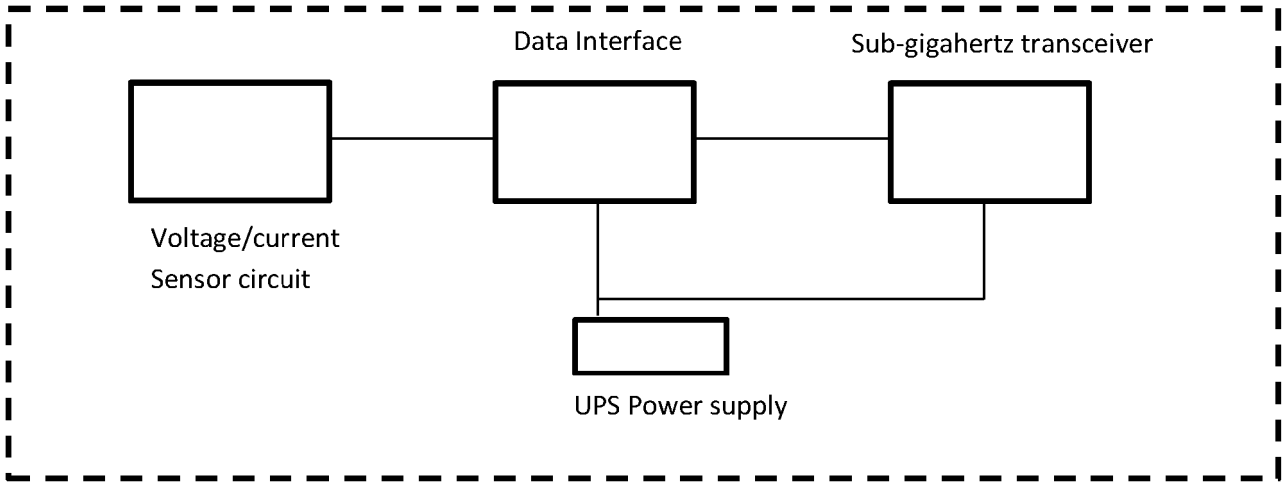
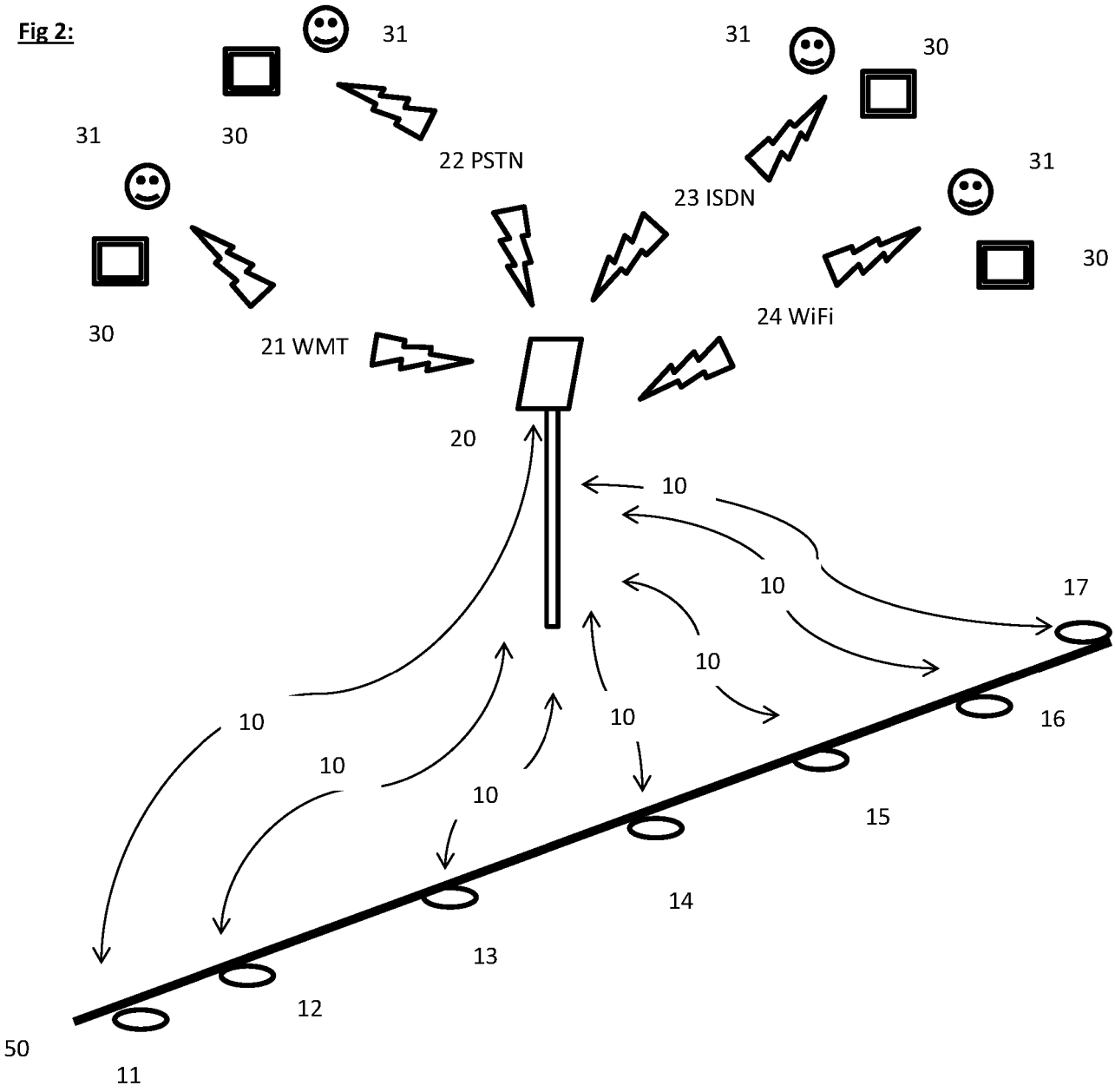


