DESCRIPTION

Title of Invention

ON-BOARD UNIT AND METHOD FOR CONTROLLING ON-BOARD UNIT

[Technical Field]

[0001]

The present disclosure relates to an on-board unit and a method for controlling an on-board unit.

[Background Art]

[0002]

For example, on toll roads, a mechanism is used in which tolls are automatically collected by performing wireless communication with an on-board unit mounted in a vehicle using an electronic toll collection system (ETC (registered trademark), also referred to as an “automatic toll collection system”). The on-board unit includes an antenna unit for wireless communication, a main unit that executes a toll collection process, and a coaxial cable that connects the antenna unit and the main unit. Patent Document 1 discloses a technique of changing a display pattern of an LED provided in an antenna unit based on control of a main unit to notify an occupant of a vehicle of the success or failure of a toll collection process. Patent Document 2 and Patent Document 3 disclose a technique of increasing the number of LEDs provided in an antenna unit to support more display patterns.

[Citation List]

[Patent Document]

[0003]

[Patent Document 1] Japanese Patent No. 4234880

[Patent Document 2] Japanese Patent No. 4639780

[Patent Document 3] Japanese Patent No. 4604252

[Summary of Invention]

[Technical Subject]

[0004]

Some roads may be provided with a time-limited parking zone in which parking is permitted only within a time limit. A user of the time-limited parking zone presents, inside a vehicle at a position visible from outside, a parking ticket issued by parking ticket issuing equipment installed on the road. In addition, a parking violation enforcement officer visually checks the information indicated on the parking ticket and determines whether or not a parking violation has occurred (that is, whether or not the vehicle is within the time limit). To reduce the burden on the enforcement officer, it is conceivable to indicate whether or not the vehicle is within the time limit by the display pattern of the LED of the on-board unit, instead of using the parking ticket. However, the LED of the on-board unit in the related art can notify the occupant of the vehicle of a state such as whether the toll collection process has succeeded or failed or whether a card has been inserted, whereas the LED cannot notify a person outside the vehicle, such as the enforcement officer or another user, of the state.

[0005]

An object of the present disclosure is to provide an on-board unit and a method for controlling an on-board unit that can perform a state display visible from outside a vehicle.

[Subject to be solved]

[0006]

An aspect of the present disclosure relates to an on-board unit including: a main unit; and an antenna unit connected to the main unit by a coaxial cable, in which the main unit includes a switch unit including a first transistor switch circuit configured to superimpose a first notification signal on a signal to be output to the antenna unit, and a CPU configured to turn on the first transistor switch circuit when a parking time of a vehicle is within a time limit, and turn off the first transistor switch circuit when the parking time is outside the time limit, and the antenna unit includes a first light-emitting element provided at a position visible from outside the vehicle, and a voltage level determination unit configured to turn on or turn off the first light-emitting element based on a voltage level of the signal input from the main unit.

[0007]

Another aspect of the present disclosure relates to a method for controlling an on-board unit including a main unit including a switch unit including a first transistor switch circuit configured to superimpose a first notification signal on a signal to be output to an antenna unit, and the antenna unit connected to the main unit by a coaxial cable and including a first light-emitting element provided at a position visible from outside a vehicle, the method including: a step of, by the main unit, turning on the first transistor switch circuit when a parking time of the vehicle is within a time limit, and turning off the first transistor switch circuit when the parking time is outside the time limit; and a step of, by the antenna unit, turning on or turning off the first light-emitting element based on a voltage level of the signal input from the main unit.

[Advantageous Effects of Invention]

[0008]

According to the above aspects, it is possible to perform the state display visible from outside the vehicle.

[Brief Description of Drawings]

[0009]

FIG. 1 is a diagram showing an overall configuration of a parking system according to a first embodiment.

FIG. 2 is a diagram showing a functional configuration of an on-board unit according to the first embodiment.

FIG. 3 is a first flowchart showing an example of a process of the on-board unit according to the first embodiment.

FIG. 4 is a diagram showing an example of an LED display pattern according to the first embodiment.

FIG. 5 is a second flowchart showing an example of the process of the on-board unit according to the first embodiment.

FIG. 6 is a diagram showing a functional configuration of an on-board unit according to a second embodiment.

