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In-vehicle equipment, vehicle, and method

Abstract

An in-vehicle equipment includes: a signal detection unit configured to detect a signal expected to be input to a communication network at a predetermined input cycle; a counting unit configured to count the number of times a signal is detected by the signal detection unit; and a determination unit configured to determine whether the number of times counted by the counting unit within a predetermined first period is equal to or less than a threshold value set between a first value calculated by dividing the first period by the input cycle and a second value calculated on the basis of the first period and the input cycle on assumption that an illegal signal is further input to the communication network.

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Background/Summary

(1) The contents of the following Japanese patent application(s) are incorporated herein by reference: NO. 2022-051388 filed in JP on Mar. 28, 2022.
BACKGROUND
1. Technical Field
(2) The present invention relates to an in-vehicle equipment, a vehicle, and a method.
2. Related Art
(3) Patent Document 1 discloses determining a normal range of an air-fuel ratio learning value in an engine.
CITATION LIST
(4) Patent Document 1: Japanese Patent Application Publication No. 2018-145817

Description

BRIEF DESCRIPTION OF THE DRAWINGS

(1) FIG. **1** conceptually illustrates a system configuration of a vehicle **10** in an embodiment.

(2) FIG. **2** is a block diagram schematically illustrating a functional configuration included in an ECU **110**.

(3) FIG. **3** illustrates comparison between a case where only a normal signal is input to a CAN communication network **180** and a case where a normal signal and an illegal signal are input to the CAN communication network.

(4) FIG. **4** is a diagram illustrating a maximum number of times of detection in which a signal can be detected when there is no impersonation attack and a minimum number of times of detection in which a signal can be detected when there is an impersonation attack.

(5) FIG. **5** is a diagram illustrating the maximum number of times of detection and the minimum number of times of detection when an actual measurement value of an input cycle F is used.

(6) FIG. **6** illustrates contents of processing of determining an illegal signal and processing of measuring the input cycle F, the processing being executed in two drive cycles.

(7) FIG. **7** is a flowchart illustrating processing executed by the ECU **110**.

(8) FIG. **8** illustrates an example of a computer **2000**.

DESCRIPTION OF EXEMPLARY EMBODIMENTS

(9) Hereinafter, embodiments of the present invention will be described, but the embodiments do not limit the invention according to the claims. In addition, not all of the combinations of features described in the embodiments are essential to the solving means of the invention.

(10) FIG. **1** conceptually illustrates a system configuration of a vehicle **10** in an embodiment. The vehicle **10** includes a system **20**. The system **20** includes a plurality of ECUs (electronic control units) including an ECU **100**, an ECU **110**, an ECU **111**, an ECU **120**, and an ECU **121**. The ECUs included in the vehicle **10** include an ECU for controlling an equipment that directly affects the traveling of the vehicle **10** such as an engine, a transmission, and a steering apparatus. The ECUs included in the vehicle **10** include an ECU for controlling an equipment that does not directly affect the traveling of the vehicle **10** such as an air conditioner and a navigation apparatus. The ECU **100**, the ECU **110**, the ECU **111**, the ECU **120**, and the ECU **121** are examples of an in-vehicle equipment.

(11) The ECUs included in the vehicle **10** communicate with each other by controller area network (CAN) communication. The ECUs included in the vehicle **10** are communicably connected to each other by a plurality of CAN communication networks **180**. The ECU **100** functions as a gateway that relays communication between the plurality of CAN communication networks **180**.

(12) FIG. **2** is a block diagram schematically illustrating a functional configuration included in the ECU **110**. The ECU **110** includes a processing unit **200** and a storage unit **280**. The ECU **110** performs processing of determining whether there is a so-called impersonation attack in which a third party impersonates an ECU and transmits an illegal signal to the CAN communication network **180**.

(13) The processing unit **200** may be implemented by a processor such as a CPU that performs arithmetic processing. The storage unit **280** may include a nonvolatile storage medium such as a flash memory and a volatile storage medium such as a random access memory. The ECU **110** may include a computer. The ECU **110** executes various controls by the processing unit **200** operating according to a program stored in the nonvolatile storage medium.

(14) The processing unit **200** includes a signal detection unit **210**, a counting unit **220**, a determination unit **230**, and a cycle measurement unit **240**. The signal detection unit **210** detects a signal expected to be input to the communication network at a predetermined input cycle. The counting unit **220** counts the number of times a signal is detected by the signal detection unit **210**.