Fig 2:



16 02 15

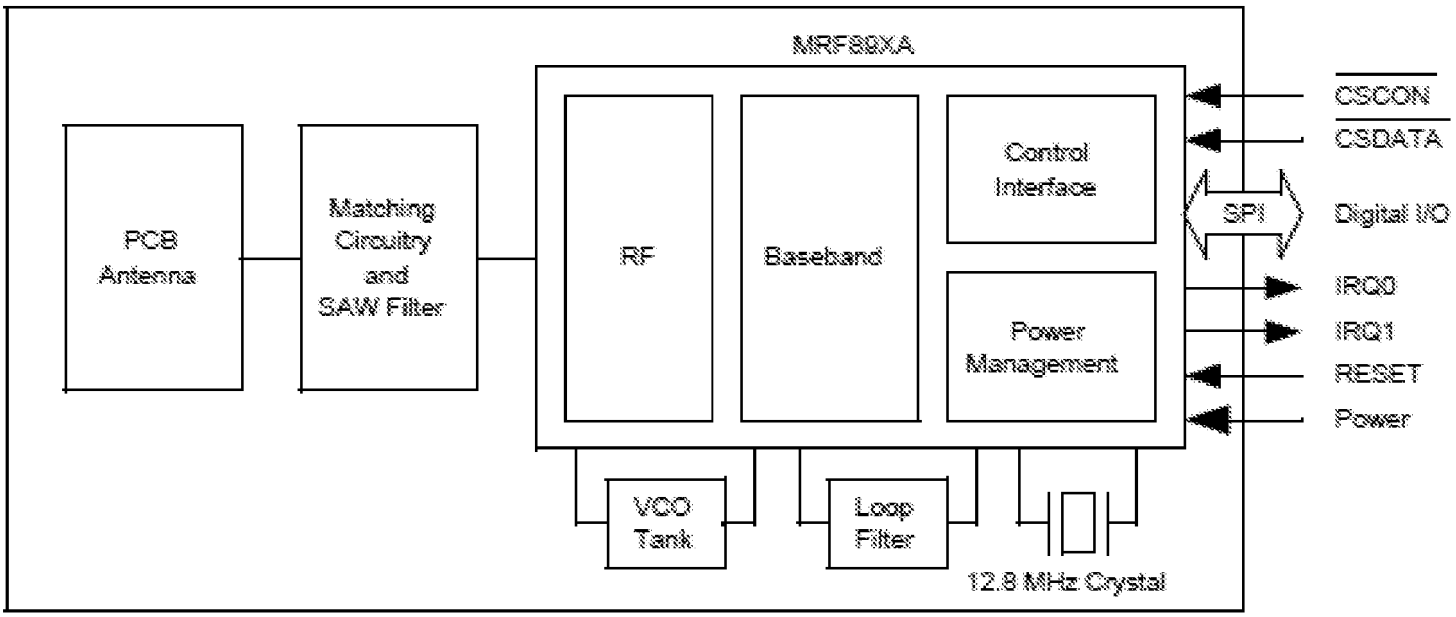
