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(54) Title: FUEL CONSUMPTION COMPUTATION DEVICE FOR INTERNAL COMBUSTION ENGINE VEHICLES

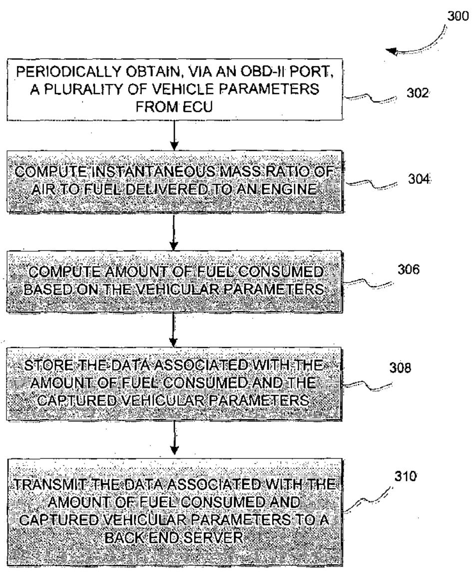

Figure 3a

(57) Abstract: The present invention provides a method and apparatus for computing fuel consumed by an engine of a vehicle. In one embodiment, a method includes obtaining vehicle parameters from an engine control unit via an OBD II port and computing instantaneous mass ratio of air to fuel delivered to an engine of the vehicle. The method also includes computing amount of fuel consumed by the engine of the vehicle using the vehicle parameters and the instantaneous mass ratio and sending data associated with amount of fuel consumed, the vehicle parameters, and instantaneous mass ratio to a backend server. Moreover, the method includes computing vehicular carbon emissions based on the amount of fuel consumed by the engine of the vehicle.

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FUEL CONSUMPTION COMPUTATION DEVICE FOR INTERNAL COMBUSTION ENGINE VEHICLES

RELATED APPLICATIONS

Benefit is claimed to India Provisional Application No. 3831/CHE/2011, entitled "Method and System for Computing Real time Vehicular Carbon Emissions and Associated Driving Characteristics" by MURUGESAN, Shanmugasundaram, et al. filed on 8th November 2011, which is herein incorporated in its entirety by reference for all purposes.

FIELD OF THE INVENTION

The present invention relates to the field of computation of fuel consumption in a vehicle, and more particularly relates to an apparatus and system for computing fuel consumption in vehicles running on gasoline and diesel.

BACKGROUND OF THE INVENTION

The accurate fuel consumption data of a vehicle has always been instrumental in deriving relation between emission of the vehicle and driving characteristics. However, the computation of fuel consumption for all types of engines such as petrol or spark ignition and diesel based or compression ignition engines has always remained elusive. Most vehicle drivers remain unaware of their driving characteristics and associated fuel consumption due to lack of any real time monitoring technology within vehicles. This may lead to improper driving behavior which adversely affects fuel efficiency of the vehicle.

The presently employed methods of computation of fuel consumption are not accurate enough to reflect the true driving characteristics of a driver. The inaccurate fuel consumption data leads to a wrong notion about the fuel consumption and driving characteristics, reducing the scope of improvement in driving. Therefore, there is a need for a method and system to provide accurate fuel consumption for vehicles running on various types of fuels.

BRIEF DESCRIPTION OF DRAWINGS OF THE ACCOMPANYING DRAWINGS

FIG. 1 is a block level diagram illustrating a vehicular emission monitoring system for computing fuel consumption in real time, according to one embodiment.

FIG. 2 illustrates a block diagram of an emission monitoring device fitted in a vehicle for computing vehicular fuel consumption in real time, according to one embodiment.

FIG. 3a is a flow diagram illustrating a method of computing fuel consumption in real time in a vehicle, according to one embodiment.

FIG. 3b is a flow diagram illustrating a method of carbon emission in real time in a vehicle, according to one embodiment.

FIG. 4 is a flow diagram illustrating a method of computing fuel consumption in real time of a vehicle utilizing a spark ignition engine, according to one embodiment.

Fig. 5 is a flow diagram illustrating a method of computing fuel consumption in real time of a vehicle utilizing a compression ignition engine, according to one embodiment.

Fig. 6 is illustrating a mode of performing the invention, according to one embodiment.

DETAILED DESCRIPTION OF THE INVENTION

The foregoing has broadly outlined the features and technical advantages of the present disclosure in order that the detailed description of the disclosure that follows may be better understood. It should be appreciated by those skilled in the art that the conception and specific embodiment disclosed may be readily utilized as a basis for modifying or designing other structures for carrying out the same purposes of the present disclosure. It should also be realized by those skilled in the art that such equivalent constructions do not depart from the spirit and scope of the disclosure as set forth in the appended claims. The novel features which are believed to be characteristic of the disclosure, both as to its organization and method of operation, together with further objects and advantages will be better understood from the following description when considered in connection with the accompanying figures. It is to be expressly understood, however, that each of the figures is provided for the purpose of illustration and description only and is not intended as a definition of the limits of the present disclosure.

Figure 1 is a block diagram illustrating a vehicular emission monitoring system 100 for computing vehicular fuel consumption in real time, according to one embodiment.

The vehicular emission monitoring system 100 includes one or more sensors 102, an engine control unit (ECU) 104, an On-Board Device (OBD) II port 106, an emission monitoring device (EMD) 108 and one or more back end servers 112. As illustrated, the ECU 104 or Power Train Control Module (PCM) receives vehicular parameters for example including, but not limited to, revolutions per minute (rpm), intake air temperature (IAT), vehicle speed, engine speed, instantaneous engine load, , manifold air pressure (MAP), distance travelled by the vehicle, fuel level, diagnostic trouble codes, oxygen sensor output, throttle position, exhaust air temperature and engine temperature from a plurality of sensors 102 deployed in the vehicle 114.

In an embodiment, the EMD 108 periodically (i.e. per second) requests and receives the vehicular parameters from ECU 104 through an on-board diagnostic interface, for example standard automotive technologies such as OBD II port 104, Controller Area Network (CAN) interface, or FMS interface. The EMD 108 requests the vehicular parameters only during the duration engine of the vehicle remains on. The EMD 108 is also communicatively coupled to the back-end server 112 via the communication network 110 (e.g. Wi-Fi®, GPRS, etc.).

Figure 2 illustrates a block diagram of an EMD 108 fitted in a vehicle for computing vehicular fuel consumption in real time, according to one embodiment. The EMD 108 includes an OBD II interface circuitry 204, a processor 202, a memory 206 and a communication unit 208.

The processor 202, as used herein, means any type of computational circuit, such as, but not limited to, a microprocessor, a microcontroller, a complex instruction set computing microprocessor, a reduced instruction set computing microprocessor, a very long instruction word microprocessor, an explicitly parallel instruction computing microprocessor, a graphics processor, a digital signal processor, or any other type of processing circuit. The processor 502 may also include embedded controllers, such as generic or programmable logic devices or arrays, application specific integrated circuits, single-chip computers, smart cards, and the like.

The memory 206 may include any suitable memory device(s) for storing data and machine-readable instructions, such as read only memory, random access memory, erasable programmable read only memory, electrically erasable programmable read only memory, memory cards, Memory Sticks™ and the like.

The memory 206 includes a fuel computation module 210 stored in the form of computer executable program, wherein the module 210 instructs the processor 202 to periodically obtain the plurality of vehicle parameters from the ECU 104 via the OBD II port 106, determine instantaneous mass ratio of air to fuel delivered in an engine of the vehicle and computing amount of fuel consumed by the engine in real time of the vehicle. Further, data associated with consumed fuel amount and the vehicular parameters are stored in the memory 206.