(15) In a first determination method, the determination unit **230** determines whether the number of times counted by the counting unit **220** within a predetermined first period is equal to or less than a threshold value set between a first value calculated by dividing the first period by the input cycle and a second value calculated on the basis of the first period and the input cycle on the assumption that an illegal signal is further input to the communication network. By setting the threshold value between the first value and the second value, a possibility of erroneously sensing detecting an impersonation attack can be reduced.
(16) In the first determination method, the determination unit **230** sets the threshold value between a maximum value of the first value and a minimum value of the second value calculated on the assumption that an error is included in the first period and the input cycle. As a result, it is possible to reduce a time until the impersonation attack is sensed while reducing the possibility of erroneously sensing the impersonation attack.
(17) In the first determination method, the cycle measurement unit **240** measures the actual measurement value of the input cycle on the basis of the number of times counted by the counting unit **220**. Until the actual measurement value of the input cycle is measured by the cycle measurement unit **240**, the determination unit **230** determines whether the number of times counted by the counting unit **220** within a predetermined second period is equal to or less than a predetermined third value. Then, when the actual measurement value of the input cycle is measured by the cycle measurement unit **240**, the determination unit **230** calculates the first value by dividing the first period by the actual measurement value of the input cycle, calculates the second value calculated on the basis of the first period and the actual measurement value of the input cycle on the assumption that an illegal signal is further input to the communication network, and starts determination as to whether the number of times counted by the counting unit **220** within the first period is equal to or less than the first value. As a result, when the actual measurement value of the input cycle is measured, it is possible to start the detection of the impersonation attack based on the actual measurement value of the input cycle.
(18) In the first determination method, when the actual measurement value of the input cycle is measured by the cycle measurement unit **240**, the determination unit **230** sets the first period shorter than the second period on the basis of the actual measurement value of the input cycle. As a result, it is possible to quickly detect the impersonation attack.
(19) In a second determination method different from the first determination method, the determination unit **230** may determine whether the number of times counted by the counting unit **220** within the predetermined first period is equal to or less than the first value calculated by dividing the first period by a past actual measurement value of the input cycle. In the second determination method, the determination unit **230** may determine whether the number of times counted by the counting unit **220** within the first period is equal to or less than the maximum value of the first value calculated on the assumption that an error is included in the first period. As a result, it is possible to shorten the time until the impersonation attack is sensed.
(20) In the second determination method, the determination unit **230** may determine whether the number of times counted by the counting unit **220** within the first period is equal to or less than the threshold value set between the first value and the second value calculated on the basis of the first period and the actual measurement value of the input cycle on the assumption that an illegal signal is further input to the communication network. As a result, it is possible to reduce the possibility of erroneously detecting the impersonation attack.
(21) In the second determination method, the determination unit **230** may set the threshold value between the maximum value of the first value and the minimum value of the second value calculated on the assumption that an error is included in the first period. As a result, it is possible to shorten the time until the impersonation attack is detected.
(22) Also in the second determination method, until the actual measurement value of the input cycle is measured by the cycle measurement unit **240**, the determination unit **230** may determine