FIG. 7 is a diagram showing an example of an LED display pattern according to the second embodiment.

FIG. 8 is a diagram showing a functional configuration of an on-board unit according to a third embodiment.

FIG. 9 is a flowchart showing an example of a process of the on-board unit according to the third embodiment.

FIG. 10 is a diagram showing an example of an LED display pattern according to the third embodiment.

FIG. 11 is a diagram showing a functional configuration of an on-board unit according to a fourth embodiment.

FIG. 12 is a diagram showing an example of an LED display pattern according

to the fourth embodiment.

FIG. 13 is a diagram showing a functional configuration of an on-board unit according to a fifth embodiment.

FIG. 14 is a diagram showing an example of an LED display pattern according to the fifth embodiment.

[Description of Embodiments]

[0010]

<First Embodiment>

Hereinafter, a first embodiment will be described in detail with reference to FIGS. 1 to 5.

[0011]

(Overall Configuration of Parking System)

FIG. 1 is a diagram showing an overall configuration of a parking system according to the first embodiment. A parking system 100 is a system for managing a parked vehicle in a predetermined parking zone (time-limited parking zone) on a road. The parking system 100 includes an on-board unit 1, a roadside unit 5, a central computer system 6, and a terminal device 7.

[0012]

The on-board unit 1 is mounted on a vehicle V. The on-board unit 1 includes a main unit 2 and an antenna unit 3. The antenna unit 3 is installed at a position visible from outside the vehicle V, such as on the inside of a windshield. The on-board unit 1 according to the present embodiment performs a parking time management process in the predetermined parking zone (time-limited parking zone). The on-board unit 1 according to the present embodiment is obtained by adding various configurations for the parking time management process to the on-board unit used for the toll collection

process using ETC in the related art. A specific functional configuration of the on-board unit 1 will be described later.

[0013]

The roadside unit 5 is installed in the parking zone. The roadside unit 5 communicates with the on-board unit 1 by short-range communication such as dedicated short range communication (DSRC). Further, the roadside unit 5 is communicably connected to the central computer system 6 through the Internet or the like, and receives an operation of the user (occupant of the vehicle V) of the parking zone to request the central computer system 6 to permit the vehicle V to park.

[0014]

The central computer system 6 is communicably connected to the on-board unit 1 and the terminal device 7 through a mobile communication network, Wi-Fi (registered trademark), and the like. When the central computer system 6 receives a request for parking permission of the vehicle V, the central computer system 6 transmits a trigger signal for parking start to the on-board unit 1 of the vehicle V. In another embodiment, the central computer system 6 may request the roadside unit 5 or the terminal device 7 to transmit the trigger signal, and the roadside unit 5 or the terminal device 7 may transmit the trigger signal to the on-board unit 1 in response to the request of the central computer system 6.

[0015]

The terminal device 7 is a smartphone, a tablet, or the like. The terminal device 7 is communicably connected to the on-board unit 1 by short-range wireless communication such as Bluetooth (registered trademark). The terminal device 7 may be communicably connected to the on-board unit 1 through Wi-Fi, instead of Bluetooth. Further, the terminal device 7 is communicably connected to the central computer

system 6 through a mobile communication network, Wi-Fi, or the like. The terminal device 7 may receive an operation of the user of the parking zone instead of the roadside unit 5 to request the central computer system 6 to permit the vehicle V to park. In this case, the roadside unit 5 may be omitted.

[0016]

(Functional Configuration of On-Board Unit)

FIG. 2 is a diagram showing a functional configuration of the on-board unit according to the first embodiment. As shown in FIG. 2, the on-board unit 1 includes the main unit 2 and the antenna unit 3. The main unit 2 and the antenna unit 3 are communicably connected by a coaxial cable 4.

[0017]

The main unit 2 includes a power supply circuit 20, a CPU 21, a self-holding circuit 22, and a switch unit 23.

[0018]

The power supply circuit 20 supplies power, which is converted to a predetermined voltage, to each of the CPU 21, the self-holding circuit 22, and the switch unit 23 of the main unit 2. Each unit of the main unit 2 is connected to a power supply B that can supply power even while an engine of the vehicle is in an OFF state, via the power supply circuit 20. The power supply B is, for example, a battery (always-on power supply) mounted on the vehicle V. Further, the power supply B may be a battery or a capacitor built in the main unit 2.