The communication unit 208 transmits the stored data associated with consumed fuel amount and the vehicular parameters to the back end server 112 over the communication network 110.

In another embodiment, the EMD 108 is further provided with carbon emission computation module (not shown in the diagram). The carbon emission computation module is configured to compute vehicular carbon emission per unit distance traveled by the vehicle in real time based on the computed vehicular fuel consumption data. Further, the communication unit transmits the data associated with fuel consumption, carbon emission per unit distance traveled by the vehicle 114 and the vehicular parameters.

In another embodiment, the vehicular carbon emission per unit distance traveled by the vehicle is computed at the back end server 112 based on the data associated with consumed fuel amount received from the EMD 108.

Figure 3a is a flow diagram illustrating a method for computing real time fuel consumption in a vehicle, according to one embodiment. At step 302, a plurality of vehicle parameters are periodically obtained from the ECU 104 via the OBD II port while the engine of the vehicle 114 is ON.

At step 304, instantaneous mass ratio of air to fuel delivered in the engine of the vehicle 114 is computed based on instantaneous engine load. For obtaining the instantaneous mass ratio of air to fuel, a minimum mass ratio of air to fuel and a maximum mass ratio of air to fuel are computed at a maximum engine load and a minimum engine load (e.g., when the engine is idling), respectively. In one embodiment, a first voltage value corresponding to amount of exhaust emissions of the vehicle 114 at the minimum engine load and the a second voltage value corresponding to amount of exhaust emissions of the vehicle 114 at the maximum engine load are obtained from a sensor such as an oxygen sensor deployed in the exhaust line of the vehicle 114. In this embodiment, the maximum mass ratio and the minimum mass ratio are computed based on the first voltage value and the second voltage value respectively. In another embodiment, a first voltage value corresponding to amount of exhaust emissions of the vehicle 114 at the minimum engine load and series of voltage values corresponding to amount of exhaust emissions of the vehicle 114 at the different engine load between the minimum engine load and the maximum engine load are obtained from the sensor. In this embodiment, the maximum mass ratio is computed based on the first voltage value, however, the minimum mass ratio at the maximum engine load is computed by extrapolating the first voltage value and the series voltage values at different engine load values. It is to be noted that, the maximum and minimum mass ratio varies with type and capacity of the engine used in different vehicles and hence it is imperative to compute the maximum mass ratio and the minimum mass ratio for determining instantaneous mass ratio of air to fuel delivered to the engine. Also, it is important to note that the instantaneous mass ratio provide greater accuracy in computation of the fuel consumed by the engine.

At step 306, amount of fuel consumed by the vehicle 114 is computed in real time based on one or more vehicular parameters and the instantaneous mass ratio. For example, if the vehicle 114 travels from point A to B, then the total fuel consumed in covering the distance between A and B is calculated in real time.

This helps in determining the actual fuel consumption of the vehicle 114. At a step 308, the data associated with amount of fuel consumed by the vehicle 114 and the vehicle parameters received from the ECU 104 are stored in the memory 206.

At a step 310, the stored data associated with consumed fuel amount and the vehicular parameters are transmitted to the back end server 112 using a defined protocol in a request and response mode, once engine of the vehicle is turned off. In some embodiments, the EMD 108 is configured to identify the turned off state of the engine of the vehicle. For example, the EMD 108 may keep requesting data from the ECU 104 and when the requested data is not received for X seconds, the EMD 108 determines that the vehicle 114 has been turned off.

FIG. 3b is a flow diagram to illustrate a method 350 of computing vehicular carbon emission in real time based on the amount of fuel consumed by the vehicle 114, according to one embodiment.

At step 352 as illustrated in **Figure 3b,** carbon emissions are computed for per unit distance traveled by the vehicle 114 in real time based on the computed vehicular fuel consumption data. For example, when a vehicle travels from point A to point B, a finite amount of fuel is consumed by the internal combustion engine of the vehicle and this is referred as miles per gallon (mpg) or kilometer per Litre (kmpl). From this parameter the quantity of CO_2 emitted into the atmosphere per unit distance is calculated.

At a step 354, the data associated with carbon emission, amount of fuel consumed by the vehicle 114 and vehicular parameters received from ECU 104 are stored in the memory 206. At step 356, the stored data associated with carbon emission, consumed fuel amount and the vehicular parameters are transmitted to the back end server 112 using a defined protocol in a request and response mode, once engine of the vehicle is turned off.

In another embodiment, the vehicle drivers are rated in a scale of 1 to 10 based on a green index. The green index is obtained based on the vehicular carbon emission data, fuel consumption data and captured parameters at the back end server 112. In some embodiments, the green index is determined by comparing the actual amount of fuel consumed by vehicle in real time with amount of fuel supposed to be consumed under ideal conditions of driving. This rating about the drivers of the vehicle 114 is further communicated to the driver or fleet managers or vehicle administrator. This enables the drivers or fleet managers or vehicle administrators to monitor and analyze the driving pattern/behaviour and efficiently carry out required improvements.

Figure 4 is illustrating a flow diagram of a method of computing amount of fuel consumed by spark ignition engine of the vehicle 114 in real time, according to one embodiment. At step 402, the EMD 108 periodically (e.g. per second) requests the plurality of vehicle parameters from ECU 104, via OBD II port 106. At step 404, the requested vehicle parameters are periodically (e.g. per second) received by the EMD 108 from ECU 104. For example, if EMD 108 requests for revolutions per minute (RPM) data then it sends a specific bytes trie and in return receives a set of data in which the RPM is embedded. The EMD 108 then extracts the requested RPM from the set of data received. For requesting and receiving the vehicular information, the EMD 108 identifies a protocol used for communication with the ECU 104 and uses the identified protocol for communicating with ECU 104 through the OBD II port 106. The aforementioned steps of requesting and receiving the vehicle parameters are performed during the time engine of the vehicle remains on. At step 406, the vehicle parameters are captured periodically by performing steps 402 and 404.

At step 408, fuel consumed by the vehicle 114 during the duration engine of the vehicle remains on is computed in real time by the EMD 108 based on one or more of the vehicular parameters captured. For example, a finite amount of fuel is consumed by the vehicle engine in propelling the vehicle from one point to another. This amount of fuel consumed is measured in terms of Miles per gallon (MPG) or Kilometers per liter (KMPL). Algorithms used for computation of fuel consumption of the vehicle, are described below.

According to one embodiment, the processor 202 of EMD 108 computes the amount of fuel consumed by a spark ignition engines in MPG using the following formula.

$$MPG = \frac{(AFR \times 6.17 \times 454 \times (VSS \times 0.621371))}{((3600 \times MAF) / 100)} \quad \rightarrow \text{Eq. 1}$$

where,

MPG is Miles per Gallon, VSS is Vehicle Speed obtained from a Vehicle Speed Sensor, MAF is Manifold Air Flow obtained from the MAF sensor, AFR is Air Fuel Ratio.

It can be noted that, the equation 1 is applicable if the MAF is available through the OBD II port. If the MAF is not provided by the ECU 104, then manifold absolute pressure (MAP) is used to derive the MAF. The equation 2 and 3 below are used for computing MAF when the MAF can not be obtained from the ECU 104:

$$IMAP = RPM \left(\frac{MAP}{IAT}\right) \quad \rightarrow \text{Eq. 2}$$

$$MAF = \frac{IMAP \times VE \times ED \times MM}{120 \times 100 \times R} \quad \rightarrow \text{Eq. 3}$$

where, IMAP is intake Manifold Air Pressure (kPa/ degree K), RPM is Engine Speed in Revolutions per Minute (1/min or 1/s), MAP is Manifold Air Pressure (kPa), IAT is Intake Air Temperature (0K), MAF is Manifold Air Flow (g/s), VE is Volumetric Efficiency (unit less), ED is Engine Displacement (L or m3), MM is Molecular Mass of Air (28.97 g/mole), and R is Gas Constant for Air (8.314 J/0K mole).