whether the number of times counted by the counting unit **220** within the predetermined second period is equal to or less than the predetermined third value. Then, when the actual measurement value of the input cycle is measured by the cycle measurement unit **240**, the determination unit **230** may calculate the first value by using the actual measurement value of the input cycle and start determination as to whether the number of times counted by the counting unit **220** within the first period is equal to or less than the first value. As a result, when the actual measurement value of the input cycle is measured, it is possible to start the detection of the impersonation attack based on the actual measurement value of the input cycle.
(23) In the second determination method, when the actual measurement value of the input cycle is measured by the cycle measurement unit **240**, the determination unit **230** may set the first period shorter than the second period on the basis of the actual measurement value of the input cycle. As a result, it is possible to quickly detect the impersonation attack.
(24) FIG. **3** illustrates comparison between a case where only a normal signal is input to the CAN communication network **180** and a case where a normal signal and an illegal signal are input to the CAN communication network. The normal signal is, for example, a signal output from the ECU **110** to the CAN communication network **180**. The ECU **110** performs control such that a signal is input to the CAN communication network **180** at a predetermined input cycle F. Since an error may occur in processing in which the ECU **110** inputs a signal to the CAN communication network **180**, an error may also occur in a time interval between consecutive normal signals, but the time interval between consecutive normal signals is approximately the input cycle F. That is, the normal signal is expected to be input to the CAN communication network **180** at the predetermined input cycle F.
(25) Next, a case will be described in which a malicious third party impersonates the ECU **111** and inputs an illegal signal to the CAN communication network **180**. For example, when it is sensed that a signal assigned with a specific CAN ID is input from the ECU **110** to the CAN communication network **180**, a malicious third party inputs an illegal signal assigned with the CAN ID to the CAN communication network **180**. As a result, about twice as many signals as that in a case where no illegal signal is input are input to the CAN communication network **180**. Therefore, the counting unit **220** counts the number of signals assigned with a specific CAN ID among the signals detected by the signal detection unit **210**, and the determination unit **230** determines whether an illegal signal has been input to the CAN communication network **180** on the basis of the number of signals counted by the counting unit **220** within a predetermined period T.
(26) FIG. **4** is a diagram illustrating a maximum number of times of detection in which a signal can be detected when there is no impersonation attack and a minimum number of times of detection in which a signal can be detected when there is an impersonation attack. FIG. **4** illustrates the maximum number of times of detection and the minimum number of times of detection when it is assumed that there is an error of ±10% in a design value T of the period in which the signal is counted and an error of ±20% may occur in the design value F of the input cycle.
(27) FIG. **4** illustrates a case where the design value of the period T for counting signals is 1500 ms and the design value of the input cycle F is 10 ms. The maximum number of times of detection in which a signal can be detected when there is no impersonation attack is calculated by 1.1T/0.8F. In a case where there is an impersonation attack, when the number of signals per unit time is twice as large as that in a case where there is no impersonation attack, the minimum number of times of detection in which a signal can be detected when there is an impersonation attack is calculated by 2×0.9T/1.2F. As illustrated in FIG. **4**, the maximum number of times of detection of signals when there is no impersonation attack is 206, and the minimum number of times of detection of signals when there is an impersonation attack is 225.
(28) In this regard, when 1500 ms is adopted as the period T, the determination unit **230** sets, between 206 and 225, a threshold value for determining whether there is an illegal signal, determines that there is no illegal signal when the number of times a signal is detected within the period of 1500 ms is equal to or less than the threshold value, and determines that there is an illegal

signal when the number of times a signal is detected within the period of 1500 ms exceeds the threshold value. A lower limit value that can be set as the threshold value is 206, and an upper limit value is 225. By setting the threshold value in this manner, it can be expected to appropriately determine whether there is an illegal signal even in consideration of an error that may occur in the period T and the input cycle F.

(29) The determination unit **230** may set the threshold value for determining whether there is an illegal signal without considering an error. For example, the determination unit **230** may set the threshold value between T/F, which is the number of times a signal can be detected when there is no impersonation attack, and 2T/F, which is the number of times a signal can be detected when there is an impersonation attack.

(30) FIG. **5** is a diagram illustrating the maximum number of times of detection and the minimum number of times of detection when the actual measurement value of the input cycle F is used. FIG. **5** illustrates the maximum number of times of detection and the minimum number of times of detection when it is assumed that an error of ±10% may occur in the design value of the period T. In the description related to FIG. **5**, the actual measurement value of the input cycle may be represented by "F".

(31) FIG. **5** illustrates a case where the design value of the period T for counting signals is 500 ms and the actual measurement value of the input cycle F is 10.1 ms. The maximum number of times of detection in which a signal can be detected when there is no impersonation attack is calculated by 1.1T/F. The minimum number of times of detection in which a signal can be detected when there is an impersonation attack is calculated by 2×0.9T/F. As illustrated in FIG. **5**, the maximum number of times of detection of signals when there is no impersonation attack is 54, and the minimum number of times of detection of signals when there is an impersonation attack is 89.

(32) In this regard, when 500 ms is adopted as the period T, the determination unit **230** sets, between 54 and 89, the threshold value for determining whether there is an illegal signal, determines that there is no illegal signal when the number of times a signal is detected within the period of 500 ms is equal to or less than the threshold value, and determines that there is an illegal signal when the number of times a signal is detected within the period of 500 ms exceeds the threshold value. The lower limit value that can be set as the threshold value is 54, and the upper limit value is 89. By setting the threshold value in this manner, it is expected that whether there is an illegal signal can be appropriately determined even in consideration of an error that may occur in the period T. As illustrated in FIG. **5**, since a difference between the maximum number of times of detection and the minimum number of times of detection is 35, which is relatively large, the possibility of occurrence of erroneous determination is also reduced.