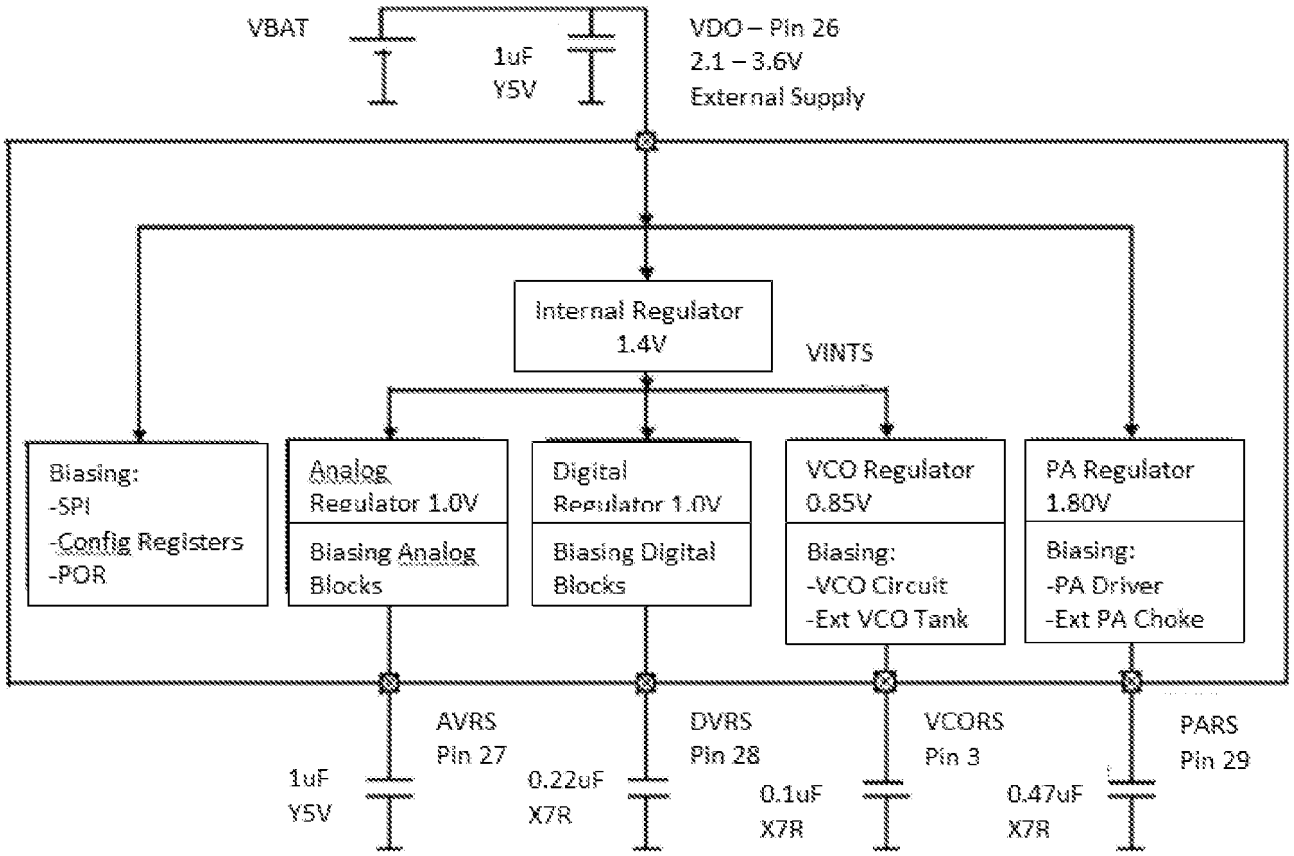


Fig: 3

16 02 15

Fig 4:



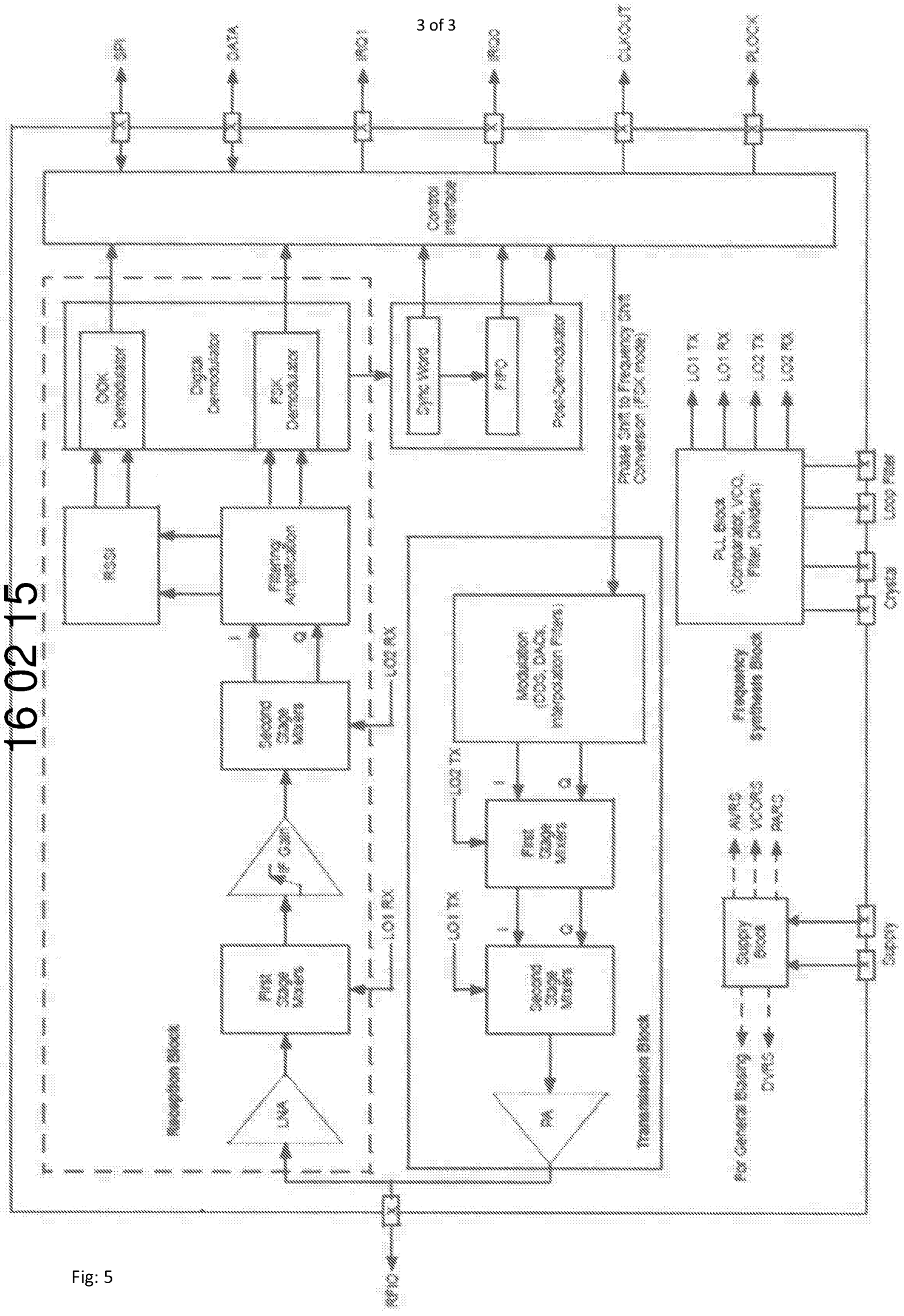

16 02 15
SPI
DATA
IRQ1
IRQ0
CLKOUT
RCLOCK
Control Interface
CGEN Generation
Digital Generation
FCW Generation
Sync Word
FIFO
Post-Generation
Phase Shift to Frequency Shift Conversion (FCW mode)
LO1 TX
LO1 RX
LO2 TX
LO2 RX
PLL Block (Comparator, VCO, Filter, Dividers)
Loop Filter
CPout
Frequency Synthesizer Block
RFIC
Filtering Amplification
Second Gain Units
First Gain Units
LO2 RX
LO1 RX
LO2 TX
LO1 TX
Modulation (I/Q, DAC, Interpolation Filters)
First Gain Units
Second Gain Units
PA
LNA
Reception Block
Transmission Block
Supply Block
AVR3
VCORE
RVR3
DVR3
For Calibration
Supply

Fig: 5

Title: Integrated long range ISM sub gigahertz network for monitoring & controlling theft, damage and loss of supply to High Voltage cables

Description:

This invention relates to the non-intrusive monitoring of voltage carrying electric cables and in particular but without limitation to monitoring the theft, loss of power or damage to high voltage cables, but without limitation to, all electric cables capable of carrying an electric current.