In one embodiment, the volumetric efficiency is computed based on percentage difference of first air density and the second air density, where the first air density is computed by dividing atmospheric air pressure by atmospheric air temperature and the second air density is computed by dividing the manifold air pressure with the intake air temperature. It is understood that, the values of manifold air pressure, intake air temperature, atmospheric air pressure and atmospheric air temperature are obtained from the ECU 104. The result from equation 3 is used to derive the MPG using the equation 1 or 2. The instantaneous amount of fuel which is consumed by the spark ignition engine is calculated from the following equation 4.

$$F = \frac{MAF}{AFR} \quad \rightarrow \text{Eq. 4}$$

where, F is Fuel Consumed (g/s), MAF is Mass Air Flow (g/s), and AFR is Instantaneous Air Fuel Ratio.

It can be noted that, equation 4 is used to calculate the amount of fuel consumed at any point in time based on the comparison with the speed and acceleration of the vehicle 114 and the amount of fuel consumed with respect to a baseline, say 1KM/H/sec.

The equation 4 can be used, in case of spark ignition engines, to calculate the amount of fuel wasted when the engine is running rich due to hard acceleration, heavy loads etc. However, compression ignition engines unlike spark ignition engines do not run at the stoichiometric ratio of 14.7:1 hence requires a different method of calculating the fuel consumption as will be illustrated in **Figure 5**. The stoichiometric ratio for compression ignition engine is 14.55:1, which means 14.55 parts of air along with one part of diesel is required to burn diesel completely in the combustion chamber.

At step 410, the computed fuel consumption data and captured vehicular parameters are stored in the memory 206 of the EMD 108.

Atstep 412, once the vehicle engine is turned off, the EMD 108 initiates transmission of the captured vehicular parameters and computed fuel consumption data to the back end server 112 (e.g., a central server) using a defined protocol in a request and response mode. The process is initiated by transmitting credentials of the EMD 108 to the back end server 112 for authentication. For example, the credentials may include vehicle identification number which is identified by the EMD 108 by reading the vehicle identification number stored in the ECU 104 and notifies the vehicle identification number to the back end server 112.

At step 414, once the EMD 108 is recognized by the back end server 112, the server 112 passes configuration parameters to the EMD 108 as a response.

At step 416, the EMD 108 reconfigures itself with the newly received configuration parameters from back end server 112 and sends the stored data associated with fuel consumption of the vehicle, carbon emission of the vehicle and the vehicular parameters to the back-end server in response to which the server 112 sends an acknowledgement to the EMD 108. The EMD 108 may send multiple iterations of the stored data and disconnects on the request of the back-end server 112. All data communications between the EMD 108 and the back-end server 112 is verified by a checksum algorithm to ensure data integrity.

Figure 5 is a method of dynamically computing fuel consumption rate of a diesel vehicle in real time, according to one embodiment. At step 506, the vehicular parameters are captured by the EMD 108 from the ECU 104 by performing steps similar to steps 402 and 404.

At step 508, the EMD 108 computes the instantaneous mass ratio of air to fuel (AFR) delivered in an engine of the vehicle 114 by using at least one of the plurality of vehicle parameters. The instantaneous mass ratio is computed by determining a percentage difference of maximum mass ratio of air to fuel and minimum mass ratio of air to fuel, multiplying instantaneous engine load with the determined percentage difference, and determining instantaneous mass ratio of air to fuel delivered to the engine by subtracting the multiplied output from the maximum mass ratio of air to fuel. For example, two variables X_{min} and X_{max} are created for defining minimum and maximum limits of boundary condition of the AFR, wherein value of the variables depend on engine load. The X_{min} of AFR is determined when the compression ignition engine is running at maximum engine load, where the proportion of air is less than 14.55 or around 14.55 causing the maximum amount of fuel to be burnt inside the combustion chamber. The X_{max} of AFR is determined when the compression ignition engine is idling, in other words, running at minimum load where the proportion of air is much higher than 14.55, which at times might be around 80.

Further, the X_{min} and X_{max} is fixed at maximum load and minimum load respectively for every type of engine, where the engine load varies from a maximum value to a minimum value and the AFR varies from a minimum value mapped to the minimum engine load value to the maximum value mapped to the maximum engine load value. For example, if engine's maximum load is 100% and the air fuel ratio is 14.55:1 then X_{min} is taken as 14.55 and mapped to 100 and if the minimum engine load at idling is 20% and air fuel ratio is 80, then X_{max} is taken as 80 is mapped to 20. The AFR values in between 20% engine load and 100% engine load is calculated proportionately. Such as, AFR at 50% engine load would be 30:1.

In one of the embodiments, the instantaneous AFR for a compression ignition vehicle are calculated by using following equations:

$$X_{instantaneous} = X_{max} - (Y \times Z) \quad \rightarrow \text{Eq. 5}$$

where,

$X_{instantaneous}$ is the instantaneous value of AFR

X_{max} is the maximum value of AFR =40

Y is the instantaneous engine load reported by ECU 104

and

$$Z = (X_{max} - X_{min}) / 100 \quad \rightarrow \text{Eq. 6}$$

where X_{min} = 14.55

At a step 510, the amount of fuel consumed by the engine of the vehicle is computed, according to one embodiment. The process initiates with computation of manifold air flow (MAF) rate by dividing product of manifold air pressure (MAP) and revolutions per minute (PRM) with the intake air temperature (IAT). Further, the amount of fuel consumed by the engine of the vehicle is computed in real time by dividing the manifold air flow (MAF) rate with the instantaneous mass ratio of air to fuel (AFR) computed in the previous step 508.

For example, the following equations can be used to calculate fuel consumption in vehicles in real time:

$$MAF = \frac{MAP \times RPM}{IAT} \quad \rightarrow \text{Eq. 7}$$

where, MAF is manifold air flow, MAP is manifold air pressure, and IAT is intake air temperature.

$$\text{Fuel Consumption} = MAF/\ AFR \quad \rightarrow \text{Eq. 8}$$

where AFR is the instantaneous AFR ($X_{instantaneous}$).

At step 512, the data associated with vehicular fuel consumption, carbon emission and the vehicular parameters are stored in the memory 206.

In further steps, once the vehicle engine is turned off, the EMD 108 initiates transmission of data associated with vehicular fuel consumption, carbon emission and the vehicular parameters to a back end server 112 using a defined protocol in a request and response mode. The process of transmitting the vehicular parameters and data to server 112 is achieved by performing steps similar to steps 412 and 416.

In yet another embodiment, the EMD 108 stores one or more of the captured vehicle parameters in its memory 206 and calculates driver associated information based on the vehicle parameters. The driver associated information includes one or more of the following:

- **Time spent at various speed bands:** The EMD 108 calculates time spent during a trip in various pre-configured speed bands such as, but not limiting to, 0-40 km/hr, 40-60 km/hr, 60-80 km/hr and more than 80 km/hr. The threshold limits and number of speed bands are configured as part of the configuration parameters sent to the EMD 108 by back end server 112,

- **Time spent idling:** The EMD 108 calculates time spent by the vehicle 114 in "ON" state i.e., engine running but without the vehicle moving,
- **Number of hard accelerations:** The EMD 108 calculates the number of times the vehicle 114 was accelerated at a value higher than a pre-configured threshold limit. The threshold limit for determining a hard acceleration is configured as part of a configuration packet parameter sent to the EMD 108 by back end server 112, and
- **Number of hard brakes:** The EMD 108 calculates the number of times the vehicle 114 braked at a value higher than a pre-configured threshold limit. The threshold limit for determining a hard brake is configured as part of a configuration packet parameter sent to the EMD 108 by back end server 112.