(33) The determination unit **230** may set the threshold value for determining whether there is an illegal signal by using the actual measurement value of the input cycle F without considering the error in the period T. For example, the determination unit **230** may set the threshold value between T/F, which is the number of times a signal can be detected when there is no impersonation attack, and 2T/F, which is the number of times a signal can be detected when there is an impersonation attack. The determination unit **230** may set, to T/F, the threshold value for determining whether there is an illegal signal. The determination unit **230** may set, to 2T/F, the threshold value for determining whether there is an illegal signal.

(34) Next, a relationship between the input cycle F and the period T will be described. In order to quickly determine whether there is an illegal signal, it is desirable to shorten the period T. In general, when the minimum number of times of detection in which a signal can be detected when there is an impersonation attack is A and the maximum number of times of detection in which a signal can be detected when there is no impersonation attack is N, it is necessary to satisfy a requirement of $A-N\geq 1$ in order to determine whether there is an illegal signal.

(35) First, as described with reference to FIG. **4**, a case will be described in which an error of ±20% occurs in the input cycle F and an error of ±10% occurs in the period T. In this case, $N=1.1\ T/0.8F$.

In a case where there is an impersonation attack, when the number of signals per unit time is twice as large as that in a case where there is no impersonation attack, A=2×0.9T/1.2F is obtained. Therefore, in order to determine whether there is an illegal signal, it is necessary to satisfy 2×0.9T/1.2F−1.1T/0.8F≥1. As a result, in order to determine whether there is an illegal signal, it is necessary to satisfy T≥8F. That is, assuming that an error of ±20% occurs in the input cycle F and an error of ±10% occurs in the period T, the period T that is eight times or more the input cycle F is required to determine whether there is an illegal signal.

(36) On the other hand, as described with reference to FIG. **5**, a case will be described in which an actual measurement value is used for the input cycle F and an error of ±10% occurs in the period T. In this case, N=1.1T/F. In a case where there is an impersonation attack, when the number of signals per unit time is twice as large as that in a case where there is no impersonation attack, A=2×0.9T/F is obtained. Therefore, in order to determine whether there is an illegal signal, it is necessary to satisfy 2×0.9T/F−1.1T/F≥1. As a result, in order to determine whether there is an illegal signal, it is sufficient if T≥1.43F. Therefore, by using the actual measurement value for the input cycle F, the period T can be shortened as compared with a case where the actual measurement value is not used for the input cycle F.

(37) FIG. **6** illustrates contents of processing of determining an illegal signal and processing of measuring the input cycle F, the processing being executed in two drive cycles. First, in a first drive cycle after the vehicle **10** is handed over to the user, the actual measurement value of the input cycle F is not obtained. For this reason, in the first drive cycle starting from time t**0**, the cycle measurement unit **240** measures the input cycle F.

(38) For example, the cycle measurement unit **240** acquires the number of times the signal is counted by the counting unit **220** every time a predetermined period elapses, and calculates the input cycle of the signal in each of a plurality of periods. The cycle measurement unit **240** averages the input cycles calculated in the plurality of periods to calculate the actual measurement value of the input cycle F.

(39) In the first drive cycle, while the cycle measurement unit **240** measures the actual measurement value of the input cycle F, the determination unit **230** determines the presence or absence of an illegal signal under a prescribed detection condition. The prescribed detection condition includes a period T and a threshold value as detection variables. The period T is set to satisfy at least a requirement of T≥8F. The threshold value is set between the maximum number of times of detection and the minimum number of times of detection calculated from the input cycle F and the period T, for example, as described with reference to FIG. **4**. The period T and the threshold value configuring the prescribed detection condition may be determined in advance according to the input cycle F.

(40) The determination unit **230** acquires the number of times of detection of the signal counted by the counting unit **220** every time the period T elapses until the end of the first drive cycle, and determines that there is an illegal signal when the acquired number of times exceeds the threshold value. When the first drive cycle ends at time t**1**, the storage unit **280** stores, in a nonvolatile storage region, the actual measurement value of the input cycle F measured by the cycle measurement unit **240** from time t**0** to time t**1**.