[0019]

The CPU 21 is a processor that executes the parking time management process. The parking time management process is a process of determining whether or not the vehicle V is parked within a time limit (for example, 60 minutes) of the parking zone in

accordance with an elapsed time from when the vehicle V is parked in the parking zone, and notifying of the determination result. The CPU 21 switches between turning on and turning off of a first light-emitting element 32 of the antenna unit 3 by turning on or off the switch unit 23 (first transistor switch circuit 24) described later, and notifies of a process result.

[0020]

Further, the CPU 21 may determine a state (normal or abnormal) of the on-board unit 1 and notify of the determination result. For example, the state of the on-board unit 1 is determined to be "normal" when a predetermined condition is satisfied, such as when an ETC card is correctly inserted. In addition, the state of the on-board unit 1 is determined to be "abnormal" when the predetermined condition is not satisfied, such as when the ETC card is not inserted, or when an error has occurred, such as when the toll collection process has failed. The CPU 21 switches between turning on and turning off of a second light-emitting element 33 of the antenna unit 3 by turning on or off the switch unit 23 (second transistor switch circuit 25) described later, and notifies of the state of the on-board unit 1.

[0021]

The self-holding circuit 22 maintains an ON state or an OFF state of the switch unit 23 (first transistor switch circuit 24 and second transistor switch circuit 25) input from the CPU.

[0022]

The switch unit 23 includes the first transistor switch circuit 24 and the second transistor switch circuit 25. The first transistor switch circuit 24 superimposes a first notification signal on the signal output to the antenna unit 3. The second transistor switch circuit 25 superimposes a second notification signal having a voltage level

different from a voltage level of the first notification signal on the signal output to the antenna unit 3. In the present embodiment, as an example, it is assumed that power supplied from the power supply circuit 20 to each transistor switch circuit is voltage-converted such that the first notification signal is 3.3 V and the second notification signal is 5 V. The voltage level of each signal may be changed arbitrarily.

[0023]

The antenna unit 3 includes a voltage level determination unit 31, the first light-emitting element 32, and the second light-emitting element 33.

[0024]

The voltage level determination unit 31 turns on or turns off each of the first light-emitting element 32 and the second light-emitting element 33 based on the voltage level of the signal input from the main unit 2. For example, in the present embodiment, the voltage level of the second notification signal (5 V) is higher than the voltage level of the first notification signal (3.3 V). Therefore, the voltage level determination unit 31 determines that the second notification signal is output when a voltage level E of the signal exceeds a predetermined threshold value E1, and determines that the first notification signal is output when the voltage level E of the signal is equal to or lower than the threshold value E1. The threshold value E1 is set, for example, to an intermediate value between the first notification signal and the second notification signal.

[0025]

The first light-emitting element 32 is provided at a position visible from outside the vehicle V. For example, a parking zone enforcement officer can easily determine whether or not the vehicle V is in violation of the parking (such as exceeding the time limit) by checking the lighting state of the first light-emitting element 32.

[0026]

The second light-emitting element 33 is provided at a position visible from inside the vehicle V. For example, the occupant of the vehicle V can easily determine whether or not the toll collection process is normally performed by checking the lighting state of the second light-emitting element 33.

[0027]

The first light-emitting element 32 and the second light-emitting element 33 are, for example, light-emitting elements such as LEDs. In the present embodiment, the first light-emitting element 32 will be described as LED1, and the second light-emitting element 33 will be described as LED2.

[0028]

The main unit 2 transmits and receives various data and signals to and from the central computer system 6 through a communication module (not shown) compatible with standards such as a mobile communication network or Wi-Fi. The main unit 2 transmits and receives various data and signals to and from the terminal device 7 through a communication module (not shown) compatible with standards such as Bluetooth or Wi-Fi. In addition, the antenna unit 3 transmits and receives various data and signals to and from the roadside unit 5 via an antenna main body (not shown).

[0029]

(Process Example 1 of On-Board Unit)

FIG. 3 is a first flowchart showing an example of a process of the on-board unit according to the first embodiment. FIG. 3 shows an example of a process of determining the state of the on-board unit 1 and notifying of the determination result when the engine of the vehicle V is in an ON state (when the vehicle V is traveling or the like).