Monitoring of electric cabling is generally done by equipment connected directly into the circuit of the cabling and relies upon sensing related to the cabling itself. This has limitations in where the connections can be made, and also the ability to report as to where the damage or theft may have occurred. This is particularly difficult when monitoring large lengths of cabling which could be on different phases of an electric supply. There is also the ever present danger associated with theft of high voltage cabling, where those individuals perpetrating the theft are putting their lives at risk attempting to steal the cabling.

One situation where high voltage cables are used which are susceptible to theft and damage are railways. Theft of cabling from the railway network is at an all-time high, due to the recycling scrap value of copper. The need therefore arises for an alternative form of cable monitoring which overcomes one or more of the above problems. This invention aims to overcome the problems associated with monitoring such a network of cabling, and provide an immediate response as to where the damage, theft or loss of power has occurred.

According to the first aspect of the invention there is provided a voltage/current monitoring/sensing circuit, which provides the detection of the loss of power to the cabling. There is a means for converting the signal from the sensing circuit to a Radio frequency signal capable of sending data using a radio frequency transceiver operating but not limited to the sub gigahertz frequency range, and a means of transmitting said signal to a corresponding radio frequency transceiver which is

operating as a base station capable of creating a local area network of units operating in but not limited to the sub gigahertz frequency range. The base station transceiver may operatively be connected to a wireless mobile telephony (WMT) transceiver or WiFi network, or PSTN telephone line capable of transmitting data locally, nationally or globally if required. The radio frequency transceiver is operatively connected to a means of sending and receiving bi-directional data simultaneously from multiple units connected to it as part of its point-to-point, local area or wide area network.

The invention may also operate on a one-to-one or one-to-many configuration as part of a closed network, local area network or wide area network, and is not restricted to any one, but could be a combination of the configurations mentioned. In essence, the network will operate in a similar way to a mobile phone network, with multiple base station repeater sites creating local and national data networks operating in the sub-gigahertz frequency range.

The invention aims to overcome one or more of the aforementioned problems by connecting in a non-intrusive way to the cable, and utilising but not limited to a voltage induction circuit which will create a hold-off voltage in the sensing circuit. The presence of this voltage/current will inhibit the initiation of the data signal from the sensing circuit transceiver to the base station transceiver. Any other suitable sensing circuit can be used which will also detect the loss of voltage/current in the cabling to be monitored. When the voltage/current is removed from the cabling a data signal will be sent via the radio frequency transceiver to the base station which in turn will be sent over the WMT or WiFi or PSTN network to a designated recipient to inform them of the cessation of power to the electric cabling, which may be as a result of damage, theft or other cause.

Power for the sensing circuit can be provided by a battery or other suitable power source capable of powering the radio frequency transceiver. A battery where provided may form part of an uninterruptable power supply (UPS) that is trickled from the mains, a vehicle power supply, such as

6V DC, 12V DC or 24V DC battery, or which is charged through a solar panel, wind turbine or the like, mounted on or adjacent to the unit housing.

The invention is not limited to use in railway network cable monitoring, but can be utilised for monitoring any mains power cables where there is a need for monitoring them against, theft, damage or loss of power. In addition the invention may suitable be applied to vehicles and plant machinery or other forms of machinery which have a power source or requirement to monitor the power and cabling.

Preferred embodiments of the invention shall now be described, by way of example only, with reference to the accompanying drawings in which:

Figure 1 is a schematic diagram showing the various modules of a monitoring/sensing system according to the invention. It does not show the full extent of the circuitry required to perform the sensing, but only an overview as to component modules of the system.

Figure 2 is a schematic system diagram showing the configuration of a system for use on high voltage cabling such as used in the railway networks, or any other high voltage cables used domestically, industrially or commercially.

Figure 3 is a schematic showing the typical component modules of a Sub-gigahertz transceiver, similar but not necessarily exact in all aspects to the type to be used in the invention.