(41) When the second drive cycle starts at time t**2**, the determination unit **230** reads the actual measurement value of the input cycle F from the storage unit **280** and calculates the detection condition by using the actual measurement value of the input cycle F. The detection condition includes a period T and a threshold value as detection variables. The determination unit **230** uses the actual measurement value of the input cycle F to set the period T to satisfy at least a requirement of T≥1.43F. In this case, the determination unit **230** can set, as the period T, a period shorter than the period configuring the prescribed detection condition. For example, as described with reference to FIG. **5**, the determination unit **230** sets the threshold value on the basis of a value obtained by dividing the period T considering the error of the period T by the input cycle F. The

determination unit **230** may set the threshold value between the calculated maximum number of times of detection and the calculated minimum number of times of detection.

(42) When the traveling of the vehicle **10** is started from time t**3**, the determination unit **230** determines the presence or absence of an illegal signal under the detection condition calculated by using the actual measurement value of the input cycle F. Specifically, the determination unit **230** acquires the number of times of detection of the signal counted by the counting unit **220** every time the period T elapses, and determines that there is an illegal signal when the acquired number of times exceeds the threshold value.

(43) In the second drive cycle, the cycle measurement unit **240** continues to measure the input cycle while the determination unit **230** determines the presence or absence of an illegal signal under the detection condition calculated by using the actual measurement value of the input cycle F. When the first drive cycle ends at time t**4**, the storage unit **280** stores the actual measurement value of the input cycle F measured by the cycle measurement unit **240** from time t**3** to time t**4**. The actual measurement value of the input cycle F stored in the storage unit **280** is used to calculate the sensing condition when the next drive cycle starts.

(44) When the measurement of the actual measurement value of the input cycle F is completed in the first drive cycle, the determination unit **230** may calculate the sensing condition on the basis of the actual measurement value of the input cycle F in the middle of the first drive cycle, and start the determination of the presence or absence of the illegal signal under the detection condition calculated by using the actual measurement value of the input cycle F.

(45) FIG. **7** is a flowchart illustrating processing executed by the ECU **110**. The processing of the flowchart illustrated in FIG. **7** is started at the start of the drive cycle.

(46) In S**702**, detection variables for detecting an illegal signal are initialized. The detection variables includes variables of the input cycle F, the actual measurement value of the input cycle F, the period T, and the threshold value. In S**704**, the values stored in the storage unit **280** are set as the detection variables. In S**706**, the determination unit **230** determines whether the input cycle F has been actually measured. When the input cycle F has not been actually measured, a prescribed period is set to the variable of the period T in S**710**, and a prescribed threshold value is set to the variable of the threshold value in S**712**. Subsequently, in S**724**, the determination unit **230** starts processing of detecting the illegal signal on the basis of the period T and the threshold value set in S**710** and S**712**.

(47) When it is determined that the actual measurement of the input cycle F has been completed in S**706**, a value considering the actual measurement value of the input cycle F is set to the variable of the period T in S**720**. In S**722**, a value based on the value obtained by dividing the period T by the actual measurement value of the input cycle F is set as the variable of the threshold value. As described with reference to FIG. **5**, the threshold value is set in consideration of the error in the period T. Subsequently, in S**724**, the determination unit **230** starts the processing of detecting the illegal signal on the basis of the period T and the threshold value set in S**720** and S**722**.

(48) According to the system **20** described above, the period T for counting signals in order to detect an illegal signal due to an impersonation attack can be shortened by using the actual measurement value of the input cycle F. As a result, it is possible to quickly detect an impersonation attack. In addition, by holding the actual measurement value of the input cycle F in the storage unit **280**, it is possible to quickly detect an impersonation attack in a short time by using the input cycle F actually measured in the past.

(49) FIG. **8** illustrates an example of a computer **2000** in which a plurality of embodiments of the present invention may be entirely or partially embodied. A program installed in the computer **2000** can cause the computer **2000** to function as a system such as the system **20** or each unit of the system, an apparatus such as the ECU **110**, or each unit of the apparatus according to the embodiment to execute an operation associated with the system or each unit of the system, the apparatus, or each unit of the apparatus and/or execute a process or a step of the process according

to the embodiment. Such a program may be executed by a CPU **2012** to cause the computer **2000** to perform certain operations associated with the processing procedures described herein and some of or all of the blocks in the block diagrams.

(50) The computer **2000** according to the present embodiment includes the CPU **2012** and a RAM **2014**, which are mutually connected by a host controller **2010**. The computer **2000** also includes a ROM **2026**, a flash memory **2024**, a communication interface **2022**, and an input/output chip **2040**. The ROM **2026**, the flash memory **2024**, the communication interface **2022**, and the input/output chip **2040** are connected to the host controller **2010** via an input/output controller **2020**.

