# WIRELESS SENSING OF VEHICLE PARAMETERS

## BACKGROUND

**[0001]** Sensors can be utilized to monitor one or more characteristics within an environment. For instance, sensors can be utilized to monitor one or more operational characteristics within an environment.

## SUMMARY

**[0002]** A system for monitoring one or more vehicle characteristics (e.g., operational characteristics) and transmitting the one or more vehicle characteristics is described. The system may include at least one sensor configured to be mounted within a vehicle. The sensor is configured to monitor and to obtain one or more operational characteristics pertaining to the vehicle. The sensor is also configured to broadcast data representing the one or more operational characteristics via a communication network. The system also includes a computing device communicatively coupled to the at least one sensor. The computing device (e.g., a mobile electronic device) includes a memory and a processor. The processor is configured to monitor for the broadcast, receive the data representing the one or more operational characteristics when the broadcast is detected, and store the data representing one or more operational characteristics in the memory upon receiving the broadcast.

**[0003]** This Summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Written Description. This Summary is not intended to identify key features or essential features of the claimed subject matter, nor is it intended to be used as an aid in determining the scope of the claimed subject matter.

## BRIEF DESCRIPTION OF THE FIGURES

**[0006]** The Written Description is described with reference to the accompanying figures. The use of the same reference numbers in different instances in the description and the figures may indicate similar or identical items.

**[0007]** FIG. 1 illustrates a flow chart of data representing wired/wireless transmission to a user interface and also to cloud storage as well as internal storage. The mobile electronic device can receive data from several different sensors, store the data internally, store the data externally (via remote storage), and display the data on the device.

**[0008]** FIG. 2 illustrates a more detailed view of a vehicle mounted wireless system described in FIG. 1. The small black dots located in the front end of the car represent the individual sensors which are measuring and transmitting data wirelessly. The red lines coming from the picture of the battery represent the power lines which may supply voltage to the individual sensors. The mobile electronic device is shown with an example user interface displayed. This user interface is displaying the data measured by the individual sensors located throughout the vehicle. A desktop device is also included which represents the ability to view the data from a secondary source.

**[0009]** FIG. 3 illustrates a single example of a particular sensor, namely the coolant temperature sensor. A single wire is utilized for reading the value of this particular sensor.

**[0010]** FIG. 4 illustrates the output of respective sensor being read using a micro-processor and then transmitted directly, via integrated Bluetooth or other wireless methods, to a mobile electronic device.

**[0011]** FIG. 5 illustrates the sensor in FIG. 3 but with the transmitter/micro-processor represented as separate entities.

**[0012]** FIG. 6 illustrates that rather than having respective sensor individually communicating directly with the mobile electronic device, the respective sensors may communicate directly with a central hub. This hub may receive input directly from a respective sensor, process the information, and then transmit the data directly to the mobile electronic device via Bluetooth or other wireless methods.

**[0013]** FIG. 7 illustrates the assembly components of a single transmitting unit. This figure is an exploded view of the assembly consisting of the outer shell, a base plate, magnets, bolts, locking washers, and nuts.

**[0014]** FIG. 8 illustrates the flow of data transmission throughout the process of the system. The data is generated at the sensors, whether it be individual wireless modules or a single central module. The data is then transmitted to the mobile electronic device where it is processed and converted to the appropriate value(s) and units. The app then transmits the data through a communication network to a remote server that can be accessed from a secondary device.

**[0015]** FIG. 9 illustrates a block diagram representation of the flow of the mobile app. The app starts on the main gauge display screen, and from this screen the user can select exactly which gauges to display as well as the model of the sensor so that the appropriate calibrations can be made to obtain accurate data. The user can then navigate to various other pages including a real-time chart view of the data, a scrollable list view of the data, and a lap view of the data.

**[0016]** FIG. 10 illustrates the central hub module concept in which multiple sensors can be directly wired into a single transmitting unit. This central hub can replace up to eight individual transmitting units.

**[0017]** FIG. 11 illustrates the flow of data in a central hub module. Because the microprocessor provides a voltage to the sensor in order to obtain a resistance reading, and because the vehicle's on-board gauges are doing the same, inaccurate measurements may be obtained when both circuits are in operation. Therefore, a digital potentiometer is implemented in order to mimic the sensor's resistance, providing an isolated component for the gauges to read. The data is then transmitted to the receiver.