In a further embodiment, the EMD 108 is configured to send heartbeat packets to the back end server 112 over a wireless network 110 at a preconfigured interval to indicate the server 112 that the EMD 108 is connected to the vehicle 114 and is in operation. The heartbeat packet contains device identifier, date and time. The heartbeat data is analyzed by a device administrator to trouble shoot connectivity related issues with the EMD 108.

The preconfigured heartbeat interval is stored at the back end server 112 which can be modified as per the specific requirement of the driver of the vehicle. The new/updated preconfigured heartbeat interval is then passed to the EMD 108 to update itself with the new interval and send heartbeat to the back end server 112 as per the new interval. The EMD 108 stores the heartbeat in memory 206 when it is unable to connect to the back end server 112 and pushes all the heartbeats once the connection is established. The heartbeats are displayed in an easy and presentable way to the device administrator and/or the driver.

In an alternate embodiment, the EMD 108 is also configured to send various alarms related to any extreme driving behavior breaching a predefined threshold for each of the behavior, for example hard acceleration, braking and over speeding. All the alarms are transmitted to the back end server 112 once the

EMD 108 is able to establish connectivity with the server 112. The EMD 108 notifies via an audible sound when a threshold is breached which is preconfigured by the driver via a web interface. The data preconfigured by driver is pulled/pushed by the EMD 108 to set itself with the predefined configuration.

In an another alternate embodiment, the EMD 108 is further configured to send alarms to the back end server 112 when its own electronics component does not work as designed or breaches any predefined threshold. All the thresholds are defined in the back end server 112 and such thresholds are then either pushed/pulled by the EMD 108 over a wireless network 110.

In a yet another alternate embodiment, the EMD 108 is configured to interact with the vehicle engine through the OBD II port 106 and receive the stored trouble codes generated by the vehicle 114. The trouble codes are pushed to the back end server 112, which are then presented to the driver or an administrator through various communication medium such as, but not limited to, SMS, Email and web interface. Upon request from the vehicle driver, the trouble codes are pushed to an auto service/repair center to take a decision if the vehicle needs to be serviced.

The back end server 112 stores mandatory maintenance details of the vehicle 114. Also, the EMD 108 communicates the distance traveled by the vehicle 114 to the back end server 112. Further, the back end server 112 notifies the driver and/or vehicle owner/administrator regarding the maintenance using communication medium such as, but not limited to, SMS, Email and web interface.

We Claim:

1. A method of computing fuel consumed by an engine of a vehicle, the method comprising:

periodically obtaining, via an On-Board Device (OBD) II port, a plurality of vehicle parameters from an engine control unit;

determining instantaneous mass ratio of air to fuel delivered in an engine of the vehicle using at least one of the plurality of vehicle parameters by a processor; and

computing amount of fuel consumed by the engine of the vehicle in real time based on at least one of the plurality of vehicle parameters and the instantaneous mass ratio of air to fuel.

2. The method of claim 1, further comprising:

providing data associated with the amount of fuel consumed, the instantaneous mass ratio of air to fuel, and the plurality of vehicle parameters to a backend server using a communication unit.

3. The method of claim 1, further comprising:

computing vehicular carbon emission of the vehicle based on the amount of fuel consumed by the engine of the vehicle in real time.

4. The method of claim 1, wherein the vehicle parameters comprises vehicle speed, engine speed, instantaneous engine load, manifold air pressure, distance traveled by the vehicle, fuel level, diagnostic trouble codes, oxygen sensor output, throttle position, exhaust air temperature, intake air temperature and engine temperature.

5. The method of claim 4, wherein determining the instantaneous mass ratio of air to fuel delivered in the engine of the vehicle comprises:

computing a minimum mass ratio of air to fuel at a maximum engine load value;

computing a maximum mass ratio of air to fuel at a minimum engine load value;

determining percentage difference of maximum mass ratio of air to fuel and minimum mass ratio of air to fuel;

multiplying the instantaneous engine load value with the determined percentage difference; and

determining instantaneous mass ratio of air to fuel delivered to the engine by subtracting the multiplied output from the maximum mass ratio of air to fuel.

6. The method of claim 5, wherein computing the maximum mass ratio of air to fuel at the minimum engine load value comprises:

determining a first voltage corresponding to amount of exhaust emission of the vehicle at the minimum engine load value; and

computing a maximum mass ratio of air to fuel based on the first voltage value.

7. The method of claim 5, wherein computing the minimum mass ratio of air to fuel at the maximum engine load value comprises:

determining a second voltage value corresponding to amount of exhaust emissions of the vehicle at the minimum engine load value; and

computing a minimum mass ratio of air to fuel based on the second voltage value.

8. The method of claim 6, wherein computing the minimum mass ratio of air to fuel at the maximum engine load value comprises:

determining a series of voltage values corresponding to the exhaust emission of the vehicle at different engine load values; and extrapolating a minimum mass ratio of air to fuel at the maximum engine load based on the first voltage value at the minimum engine load value and the series of voltage values at the different engine load values.

9. The method of claim 5, wherein computing the amount of fuel consumed by the engine of the vehicle comprises:

computing manifold air flow rate by dividing product of manifold air pressure value and revolutions per minute with the intake air temperature; and

computing the amount of fuel consumed by the engine of the vehicle by dividing the manifold air flow rate with the instantaneous mass ratio of air to fuel.

10. The method of claim 5, wherein computing the amount of fuel consumed by the engine of the vehicle comprises:

computing an intake manifold air pressure value by dividing the manifold air pressure value by the intake air temperature value and multiplying the divided output with the engine speed value;

computing volumetric efficiency associated with the engine of the vehicle;

computing manifold air flow rate based on the intake manifold pressure value, and the volumetric efficiency; and

computing the amount of fuel consumed by the engine of the vehicle by dividing the manifold air flow rate with the instantaneous mass ratio of air to fuel.

11. The method of claim 10, wherein computing the volumetric efficiency associated with the engine of the vehicle comprises:

computing a first density of air by dividing atmospheric air pressure by atmospheric air temperature;

computing a second density of air by dividing the manifold air pressure with the intake air temperature; and

computing volumetric efficiency based on the percentage difference of the second density and the first density.

12. An apparatus for computing real time fuel consumption in a vehicle, comprising:

an OBD II interface for connecting to an OBD II port;

a processor configured to compute real time fuel consumption in the vehicle;

a memory coupled to the processor; and

a communication unit for connecting to a back-end server.

13. The apparatus of claim 12, the memory comprises a fuel consumption computation module stored in the form of computer executable program, wherein the module instructs the processor to perform the following steps comprising:

periodically obtaining, a plurality of vehicle parameters from an OBD-II port;

determining instantaneous mass ratio of air to fuel delivered in an engine of the vehicle using at least one of the plurality of vehicle parameters by a processor;

computing amount of fuel consumed by the engine in real time of the vehicle based on at least one of the plurality of vehicle parameters and the instantaneous mass ratio of air to fuel; and

providing data associated with the amount of fuel consumed, the instantaneous mass ratio of air to fuel, and the plurality of vehicle parameters to a backend server using the communication unit.

14. The apparatus of claim 12, the memory comprises a fuel consumption computation module stored in the form of computer executable program, wherein the module further instructs the processor to compute vehicular carbon emission of the vehicle based on the amount of fuel consumed by the engine of the vehicle in real time.