(51) The CPU **2012** operates according to programs stored in the ROM **2026** and the RAM **2014**, thereby controlling each unit.

(52) The communication interface **2022** communicates with other electronic devices via a network. The flash memory **2024** stores programs and data used by the CPU **2012** within the computer **2000**. The ROM **2026** stores therein a boot program or the like executed by the computer **2000** at the time of activation, and/or a program depending on the hardware of the computer **2000**. The input/output chip **2040** may connect various input/output units such as a keyboard, a mouse, and a monitor to the input/output controller **2020** via input/output ports such as a serial port, a parallel port, a keyboard port, a mouse port, a monitor port, a USB port, and a HDMI (registered trademark) port.

(53) A program is provided via a network or computer-readable storage media such as a CD-ROM, a DVD-ROM, or a memory card. The RAM **2014**, the ROM **2026**, or the flash memory **2024** is an example of the computer-readable storage medium. Programs are installed in the flash memory **2024**, the RAM **2014**, or the ROM **2026** and executed by the CPU **2012**. The information processing written in these programs is read by the computer **2000**, and thereby cooperation between a program and the above-described various types of hardware resources is achieved. An apparatus or method may be constituted by carrying out the operation or processing of information by using the computer **2000**.

(54) For example, when communication is carried out between the computer **2000** and an external device, the CPU **2012** may execute a communication program loaded onto the RAM **2014** to instruct communication processing to the communication interface **2022**, based on the processing written in the communication program. The communication interface **2022**, under control of the CPU **2012**, reads transmission data stored on transmission buffering regions provided in recording media such as the RAM **2014** and the flash memory **2024**, and transmits the read transmission data to a network and writes reception data received from a network to reception buffering regions or the like provided on the recording media.

(55) In addition, the CPU **2012** may cause all or a necessary portion of a file or a database to be read into the RAM **2014**, the file or the database having been stored in a recording medium such as the flash memory **2024**, etc., and perform various types of processing on the data on the RAM **2014**. The CPU **2012** may then write back the processed data to the recording medium.

(56) Various types of information, such as various types of programs, data, tables, and databases, may be stored in the recording medium to undergo information processing. The CPU **2012** may perform various types of processing on the data read from the RAM **2014**, which includes various types of operations, information processing, conditional judging, conditional branch, unconditional branch, search/replace of information, etc., as described herein and designated by an instruction sequence of programs, and writes the result back to the RAM **2014**. In addition, the CPU **2012** may search for information in a file, a database, etc., in the recording medium. For example, when a plurality of entries, each having an attribute value of a first attribute associated with an attribute value of a second attribute, are stored in the recording medium, the CPU **2012** may search for an entry matching the condition whose attribute value of the first attribute is designated, from among the plurality of entries, and read the attribute value of the second attribute stored in the entry, thereby acquiring the attribute value of the second attribute associated with the first attribute satisfying the predetermined condition.