[0030]

First, the CPU 21 of the main unit 2 determines whether the state of the on-board unit 1 is normal or abnormal (step S101). When the state of the on-board unit 1 is normal (step S101; YES), the CPU 21 of the main unit 2 turns on the LED2 (second light-emitting element 33) of the antenna unit 3 (step S102). Specifically, the CPU 21 of the main unit 2 turns on the second transistor switch circuit 25. As a result, the second notification signal is superimposed on the signal output from the main unit 2 to the antenna unit 3. In addition, when the voltage level determination unit 31 of the antenna unit 3 determines that the second notification signal is input, based on the voltage level E of the signal input from the main unit 2, the LED2 is turned on.

[0031]

On the other hand, when the state of the on-board unit 1 is abnormal (step S101; NO), the CPU 21 of the main unit 2 turns off the LED2 of the antenna unit 3 (step S103). Specifically, the CPU 21 of the main unit 2 turns off the second transistor switch circuit 25. As a result, the second notification signal is not superimposed on the signal output from the main unit 2 to the antenna unit 3. In addition, when the voltage level determination unit 31 of the antenna unit 3 determines that the second notification signal is not input, based on the voltage level E of the signal input from the main unit 2, the LED2 is turned off.

[0032]

The on-board unit 1 periodically repeats the process of FIG. 3 when the engine is in an ON state, and notifies the occupant of the vehicle V of the state of the on-board unit 1. FIG. 4 is a diagram showing an example of an LED display pattern according to the first embodiment. As a result of the process of FIG. 3, as shown in FIG. 4, the LED2 is turned on when the engine of the vehicle V is on and the state of the on-board unit 1 is "normal", and the LED2 is turned off when the state of the on-board unit 1 is

"abnormal". In addition, when the engine of the vehicle V is on, the LED1 remains off regardless of the state of the on-board unit 1. The occupant of the vehicle V can easily ascertain the state of the on-board unit 1 by checking the LED2.

[0033]

(Process Example 2 of On-Board Unit)

FIG. 5 is a second flowchart showing an example of a process of the on-board unit according to the first embodiment. FIG. 5 shows an example of a process (parking time management process) of determining whether the parking is within the time limit and notifying of the determination result when the vehicle V is parked in the parking zone.

[0034]

For example, the user performs a usage-fee payment operation and a parking start operation (pressing a start button or the like) from the terminal device 7. As a result, the terminal device 7 transmits, to the central computer system 6, a request to park in the parking zone together with identification information of the on-board unit 1 registered in advance. When the central computer system 6 receives the parking request, the central computer system 6 records the identification information of the on-board unit 1 and a parking start time, and transmits a trigger signal for parking start to the on-board unit 1. In this case, the CPU 21 of the main unit 2 receives the trigger signal for parking start from the central computer system 6 (step S111). The trigger signal may be transmitted from the central computer system 6 to the on-board unit 1 via the roadside unit 5 or the terminal device 7.

[0035]

When the trigger signal is received, the CPU 21 of the main unit 2 turns on the LED1 (first light-emitting element 32), and starts a timer (step S112). Specifically, the

CPU 21 of the main unit 2 turns on the first transistor switch circuit 24. As a result, the first notification signal is superimposed on the signal output from the main unit 2 to the antenna unit 3. In addition, when the voltage level determination unit 31 of the antenna unit 3 determines that the first notification signal is input, based on the voltage level E of the signal input from the main unit 2, the LED1 is turned on.

[0036]

After checking that the LED1 is turned on, the user leaves the vehicle V. In this case, the vehicle V is in a state in which the engine is off, and the CPU 21 of the main unit 2 is in a sleep state.

[0037]

Next, the CPU 21 of the main unit 2 cancels the sleep state when the parking time of the vehicle V (elapsed time after receiving the trigger signal for parking start) exceeds the time limit by the timer (step S113). The time limit for each parking zone may be acquired from the roadside unit 5 when the operation of parking start is performed, or may be acquired from the central computer system 6 together with the trigger signal.

[0038]

When the sleep state is canceled, the CPU 21 of the main unit 2 turns off the LED1 (step S114). Specifically, the CPU 21 of the main unit 2 turns off the first transistor switch circuit 24. As a result, the first notification signal is not superimposed on the signal output from the main unit 2 to the antenna unit 3. In addition, when the voltage level determination unit 31 of the antenna unit 3 determines that the first notification signal is not input, based on the voltage level E of the signal input from the main unit 2, the LED1 is turned off.