## WRITTEN DESCRIPTION

**[0006]** Vehicle owners desire to maintain complete and accurate records concerning their vehicles. For instance, some vehicle users desire to track statistical information which is readily available to them. Unfortunately, it is often a tedious task to manually record statistical information regarding the vehicle.

**[0007]** Conventional on-vehicle computer systems mounted in vehicles for diagnostics purposes exist. Such on-vehicle systems typically maintain some basic data regarding the vehicle's operational statistics and other various recorded data, or are focused on engine performance alone. However, this conventionally maintained information is not readily available to the vehicle's owner without specialized monitoring equipment manually plugged into the vehicle and outputted.

**[0008]** The proposed invention offers an entirely wireless solution, automatically compiling, organizing and relaying the desired information with an easy to use interface on a hand-held or desktop device.

**[0009]** Thus, in an example implementation, a wireless transmitter can be mounted in a vehicle and a wireless receiver is placed in a vehicle for communication. The vehicle establishes a connection with the user's mobile device and/or wireless receiver. Vehicle operational statistics (e.g., vehicle characteristics, operational characteristics) are tracked and maintained in a centralized vehicle database. This database can be manipulated to store the data desired by the vehicle owner, and adapt to a variety of sensors both in the vehicle and added to the vehicle. Via a wireless connection, this information can be transmitted to another device for further processing, if desired by the user. The mobile electronic device within the vehicle can be connected to the sensors within the car wirelessly, using methods such as Bluetooth or Bluetooth LE. This provides the user with the ability to monitor vehicle parameters with external wireless devices such as, but not limited to, a cell phone, PDA, or computers. This system may allow for the selection of desired vehicle data to be tracked. The configuration can take place on the owner's device and consequently read only the specified transmitted data. Exemplary vehicle statistics which may be tracked include, but are not limited to, miles per gallon, average miles per hour (MPH), maximum MPH, miles driven per trip, driving statistics based on time of day and/or on identified driver, rotations of the engine per minute (RPM), temperature of engine coolant, fuel gauge level, oil temperature and pressure, tire pressure, brake wear, and/or wiper fluid level.

**[0010]** In accordance with various implementations of the present disclosure, a system including one or more wireless network of sensors for mounting in a vehicle. FIGS. 1 through 11 illustrate various embodiments of the present disclosure as described herein in greater detail. The one or more sensors comprise one or more respective micro-processors/transmitters that are adapted to output vehicle parameters (e.g., vehicle characteristics, operational characteristics, etc.) and a mobile electronic device (e.g., a Bluetooth enabled smartphone, etc.). In general, the input to electric gauges are a voltage or a resistance change output by the sensor. In the case of a voltage output from the sensor, the voltage can be converted to a temperature, pressure, etc. based on a correlative equation defined for the given sensor. In the case of sensors with variable resistance, the sensor can be integrated into a circuit in the module in order to generate the variable voltage to be read by the microprocessor. If a vehicle is equipped with mechanical gauges, these mechanical gauges may require replacement with electrical gauges. In some embodiments, custom modules may be utilized for the given application in order to convert the mechanical output to a corresponding electrical output which the microprocessor can read.

**[0011]** The present disclosure describes a system that includes an apparatus and technique for allowing a vehicle to establish a wireless network to receive sensor data. Vehicle performance can be monitored by the use of a host of sensors measuring fluid and component temperatures, oil and tire pressures, engine speed, as well as a host of other metrics. The other vehicle parameters (e.g., vehicle characteristics, etc.) can include, but are not limited to, tire pressure, RPM, vehicle speed, battery voltage, etc. The wireless sensor system could relay these measurements to an app on the user's mobile electronic device or other wireless receiving unit for various uses.

**[0012]** With respect to FIG. 4, the output of each sensor may be read using a micro-processor and then transmitted directly, via integrated Bluetooth or other wireless methods, to a mobile electronic device. In this case, each sensor may have its own transmitter.

**[0013]** With respect to FIG. 5, the architecture can remain the same, although the transmitter/micro-processor may be replaced with dedicated alternatives. In this case, the transmitter and micro-processor may be separate entities.

**[0014]** With respect to FIG. 6, rather than having each sensor individually communicating directly with the mobile electronic device, the respective sensors communicate directly with a central hub. This hub receives input directly from each sensor, processes the information, and then transmits the data directly to the mobile electronic device via Bluetooth or other wireless method.