15. The apparatus of claim 13, wherein the plurality of vehicle parameters comprises vehicle speed, engine speed, instantaneous engine load, mass air flow, manifold air pressure, distance traveled by the vehicle, fuel level, diagnostic

trouble codes, oxygen sensor output, throttle position, exhaust air temperature, intake air temperature and engine temperature.

16. The apparatus of claim 13, wherein in determining the instantaneous mass ratio of air to fuel delivered in the engine of the vehicle, the module further instructs the processor to perform the following steps comprising:

computing a minimum mass ratio of air to fuel at a maximum engine load value;

computing a maximum mass ratio of air to fuel at a minimum engine load value; determining percentage difference of maximum mass ratio of air to fuel and minimum mass ratio of air to fuel;

multiplying the instantaneous engine load value with the determined percentage difference; and

determining instantaneous mass ratio of air to fuel delivered to the engine by subtracting the multiplied output from the maximum mass ratio of air to fuel.

17. The apparatus of claim 16, wherein in computing the maximum mass ratio of air to fuel at the minimum engine load value, the module further instructs the processor to perform the following steps comprising:

determining a first voltage corresponding to amount of exhaust emission of the vehicle at the minimum engine load value; and

computing a maximum mass ratio of air to fuel based on the first voltage value.

18. The apparatus of claim 16, wherein in computing the minimum mass ratio of air to fuel at the maximum engine load value, the module further instructs the processor to perform the following steps comprising:

determining a second voltage value corresponding to amount of exhaust emissions of the vehicle at the minimum engine load value; and computing a minimum mass ratio of air to fuel based on the second voltage value.

19. The apparatus of claim 18, wherein in computing the minimum mass ratio of air to fuel at the maximum engine load value, the module further instructs the processor to perform the following steps comprising:

determining a series of voltage values corresponding to the exhaust emission of the vehicle at different engine load values; and

extrapolating a minimum mass ratio of air to fuel at the maximum engine load based on the first voltage value at the minimum engine load value and the series of voltage values at the different engine load values.

20. The apparatus of claim 16, wherein in computing the amount of fuel consumed by the engine of the vehicle, the module further instructs the processor to perform the following steps comprising:

computing manifold air flow rate by dividing product of manifold air pressure value and revolutions per minute with the intake air temperature; and

computing the amount of fuel consumed by the engine of the vehicle by dividing the manifold air flow rate with the instantaneous mass ratio of air to fuel.

21. The apparatus of claim 16, wherein in computing the amount of fuel consumed by the engine of the vehicle, the module further instructs the processor to perform the following steps comprising:

computing an intake manifold air pressure value by dividing the manifold air pressure value by the intake air temperature value and multiplying the divided output with the engine speed value;

computing volumetric efficiency associated with the engine of the vehicle;

computing manifold air flow rate based on the intake manifold pressure value, and the volumetric efficiency; and

computing the amount of fuel consumed by the engine of the vehicle by dividing the manifold air flow rate with the instantaneous mass ratio of air to fuel.

22. The apparatus of claim 21, wherein in computing the volumetric efficiency associated with the engine of the vehicle, the module further instructs the processor to perform the following steps comprising:

computing a first density of air by dividing atmospheric air pressure by atmospheric air temperature;

computing a second density of air by dividing the manifold air pressure with the intake air temperature; and

computing volumetric efficiency based on the percentage difference of the second density and the first density.

23. A system for computing real time fuel consumption in a vehicle, comprising:

an emission monitoring device comprising:

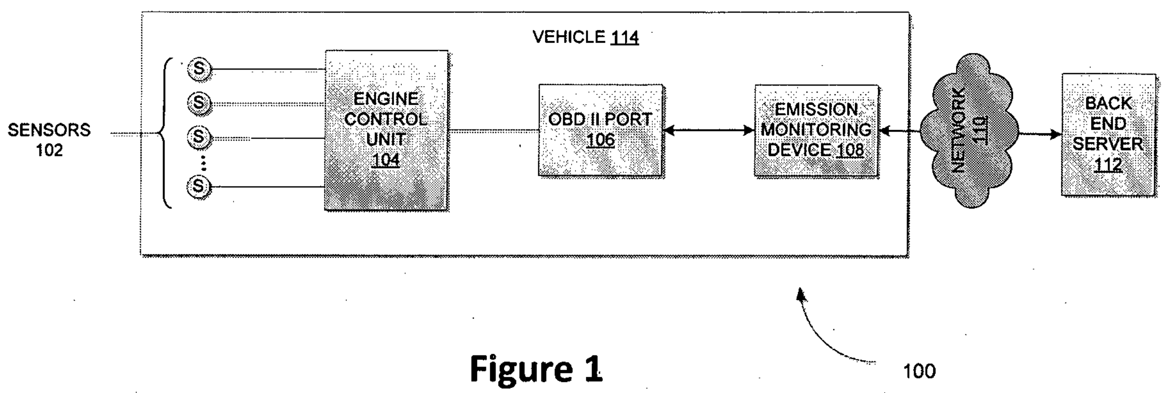
an On-Board Device (OBD) II port for periodically obtaining a plurality of vehicle parameters from an engine control unit; and

a fuel consumption computation module for:

determining instantaneous mass ratio of air to fuel delivered in an engine of the vehicle using at least one of the plurality of vehicle parameters by a processor; and

computing amount of fuel consumed by the engine of the vehicle in real time based on at least one of the plurality of vehicle parameters and the instantaneous mass ratio of air to fuel; and

a backend server for receiving and processing data associated with the amount of fuel consumed, the instantaneous mass ratio of air to fuel, and the plurality of vehicle parameters.


VEHICLE 114
SENSORS 102
S
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S
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ENGINE CONTROL UNIT 104
OBD II PORT 106
EMISSION MONITORING DEVICE 108
NETWORK 110
BACK END SERVER 112
100

Figure 1

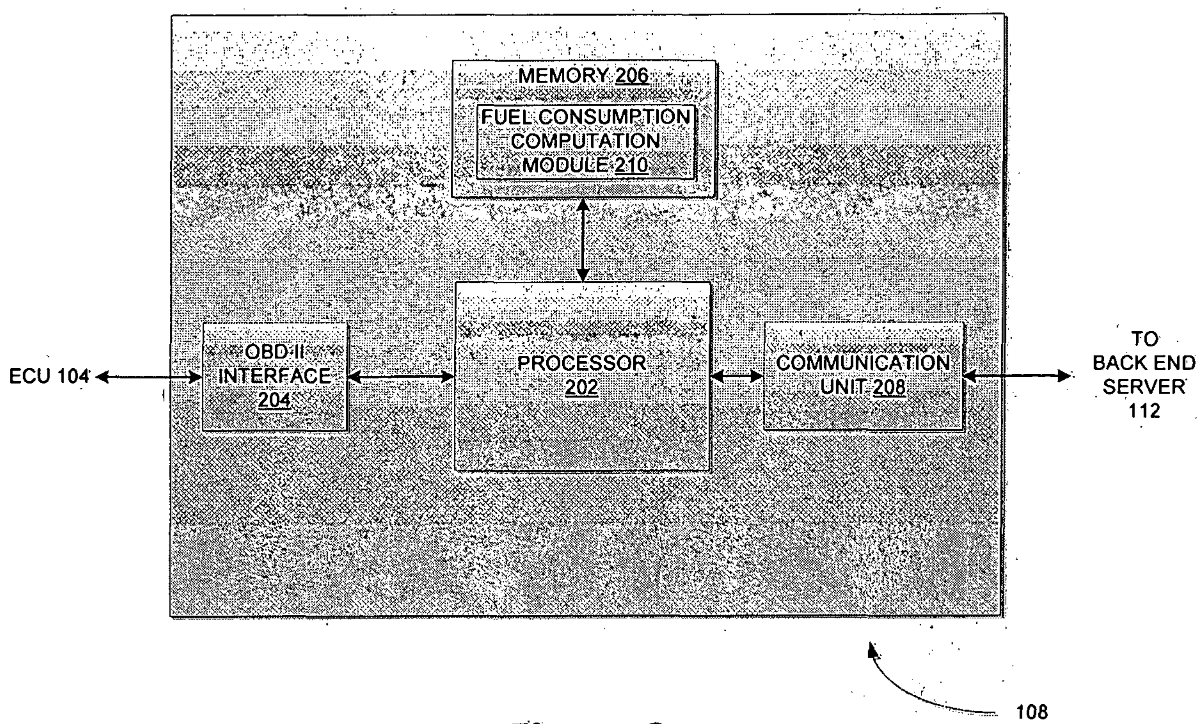

MEMORY 206
FUEL CONSUMPTION COMPUTATION MODULE 210
ECU 104
OBD II INTERFACE 204
PROCESSOR 202
COMMUNICATION UNIT 208
TO BACK END SERVER 112
108