(57) The programs or software modules described above may be stored in the computer-readable storage medium on the computer **2000** or in the vicinity of the computer **2000**. A recording medium such as a hard disk or a RAM provided in a server system connected to a dedicated communication network or the Internet can be used as the computer-readable storage media. A program stored in the computer-readable storage medium may be provided to the computer **2000** via a network.
(58) A program that is installed in the computer **2000** and causes the computer **2000** to function as the ECU **110** may work on the CPU **2012** and the like to cause the computer **2000** to function as each unit of the ECU **110**, respectively. Information processing described in these programs are read into the computer **2000** to cause the computer to function as each unit of the ECU **110**, which is a specific means realized by cooperation of software and the various types of hardware resources described above. Then, with these specific means, by realizing computing or processing of information according to an intended use of the computer **2000** in the present embodiment, the specific ECU **110** is constructed according to the intended use.
(59) Various embodiments have been described by referring to the block diagrams and the like. In the block diagram, each block may represent (1) a step of a process in which an operation is executed, or (2) each unit of the apparatus having a role of executing the operation. Certain steps and sections may be implemented by dedicated circuitry, programmable circuitry supplied with computer-readable instructions stored on computer-readable storage media, and/or processors supplied with computer-readable instructions stored on computer-readable storage media. Dedicated circuit may include digital and/or analog hardware circuits and may include integrated circuits (IC) and/or discrete circuits. Programmable circuit may include reconfigurable hardware circuits including logical AND, logical OR, logical XOR, logical NAND, logical NOR, and other logical operations, flip-flops, registers, memory elements, etc., such as field-programmable gate arrays (FPGA), programmable logic arrays (PLA), etc.
(60) Computer-readable storage media may include any tangible device that can store instructions for execution by a suitable device, such that the computer-readable storage medium having instructions stored therein forms at least a portion of an article of manufacture including instructions which can be executed to create means for performing processing operations or operations specified in the block diagrams. Examples of the computer-readable storage medium may include an electronic storage medium, a magnetic storage medium, an optical storage medium, an electromagnetic storage medium, a semiconductor storage medium, and the like. More specific examples of the computer readable storage medium may include a floppy (registered trademark) disk, a diskette, a hard disk, a random access memory (RAM), a read only memory (ROM), an erasable programmable read only memory (EPROM or flash memory), an electrically erasable programmable read only memory (EEPROM), a static random access memory (SRAM), a compact disk read only memory (CD-ROM), a digital versatile disk (DVD), a Blu-ray (registered trademark) disk, a memory stick, an integrated circuit card, or the like.
(61) The computer-readable instruction may include an assembler instruction, an instruction-set-architecture (ISA) instruction, a machine instruction, a machine dependent instruction, a microcode, a firmware instruction, state-setting data, or either of source code or object code written in any combination of one or more programming languages including an object-oriented programming language such as Smalltalk (registered trademark), JAVA (registered trademark), and C++, and a conventional procedural programming language such as a “C” programming language or a similar programming language.
(62) Computer-readable instructions may be provided to a processor of a general purpose computer, special purpose computer, or other programmable data processing apparatus, or to programmable circuit, locally or via a local area network (LAN), wide area network (WAN) such as the Internet, etc., to execute the computer-readable instructions to provide means for performing described processing procedure or operations specified in the block diagrams. Examples of the processor include a computer processor, a processing unit, a microprocessor, a digital signal processor, a

controller, a microcontroller, and the like.
(63) While the embodiments of the present invention have been described, the technical scope of the invention is not limited to the above described embodiments. It is apparent to persons skilled in the art that various alterations and improvements can be added to the above-described embodiments. It is also apparent from the description of the claims that the embodiments to which such alterations or improvements are made can be included in the technical scope of the present invention.
(64) The operations, procedures, steps, and stages of each process performed by an apparatus, system, program, and method shown in the claims, embodiments, or diagrams can be performed in any order as long as the order is not indicated by “prior to,” “before,” or the like and as long as the output from a previous process is not used in a later process. Even if the process flow is described using phrases such as “first” or “next” in the claims, specification, or drawings, it does not necessarily mean that the process must be performed in this order.
EXPLANATION OF REFERENCES
(65) **10**: vehicle; **20**: system; **100**: ECU; **110**: ECU; **111**: ECU; **120**: ECU; **121**: ECU; **180**: CAN communication network; **210**: signal detection unit; **220**: counting unit; **230**: determination unit; **240**: cycle measurement unit; **280**: storage unit; **2000**: computer; **2010**: host controller; **2012**: CPU; **2014**: RAM; **2020**: input/output controller; **2022**: communication interface; **2024**: flash memory; **2026**: ROM; and **2040**: input/output chip.

Claims

1. An in-vehicle equipment comprising: a signal detection unit configured to detect a signal expected to be input to a communication network at a predetermined input cycle; a counting unit configured to count a number of times a signal is detected by the signal detection unit; and a determination unit configured to determine whether the number of times counted by the counting unit within a predetermined first period is equal to or less than a threshold value set between a first value calculated by dividing the first period by the input cycle and a second value calculated on a basis of the first period and the input cycle on assumption that an illegal signal is further input to the communication network, wherein the determination unit is configured to set the threshold value between a maximum value of the first value and a minimum value of the second value calculated on assumption that an error is included in the first period and the input cycle.
2. The in-vehicle equipment according to claim 1, further comprising a cycle measurement unit configured to measure an actual measurement value of the input cycle on a basis of the number of times counted by the counting unit, wherein the determination unit is configured to determine whether the number of times counted by the counting unit within a predetermined second period is equal to or less than a predetermined third value until the actual measurement value of the input cycle is measured by the cycle measurement unit, and calculate the first value by dividing the first period by the actual measurement value of the input cycle when the actual measurement value of the input cycle is measured by the cycle measurement unit, calculate the second value calculated on a basis of the first period and the actual measurement value of the input cycle on assumption that an illegal signal is further input to the communication network, and start determination as to whether the number of times counted by the counting unit within the first period is equal to or less than the first value.
3. The in-vehicle equipment according to claim 2, wherein when the actual measurement value of the input cycle is measured by the cycle measurement unit, the determination unit is configured to set the first period shorter than the second period on a basis of the actual measurement value of the input cycle.
4. A vehicle comprising the in-vehicle equipment according to claim 1.
5. An in-vehicle equipment comprising: a signal detection unit configured to detect a signal