**[0015]** FIG. 8 illustrates the hardware as a central module wirelessly communicating with the mobile electronic device/app. The device is showing a gauge view screen. The device then relays the data to the remote server through a wireless connection. As can be seen on the secondary device illustration, the data can then be viewed in various ways, including a lap view option where the user can select a point in time to view data.

**[0016]** FIG. 9 illustrates a block diagram including a flow chart showing page transitions. In this case, the user can navigate to three different pages from the main page. These three pages are a chart view, where real time data is shown as a line graph. There is a list view, where the user can scroll through the data in a text display, and there is a lap view option, where the user can see a particular lap that was completed by the vehicle and select an exact point in that lap to view the data at that point in time. From the main gauge display the user may also be able to select a particular manufacturer and model number of the sensor being used, as well as filter out which gauges the user would like to view and display.

**[0017]** With regards to FIG. 11, when measuring the resistance of a sensor, a voltage is applied by the microprocessor and the resulting voltage drop across the sensor is read by the microprocessor via an analog to digital converter. From this, the resistance can be determined based on the other resistor value in the circuit. This reading can be obfuscated if two circuits are trying to read the same sensor at the same time. To overcome this, a digital potentiometer is employed. After determining the sensor's resistance, a digital potentiometer can be controlled to replicate the resistance. The vehicle's gauges, which may be wired into this digital potentiometer, is then read the resistance of the potentiometer, as opposed to the resistance of the sensor.

**[0018]** When the parameter being measured can be evaluated by a change in resistance, such as a thermistor or pressure gauge, the voltage drop can be evaluated via a voltage-divider circuit. Converting measured parameters into a proportional voltage is the basis for evaluating several of the parameters.

**[0019]** Once a sensor reading is obtained, respective transmitter may broadcast a message containing the sensor ID and the sensor reading at regular intervals. In some implementations, respective sensor transmits the sensor reading to a centralized hub via a wired network. This central hub can then concatenate the sensor readings and broadcast a signal transmission reducing the number of broadcasts to be read by a receiver. Thus, the system described herein may utilize a single transmitter.

**[0020]** A computing device (e.g., a mobile electronic device or mobile electronic device, such as a Bluetooth enabled smartphone, etc.) can be uploaded with an application (e.g., an "app") configured to monitor for Bluetooth or wireless broadcasts. For instance, the mobile electronic device may comprise non-transitory computer readable media having stored thereon a computer program (e.g., the application) that is configured to cause a processor associated with the computing device to perform one or more functions as described herein. The application filters any incoming transmissions that do not contain a valid sensor ID. For instance, the application is configured to cause the processor to determine (e.g., detect) when a broadcast has occurred based upon valid sensor IDs. Thus, the processor filters transmissions based upon the valid sensor IDs. Data representing the sensor IDs may be in a header portion of a data packet of the broadcast. Once the processor determines the communication (e.g., broadcast of data packets) includes a data representing a valid sensor ID, the processor receives and stores the data representing operational characteristics monitored and measured by the one or more sensors. The remaining messages may then be passed (e.g., received) to virtual in-app gauges and stored in the device. The data stored in the device can then be uploaded to cloud storage via a communication network (e.g., an Internet connection). Once uploaded, this data can be viewed from suitable computing device (e.g., desktop, laptop, smartphone, etc.). In one or more implementations, the data may be transmitted over a communication network (e.g., a wired or a wireless network). Examples of wireless networks include, but are not limited to: networks configured for communications according to: one or more standard of the Institute of Electrical and Electronics Engineers (IEEE), such as 802.11 or 802.16 (Wi-Max) standards; Wi-Fi standards promulgated by the Wi-Fi Alliance; Bluetooth standards promulgated by the Bluetooth Special Interest Group; and so on. Wired communications are also contemplated such as through universal serial bus (USB), Ethernet, serial connections, and so forth.

**[0021]** To power the sensors, multiple power options have been discovered and implemented. The main methods discussed here are individual power supplies and power from the car battery.

**[0022]** Individual power supplies refer to the possibility of respective sensor having their own battery or another power source that is independent of the power sources of the other sensors. This option allows respective of the sensors to be totally self-contained units. In the case of individual power supplies, a common ground is established between the ground terminal of the power source and the metal frame of the vehicle. This can be done by creating a conductive path, or short circuit, between the ground terminal of the power source and the metal frame of the vehicle.