Figure 2

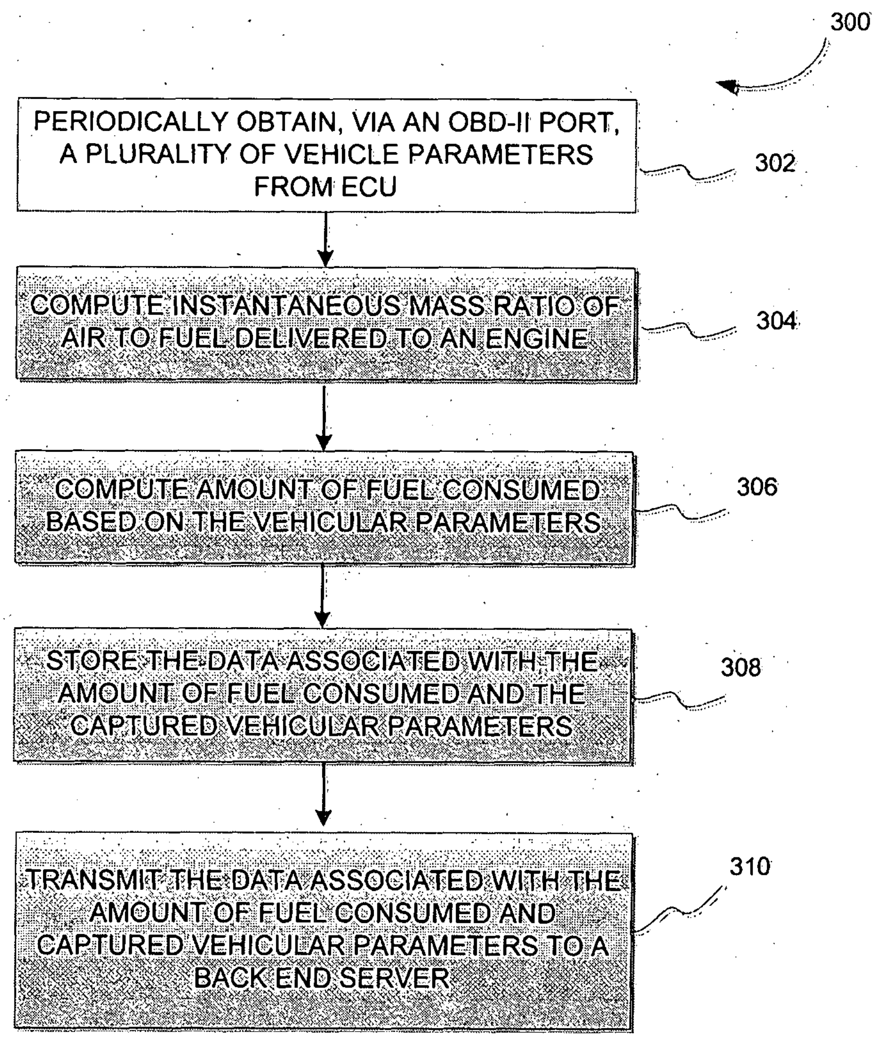
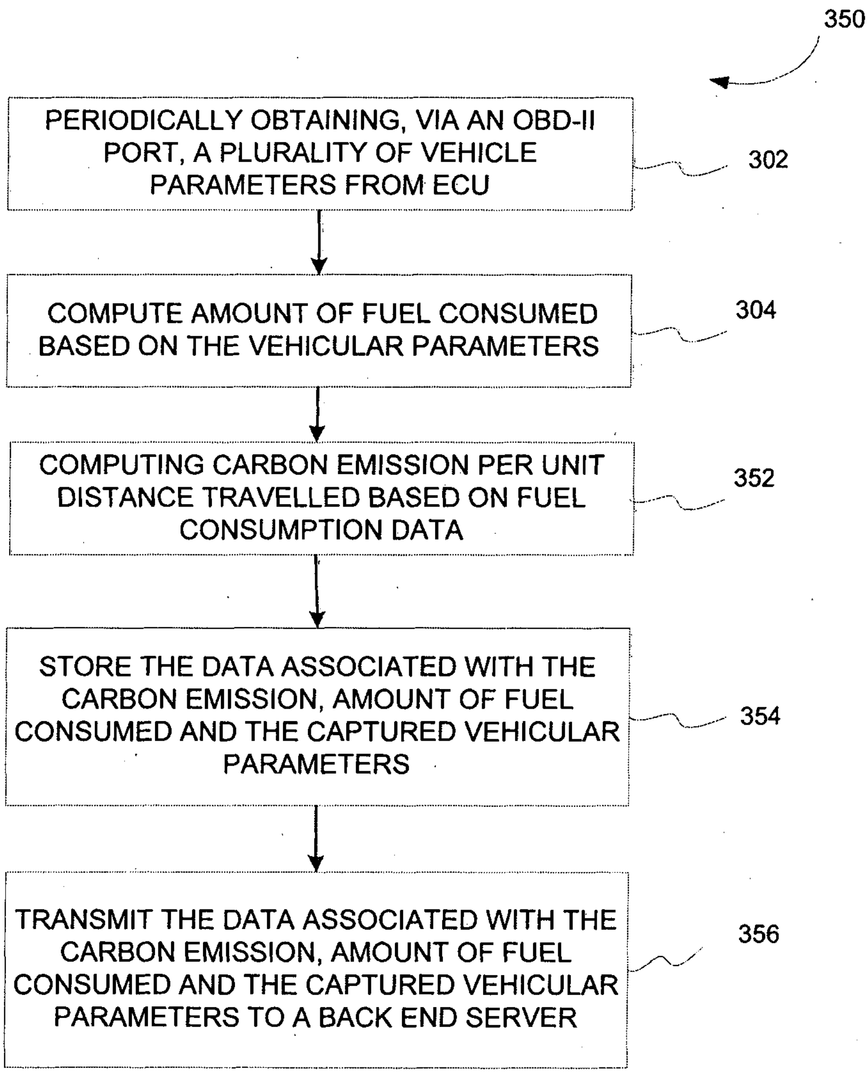

300
PERIODICALLY OBTAIN, VIA AN OBD-II PORT, A PLURALITY OF VEHICLE PARAMETERS FROM ECU
302
COMPUTE INSTANTANEOUS MASS RATIO OF AIR TO FUEL DELIVERED TO AN ENGINE
304
COMPUTE AMOUNT OF FUEL CONSUMED BASED ON THE VEHICULAR PARAMETERS
306
STORE THE DATA ASSOCIATED WITH THE AMOUNT OF FUEL CONSUMED AND THE CAPTURED VEHICULAR PARAMETERS
308
TRANSMIT THE DATA ASSOCIATED WITH THE AMOUNT OF FUEL CONSUMED AND CAPTURED VEHICULAR PARAMETERS TO A BACK END SERVER
310