expected to be input to a communication network at a predetermined input cycle; a counting unit configured to count a number of times a signal is detected by the signal detection unit; and a determination unit configured to determine whether the number of times counted by the counting unit within a predetermined first period is equal to or less than a first value calculated by dividing the first period by a past actual measurement value of the input cycle, wherein the determination unit is configured to determine whether the number of times counted by the counting unit within the first period is equal to or less than a maximum value of the first value calculated on assumption that an error is included in the first period.

6. The in-vehicle equipment according to claim 5, wherein the determination unit is configured to determine whether the number of times counted by the counting unit within the first period is equal to or less than a threshold value set between the first value and a second value calculated on a basis of the first period and the actual measurement value of the input cycle on assumption that an illegal signal is further input to the communication network.

7. The in-vehicle equipment according to claim 6, wherein the determination unit is configured to set the threshold value between a maximum value of the first value and a minimum value of the second value calculated on assumption that an error is included in the first period.

8. The in-vehicle equipment according to claim 5, further comprising a cycle measurement unit configured to measure the actual measurement value of the input cycle on a basis of the number of times counted by the counting unit, wherein the determination unit is configured to determine whether the number of times counted by the counting unit within a predetermined second period is equal to or less than a predetermined third value until the actual measurement value of the input cycle is measured by the cycle measurement unit, and when the actual measurement value of the input cycle is measured by the cycle measurement unit, calculate the first value by using the actual measurement value of the input cycle, and start determination as to whether the number of times counted by the counting unit within the first period is equal to or less than the first value.

9. The in-vehicle equipment according to claim 8, wherein when the actual measurement value of the input cycle is measured by the cycle measurement unit, the determination unit is configured to set the first period shorter than the second period on a basis of the actual measurement value of the input cycle.

10. The in-vehicle equipment according to claim 6, further comprising a cycle measurement unit configured to measure the actual measurement value of the input cycle on a basis of the number of times counted by the counting unit, wherein the determination unit is configured to determine whether the number of times counted by the counting unit within a predetermined second period is equal to or less than a predetermined third value until the actual measurement value of the input cycle is measured by the cycle measurement unit, and when the actual measurement value of the input cycle is measured by the cycle measurement unit, calculate the first value by using the actual measurement value of the input cycle, and start determination as to whether the number of times counted by the counting unit within the first period is equal to or less than the first value.

11. The in-vehicle equipment according to claim 7, further comprising a cycle measurement unit configured to measure the actual measurement value of the input cycle on a basis of the number of times counted by the counting unit, wherein the determination unit is configured to determine whether the number of times counted by the counting unit within a predetermined second period is equal to or less than a predetermined third value until the actual measurement value of the input cycle is measured by the cycle measurement unit, and when the actual measurement value of the input cycle is measured by the cycle measurement unit, calculate the first value by using the actual measurement value of the input cycle, and start determination as to whether the number of times counted by the counting unit within the first period is equal to or less than the first value.

12. The in-vehicle equipment according to claim 10, wherein when the actual measurement value of the input cycle is measured by the cycle measurement unit, the determination unit is configured to set the first period shorter than the second period on a basis of the actual measurement value of

the input cycle.

13. The in-vehicle equipment according to claim 11, wherein when the actual measurement value of the input cycle is measured by the cycle measurement unit, the determination unit is configured to set the first period shorter than the second period on a basis of the actual measurement value of the input cycle.

14. A vehicle comprising the in-vehicle equipment according to claim 5.

15. A method comprising: detecting a signal expected to be input to a communication network at a predetermined input cycle; counting a number of times the signal is detected; determining whether the number of times counted within a predetermined first period is equal to or less than a threshold value set between a first value calculated by dividing the first period by the input cycle and a second value calculated on a basis of the first period and the input cycle on assumption that an illegal signal is further input to the communication network; and setting the threshold value between a maximum value of the first value and a minimum value of the second value calculated on assumption that an error is included in the first period and the input cycle.