**[0023]** Power from the car battery can be achieved in multiple ways. Ideally, the sensors may include a power line that runs to a fuse box which receives power from the battery when the vehicle's accessories are being powered. In another implementation, the power lines can be run directly to the car battery. In the case of power being drawn from the car battery, a common ground is established with the sensors via the vehicle's metal frame which is connected to the ground terminal of the battery.

**[0024]** Many elements of the car are allowable for common ground. Examples include, but are not limited to: the ground of the battery terminal, ground in the fuse box, parts of the frame, some bolts, and other sensor grounds. The existence of a common ground is utilized when powering the unit because the car sensors include variable resistors and a potential must be read across the sensor.

**[0025]** Bluetooth Low Energy (BLE) is a recent addition to the Bluetooth protocol options. This option allows for beacon services for hardware one-way communication with mobile applications. In an implementation, the hardware incorporates a microcontroller with a Nordic nRF51822 BLE chip and onboard antenna. This chip acts as a one-stop-shop for the wireless communication capabilities of the hardware. The microcontroller utilizes the mbed.org software development kit (SDK). The main type of wireless used for these units is Bluetooth Low Energy, but that does not limit wireless transfer to only Bluetooth Low Energy. Bluetooth may be preferred due to convenience with interfacing with phones, tablets, and computers. Another option would be to create a local wireless network using the phone/tablet/computer WiFi and have the sensors use WiFi to broadcast the data. Another option would be to use radio broadcasts and have a receiver and transmitter to read sensor data. This method may be preferred if the vehicle was to transmit the data at longer distances. Other wireless concepts include, but are not limited to, microwave and infrared.

**[0026]** If an existing sensor is attached to the gauge in the car, a slight variation on the circuit is required to properly account for the readings from both devices. Otherwise, the two circuits interact with respective other and create unwanted interference on both devices. One option is to remove the gauge in the car and use only the device. The other solution is to isolate the two circuits to avoid vehicle specific properties such as sensing voltage, wire length, and/or resistance. The isolation option provides improvement by allowing the sensor in the car to be read by the microprocessor and then changing the resistance of a digital potentiometer. The resistance of this digital potentiometer replicates the resistance of the sensor and is what the existing car gauges may read.

**[0027]** In implementations, the hardware is equipped with a firmware written in the mbed language. The firmware is responsible for receiving an analog signal from the vehicle sensor and transmitting this information through the BLE protocol. The analog signal is a value between 0 and 1 and can be processed as a double and converted to hex datatypes for data transmission. The device's MAC address is also converted to hex and together these two pieces of information form the message that may be sent to the phone/tablet/computer. In some implementations, the message can be transmitted at a latency of one second.

**[0028]** The wireless sensors communicate directly with a mobile electronic device possessing the user-interface application. The app can be used on a mobile phone, tablet, or similar hand-held device with Android operating system capabilities. The device should have Bluetooth capabilities as well as GPS for full functionality. Upon start-up, the app defaults to the main gauge display where users may be able to view all connected and functioning sensors. From the main display, the user is able to toggle between various sensor models to select the appropriate calibration for their particular sensors. From the main page the user may also have the option to navigate to various pages for additional functionality. One of these pages may include a real-time data feed in a chart view. This may allow the user to view how a particular sensor’s data is trending. Another page option may offer a list view of all data collected. The user can navigate to a particular moment in time to view the value(s) that were collected. While the app is connected to the Internet, data is constantly pushed to a dedicated cloud server to collect and organize the sensor data. The user can then access an online interface where the data can be further analyzed, included racing lap data based on the GPS data collected by the device. This may allow the user to view the lap(s) that were completed and click on a specific area of the lap and analyze the data for that instance in time.

**[0029]** Because there are several different types of sensors on the market, all with different equations that represent the evaluation of their output voltage, the app provides the ability to input that equation. While these equations can sometimes be obtained from manufacturers, they must other times be determined through experimentation. Such as in the case of a thermistor or pressure gauge, an experimental setup can be created to measure resistance at various test points. Once several data points have been obtained, they can be plotted and a best-fit equation can be determined. This equation can be entered in the app and may be used to evaluate the corresponding measured parameter.