Figure 4 is a schematic showing the power supply and connection requirements of a sub-gigahertz transceiver, similar but not necessarily exact in all aspects to the type to be used in the invention.

Figure 5 is a schematic showing the various component stages of a typical sub-gigahertz transceiver, similar but not necessarily exact in all aspects to the type to be used in the invention.

In figure 2 a system comprises a number of monitoring/sensing circuit nodes 11 - 17, connected to the cabling 50 operating within a 10km radius of base stations 20. The nodes are in a quiescent/standby state until the power is removed to the cabling. Up to 10,000 nodes can be connected to one base station collectively. Once the power is removed the sensing circuit detects its removal and initiates a radio frequency transmission from the node to the base stations within its 10km radius of operation. The base station upon receipt of the data transmission from the node then sends a corresponding data transmission via WMT 21, PSTN 22 ISDN 23, or WiFi 24 to a designated recipient 31 or control room 30. The notification to the control room or designated recipient can be made by either SMS, Voice annunciation or any other means deemed suitable to provide a warning notification of power failure, damage or theft. Data relating to the usage, power levels or other information deemed necessary may also be routinely sent and logged into a database running on a host computer or other device capable of receiving data.

If a person or persons attempting to steal power cabling cuts the cable, power is automatically removed therefore nodes operating and connected along that line of cabling will detect the loss of power to the cable and send a signal to the base station which subsequently sends a signal to a control room or individual responsible for monitoring or controlling the cables. The operator can then if required send a signal back to one or more of the nodes to initiate a voice annunciation or other output as required such as turning on a siren or lighting etc. The same process would apply if a fault developed on the cable resulting in a loss of power or if the cable was damaged in any way with the same resultant loss of power.

Data can be sent routinely as required via sub-gigahertz transmissions 10 from the nodes 11 – 17 up to a maximum of 10,000 nodes collectively connected to the base station(s) 20 without the need for human intervention as part of an automated data-logging process.

CLAIMS

1. A Current/voltage sensing node, comprising a current/voltage sensing circuit and data interface which when the current/voltage in the cabling is removed initiates a data signal to be sent via a sub-gigahertz transceiver operatively connected to the sensor and an integral power supply. This in turn is received by a base station repeater configured to receive a data signal in the sub-gigahertz frequency range providing bi-directional data over the signal connection and wherein both the repeater base station and current/voltage sensing nodes comprise one or more data inputs or data output ports providing the bi-directional data. The sub gigahertz base station may be individual, or part of a network of sub-gigahertz base station repeaters used to form a local area or wide area network. The base station repeater and current/voltage sensing node facilitate remote control functionality over the sub-gigahertz network in addition to providing monitoring of high voltage cabling. In addition to the data capability there is also the ability to send digital audio over the network, which can be used to provide a public address function if required, or initiate pre-recorded audio messages.
2. A Current/voltage sensing node as claimed in claim 1, wherein the node comprises a current/voltage sensing circuit and sub-gigahertz long range transceiver.
3. A current/voltage sensing node as claimed in claim 1 or claim 2 further comprising a water and/or weatherproof enclosure.
4. A current/voltage sensing node as claimed in any of the claims 1, 2 or 3, wherein the transceiver for sending the data signal comprises a transceiver operating in the sub-gigahertz frequency range which is uniquely identifiable on the sub-gigahertz network.
5. A current/voltage sensing node as claimed in claim 4 further comprising a switching circuit for initiating the data communication.

6. A current/voltage sensing node as claimed in any preceding claim, comprising a plurality of individually selectable inputs or outputs.
7. A current/voltage sensing node as claimed in any preceding claim where the sub-gigahertz transceiver is remotely programmable and configurable.
8. A current/voltage sensing node as claimed in any preceding claim which comprises a battery monitoring circuit adapted to monitor the status of the supply battery and/or power supply and automatically send a message indicating the power status.
9. A current/voltage sensing node as claimed in any preceding claim further comprising a monitoring circuit that is adapted to monitor the status of the unit and automatically re-boot in the event of a system failure or crash.
10. A current/voltage sensing node as claimed in any preceding claim, further comprising a power management circuit for controlling the power to the unit.
11. A current/voltage sensing node as claimed in any preceding claim wherein a data port is operatively connected to a sensor for transmitting data over the sub-gigahertz network.
12. A current/voltage sensing node as claimed in any preceding claim wherein the functionality of any of the data input or output ports is remotely programmable/re-programmable by way of data commands sent to the unit by way of the sub-gigahertz network.
13. A current/voltage sensing node as in any preceding claim further comprising a digital audio circuit.
14. A current/voltage sensing node as claimed in any preceding claim, further comprising an uninterruptable power supply.
15. A current/voltage sensing node as claimed in claim 14, wherein the uninterruptable power supply comprises a battery and a means for trickle charging the battery, the trickle charging comprising: a mains power supply; a vehicle power supply; a solar panel; a solar photovoltaic cell; a wind turbine, or any other suitable means for charging a battery.