Figure 3a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PERIODICALLY OBTAINING, VIA AN OBD-II PORT, A PLURALITY OF VEHICLE PARAMETERS FROM ECU
302
COMPUTE AMOUNT OF FUEL CONSUMED BASED ON THE VEHICULAR PARAMETERS
304
COMPUTING CARBON EMISSION PER UNIT DISTANCE TRAVELLED BASED ON FUEL CONSUMPTION DATA
352
STORE THE DATA ASSOCIATED WITH THE CARBON EMISSION, AMOUNT OF FUEL CONSUMED AND THE CAPTURED VEHICULAR PARAMETERS
354
TRANSMIT THE DATA ASSOCIATED WITH THE CARBON EMISSION, AMOUNT OF FUEL CONSUMED AND THE CAPTURED VEHICULAR PARAMETERS TO A BACK END SERVER
356

Figure 3b

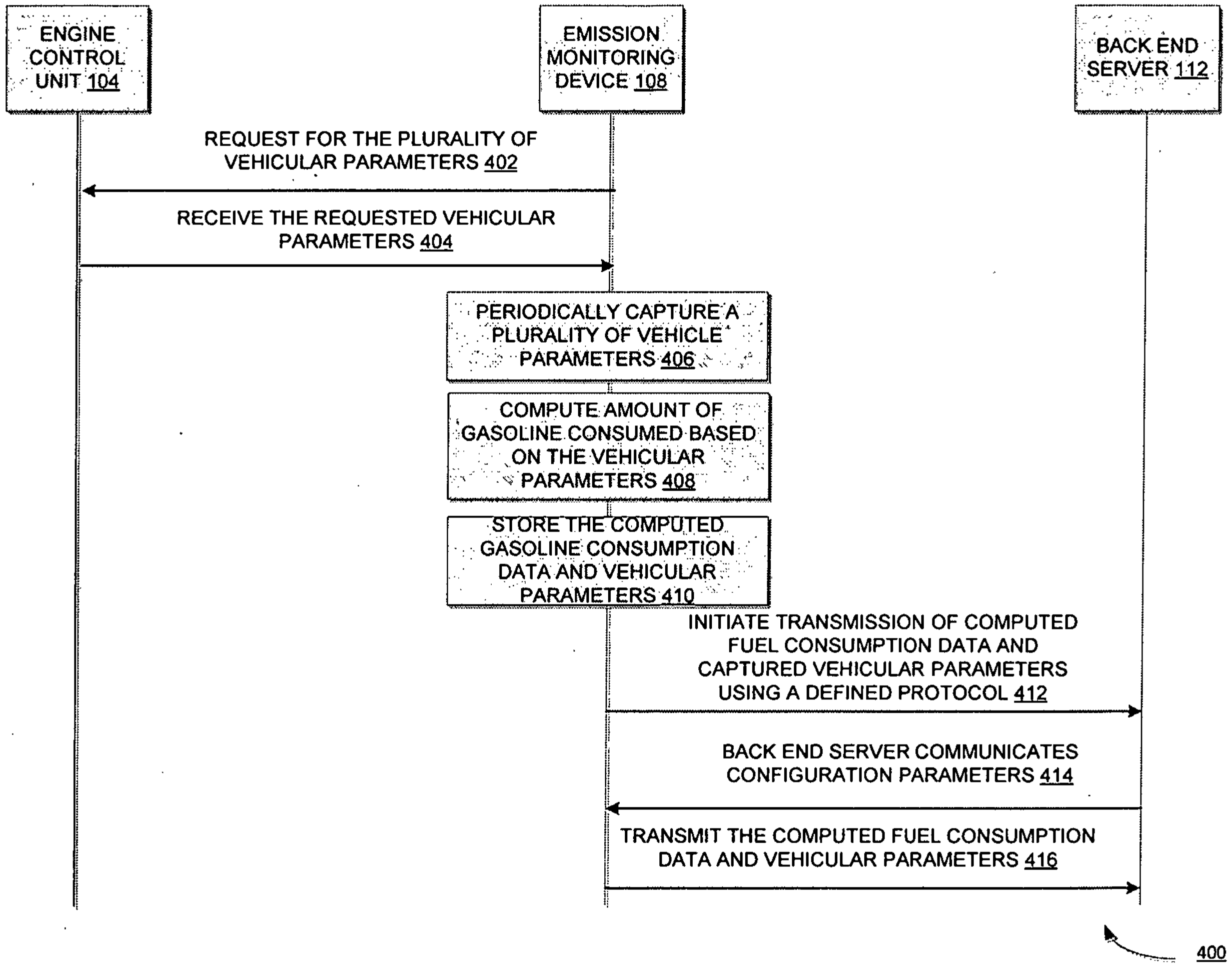
ENGINE CONTROL UNIT 104
EMISSION MONITORING DEVICE 108
BACK END SERVER 112
REQUEST FOR THE PLURALITY OF VEHICULAR PARAMETERS 402
RECEIVE THE REQUESTED VEHICULAR PARAMETERS 404
PERIODICALLY CAPTURE A PLURALITY OF VEHICLE PARAMETERS 406
COMPUTE AMOUNT OF GASOLINE CONSUMED BASED ON THE VEHICULAR PARAMETERS 408
STORE THE COMPUTED GASOLINE CONSUMPTION DATA AND VEHICULAR PARAMETERS 410
INITIATE TRANSMISSION OF COMPUTED FUEL CONSUMPTION DATA AND CAPTURED VEHICULAR PARAMETERS USING A DEFINED PROTOCOL 412
BACK END SERVER COMMUNICATES CONFIGURATION PARAMETERS 414
TRANSMIT THE COMPUTED FUEL CONSUMPTION DATA AND VEHICULAR PARAMETERS 416
400