**[0030]** To avoid user error in evaluating these equations, a wide selection of sensor calibration equations may be available within the app. The user may be able to select a sensor from the app which corresponds to the sensor they have installed in their vehicle. The app may then use the selected sensor's calibration equation for evaluating the data received from the sensor. However, in the case that a user cannot find their sensor's calibration equation, the aforementioned calibration method can be implemented. In the case of a sensor with a log scale, the Steinhart-Hart equation can be used to approximate a natural log equation.

**[0018]** In order to provide a method of mounting the sensors in the vehicle, a case has been designed which provides a convenient method of attaching to the vehicle, as well as providing protection to the circuitry from debris, thermal effects, and/or other elements. The entire assembly can be mounted to any steel portion of the vehicle's frame or body, via magnets, and the wires are run to their power sources and respective sensors. The module can also be mounted more permanently via a bolt-on connection to the vehicle. Special care should be taken in placement to avoid moving parts, vibrating elements, heat conducting elements, wires that may fall into moving parts, and parts that create electronic noise.

**[0019]** Generally, any of the functions described herein can be implemented using hardware (e.g., fixed logic circuitry such as integrated circuits), software, firmware, or a combination thereof. Thus, the blocks discussed in the above disclosure generally represent hardware (e.g., fixed logic circuitry such as integrated circuits), software, firmware, or a combination thereof. In embodiments of the disclosure that manifest in the form of integrated circuits, the various blocks discussed in the above disclosure can be implemented as integrated circuits along with other functionality. Such integrated circuits can include all of the functions of a given block, system, or circuit, or a portion of the functions of the block, system or circuit. Further, elements of the blocks, systems, or circuits can be implemented across multiple integrated circuits. Such integrated circuits can comprise various integrated circuits including, but not necessarily limited to: a system on a chip (SoC), a monolithic integrated circuit, a flip chip integrated circuit, a multichip module integrated circuit, and/or a mixed signal integrated circuit. In embodiments of the disclosure that manifest in the form of software, the various blocks discussed in the above disclosure represent executable instructions (e.g., program code) that perform specified tasks when executed on a processor. These executable instructions can be stored in one or more tangible computer readable media. In some such embodiments, the entire system, block or circuit can be implemented using its software or firmware equivalent. In some embodiments, one part of a given system, block or circuit can be implemented in software or firmware, while other parts are implemented in hardware.

**[0020]** Although embodiments of the disclosure have been described in language specific to structural features and/or methodological acts, it is to be understood that the subject matter defined in the appended claims is not necessarily limited to the specific embodiments described. Although various configurations are discussed, the apparatus, systems, subsystems, components and so forth can be constructed in a variety of ways without departing from this disclosure. Rather, the specific features and acts are disclosed as embodiments of implementing the claims.

What is claimed is:

1. A system comprising:

at least one sensor configured to be mounted within a vehicle, the sensor configured to monitor and to obtain one or more operational characteristics pertaining to the vehicle, the sensor configured to broadcast data representing the one or more operational characteristics via a communication network;

a computing device communicatively coupled to the at least one sensor, the computing device including:

a memory including one or more computer-readable instructions; and

a processor configured to execute the one or more computer-readable instructions to cause the processor to:

monitor for the broadcast;

receive the data representing the one or more operational characteristics when the broadcast is detected; and

store the data representing one or more operational characteristics in the memory upon receiving the broadcast.

2. The system as recited in claim 1, wherein the computing device comprises a mobile electronic device.

3. The system as recited in claim 1, wherein the communication network comprises a Bluetooth communication network.

4. The system as recited in claim 1, wherein the processor is further configured to cause transmission of the data representing the one or more operational characteristics to a cloud storage network.

5. The system as recited in claim 1, wherein the at least one sensor is configured to generate a voltage output corresponding to the one or more measured operational characteristics.

ABSTRACT

A system for monitoring one or more vehicle characteristics (e.g., operational characteristics) and transmitting the one or more vehicle characteristics is described. The system may include at least one sensor configured to be mounted within a vehicle. The sensor is configured to monitor and to obtain one or more operational characteristics pertaining to the vehicle. The sensor is also configured to broadcast data representing the one or more operational characteristics via a communication network. The system also includes a computing device communicatively coupled to the at least one sensor. The computing device (e.g., a mobile electronic device) includes a memory and a processor. The processor is configured to monitor for the broadcast, receive the data representing the one or more operational characteristics when the broadcast is detected, and store the data representing one or more operational characteristics in the memory upon receiving the broadcast.