16. A current/voltage sensing node as claimed in any preceding claim that is addressable by the base station either individually or collectively.
17. A repeater base station as claimed in claim 1 which comprises a sub-gigahertz long range transceiver
18. A repeater base station as claimed in claim 1 or 17 further comprising a water and/or weatherproof enclosure.
19. A repeater base station node as claimed in any of the claims 1, 17 or 18, wherein the transceiver for sending the data signal comprises a transceiver operating in the sub-gigahertz frequency range which is uniquely identifiable on the sub-gigahertz long range network.
20. A repeater base station as claimed in any preceding claim, comprising a plurality of individually selectable inputs or outputs.
21. A repeater base station as claimed in any preceding claim where the sub-gigahertz long range transceiver is remotely programmable and configurable.
22. A repeater base station as claimed in any preceding claim which comprises a battery monitoring circuit adapted to monitor the status of the supply battery and/or power supply and automatically send a message indicating the power status.
23. A repeater base station as claimed in any preceding claim further comprising a monitoring circuit that is adapted to monitor the status of the unit and automatically re-boot in the event of a system failure or crash.
24. A repeater base station as claimed in any preceding claim, further comprising a power management circuit for controlling the power to the unit.
25. A repeater base station as claimed in any preceding claim wherein a data port is operatively connected to a sensor for transmitting data over the sub-gigahertz network.

26. A repeater base station as claimed in any preceding claim wherein the functionality of any of the data input or output ports is remotely programmable/re-programmable by way of data commands sent to the unit by way of the sub-gigahertz long range network.
27. A repeater base station as in any preceding claim further comprising a digital audio circuit.
28. A repeater base station as claimed in any preceding claim, further comprising an uninterruptable power supply.
29. A repeater base station as claimed in claim 28, wherein the uninterruptable power supply comprises a battery and a means for trickle charging the battery, the trickle charging comprising: a mains power supply; a vehicle power supply; a solar panel; a solar photovoltaic cell; a wind turbine, or any other suitable means for charging a battery.
30. A repeater base station as claimed in any preceding claim that is capable as acting as a gateway for establishing one-to-many communications with current/voltage sensing nodes.
31. A repeater base station as claimed in any preceding claim that is connected to a wireless mobile telephony network, a PSTN network, or a WiFi network or any system capable of facilitating transfer of data communications from the sub-gigahertz long range network to either a mobile telephony device, PC, tablet computer or any other device capable of receiving a data signal/message.
32. A repeater base station as claimed in any preceding claim which forms part of a network of other repeater base stations operating in the sub-gigahertz frequency range facilitating local and or wide area coverage of sub-gigahertz long range data communications.

Intellectual Property Office

Application No:	GB1421736.8	**Examiner:**	Mr Tyrone Moore
Claims searched:	1-32	**Date of search:**	24 November 2015

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1 at least	US 2014/11222 A1 (JAFARIAN AMIN et al.) See whole document, an example of wireless communication apparatus using sub-gigahertz bands.
X	1 at least	CN 201820326 U (SUZHOU DENGWEI COMMERCIAL INSTALLATION CO LTD) See whole document an example of a cable anti-theft device.
X	1 at least	CN 101408581 A (SHANDONG SENTER ELECTRONIC CO) See whole document an example of a cable wire break detection alarming device.
X	1 at least	US 8860580 B1 (WONG THOMAS K) See whole document an example system for protecting against theft of metal wire and other objects.

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{X} :

Worldwide search of patent documents classified in the following areas of the IPC

H04B

The following online and other databases have been used in the preparation of this search report

EPODOC; WPI

International Classification:

Subclass	Subgroup	Valid From
H04B	0007/00	01/01/2006
G01R	0031/02	01/01/2006