Figure 4

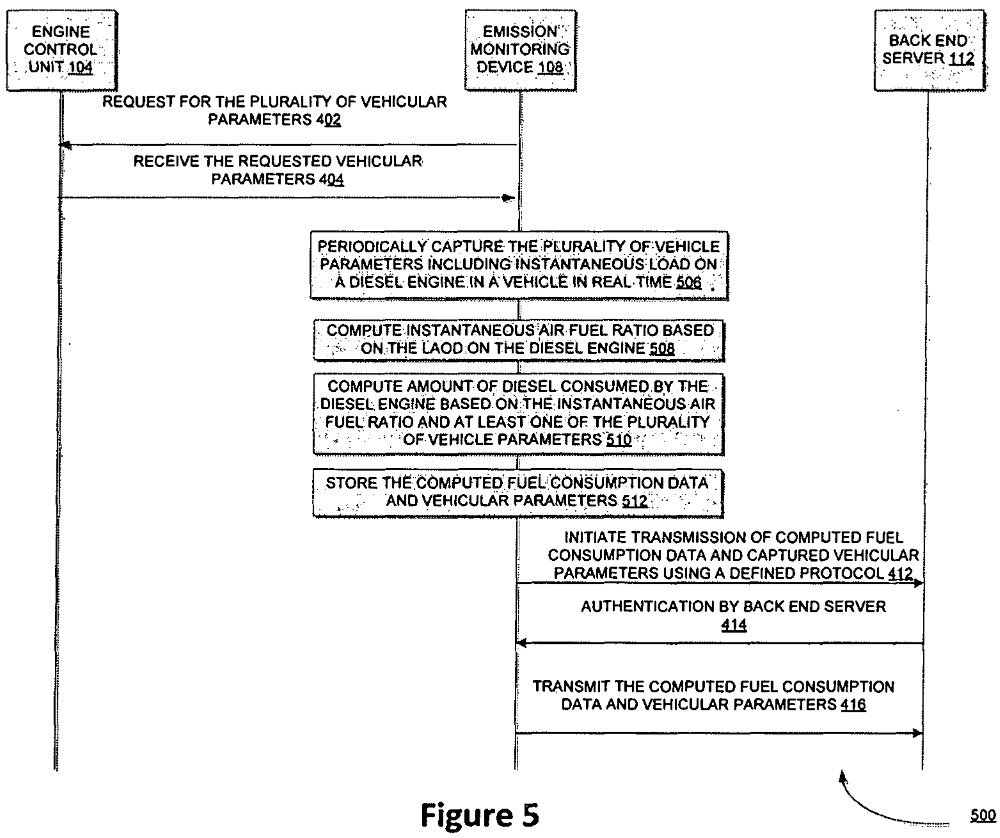
ENGINE CONTROL UNIT 104
EMISSION MONITORING DEVICE 108
BACK END SERVER 112
REQUEST FOR THE PLURALITY OF VEHICULAR PARAMETERS 402
RECEIVE THE REQUESTED VEHICULAR PARAMETERS 404
PERIODICALLY CAPTURE THE PLURALITY OF VEHICLE PARAMETERS INCLUDING INSTANTANEOUS LOAD ON A DIESEL ENGINE IN A VEHICLE IN REAL TIME 506
COMPUTE INSTANTANEOUS AIR FUEL RATIO BASED ON THE LAOD ON THE DIESEL ENGINE 508
COMPUTE AMOUNT OF DIESEL CONSUMED BY THE DIESEL ENGINE BASED ON THE INSTANTANEOUS AIR FUEL RATIO AND AT LEAST ONE OF THE PLURALITY OF VEHICLE PARAMETERS 510
STORE THE COMPUTED FUEL CONSUMPTION DATA AND VEHICULAR PARAMETERS 512
INITIATE TRANSMISSION OF COMPUTED FUEL CONSUMPTION DATA AND CAPTURED VEHICULAR PARAMETERS USING A DEFINED PROTOCOL 412
AUTHENTICATION BY BACK END SERVER 414
TRANSMIT THE COMPUTED FUEL CONSUMPTION DATA AND VEHICULAR PARAMETERS 416
500

Figure 5

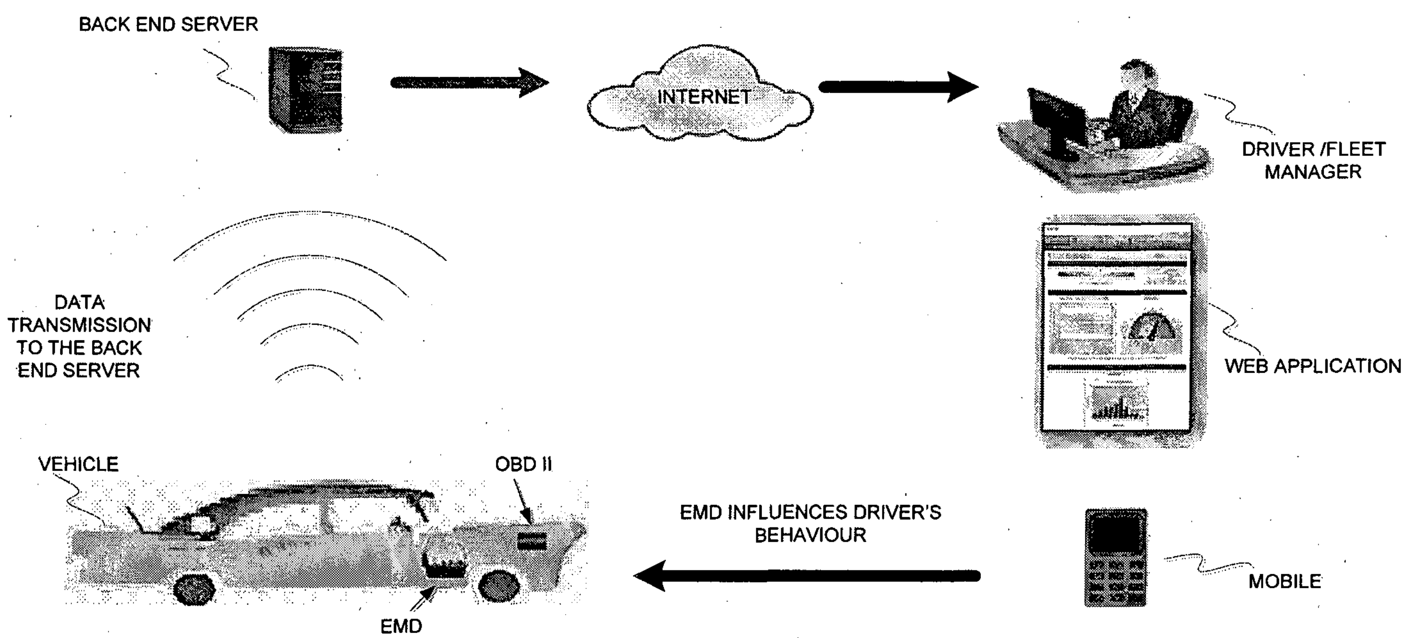
BACK END SERVER
INTERNET
DRIVER /FLEET MANAGER
WEB APPLICATION
DATA TRANSMISSION TO THE BACK END SERVER
VEHICLE
OBD II
EMD
EMD INFLUENCES DRIVER'S BEHAVIOUR
MOBILE

Figure 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/IN2012/000739

A. CLASSIFICATION OF SUBJECT MATTER
INV. B60W10/06 G07C5/00 G07C5/08 G08G1/00
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)
B60W G07C G08G

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2008/319605 A1 (DAVIS JAMES KEITH [US]) 25 December 2008 (2008-12-25) abstract; claims 1-4; figures 1-4 paragraph [0001] paragraph [0008] - paragraph [0013] paragraph [0024] - paragraph [0026] paragraph [0028] - paragraph [0033] paragraph [0038] paragraph [0041] - paragraph [0047] -----	1-23
X	US 6 594 579 B1 (LOWREY LARKIN HILL [US] ET AL) 15 July 2003 (2003-07-15) abstract; claims; figures 1-6 column 1, line 7 - line 9 column 1, line 46 - column 2, line 31 column 2, line 50 - line 58 column 3, line 8 - line 37 column 4, line 66 - column 7, line 15 ----- -/--	1-23

[X] Further documents are listed in the continuation of Box C.

[X] 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	Date of mailing of the international search report
4 April 2013	12/04/2013

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Rother, Stefan

1

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2011/035427 A1 (STEVENS MATTHEW [CA]; MENDES CHRISTOPHER J [CA]) 31 March 2011 (2011-03-31) abstract; claim 1; figures 1,3 page 2, line 19 - page 3, line 7 page 4, line 21 - page 6, line 12 page 11, line 4 - line 20 -----	1-23
A	US 2010/094493 A1 (ATSUMI YOSHIAKI [JP]) 15 April 2010 (2010-04-15) abstract; claims; figure 8 paragraph [0092] - paragraph [0104] -----	1-23
A	US 2007/129878 A1 (PEPPER GARY T [CA] PEPPER GARY THOMAS [CA]) 7 June 2007 (2007-06-07) abstract; claim 8; figures -----	1

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IN2012/000739

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			US 6988033	B1	17-01-2006
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			US 2007129878	A1	07-06-2007