[0039]

When the LED1 is turned off, the CPU 21 of the main unit 2 transitions to the sleep state again to suppress unnecessary power consumption (step S115).

[0040]

As a result of the process of FIG. 5, as shown in FIG. 4, when the engine of the vehicle V is off, the LED2 remains off. Meanwhile, the LED1 is turned on when the parking time of the vehicle V is within the time limit, and the LED1 is turned off when the parking time is outside the time limit. Since the LED1 is provided at a position visible from outside the vehicle V, the enforcement officer of the parking zone can easily ascertain that there is a parking violation (exceeding the time limit or not performing the operation of parking start) when the LED1 is turned off.

[0041]

The user may perform the usage-fee payment operation and the parking start operation by operating the roadside unit 5 instead of the terminal device 7. In this case, the roadside unit 5 acquires the identification information from the on-board unit 1 through short-range communication, and transmits the parking request to the central computer system 6.

[0042]

(Operation and Effect)

As described above, the on-board unit 1 according to the present embodiment includes the main unit 2 and the antenna unit 3 connected to the main unit 2 by the coaxial cable 4. The main unit 2 includes the switch unit 23 including the first transistor switch circuit 24 that superimposes the first notification signal on the signal output to the antenna unit 3, and the CPU 21 that turns on the first transistor switch circuit 24 when the parking time of the vehicle V is within the time limit and turns off the first transistor switch circuit 24 when the parking time is outside the time limit. The

antenna unit 3 includes the first light-emitting element 32 (LED1) provided at a position visible from outside the vehicle V, and the voltage level determination unit 31 that turns on or turns off the first light-emitting element 32 based on the voltage level of the signal input from the main unit 2.

[0043]

In the related art, the enforcement officer of the parking zone needs to perform time-consuming work of determining whether or not there is a parking violation by comparing the date and time described in the parking ticket with the current date and time. In addition, in the on-board unit in the related art, the LED provided in the antenna unit notifies the state to the occupant of the vehicle. Therefore, a person outside the vehicle cannot check the lighting state of the LED. On the other hand, the on-board unit 1 according to the present embodiment can easily allow a person outside the vehicle V to ascertain whether or not the vehicle V is parked beyond the time limit, with the above-described configuration. Therefore, it is possible to reduce the burden on the enforcement officer.

[0044]

In addition, the main unit 2 further includes the self-holding circuit 22 that maintains an ON state or an OFF state of the switch unit 23. The switch unit 23, the CPU 21, and the self-holding circuit 22 of the main unit 2 are connected to the power supply B that can supply power even while the engine of the vehicle V is in an OFF state.

[0045]

In this way, the on-board unit 1 can switch between turning on and turning off the first light-emitting element 32 (LED1) even while the vehicle V is parked and the engine is turned off.

[0046]

In addition, the switch unit 23 further includes the second transistor switch circuit 25 that superimposes the second notification signal having a voltage level different from the voltage level of the first notification signal on the signal output to the antenna unit 3. The CPU 21 turns on the second transistor switch circuit 25 when the state of the on-board unit 1 satisfies a predetermined condition, and turns off the second transistor switch circuit 25 when the state of the on-board unit 1 does not satisfy the condition or when an error has occurred. The antenna unit 3 further includes the second light-emitting element 33 provided at a position visible from inside the vehicle V. The voltage level determination unit 31 turns on or turns off each of the first light-emitting element 32 and the second light-emitting element 33 based on the voltage level of the signal input from the main unit 2.

[0047]

In this way, the on-board unit 1 can notify the enforcement officer outside the vehicle V of the presence or absence of the parking violation, and can notify the occupant of the vehicle V of the state of the on-board unit 1. As a result, since one on-board unit 1 can be used for both the toll collection process and the parking time management process, the installation space can be reduced as compared with the introduction of individual on-board units. Further, it is possible to suppress an increase in introduction cost.

[0048]

In addition, the CPU 21 turns on the first transistor switch circuit 24 and transitions to the sleep state when the trigger signal, defined in advance, indicating the parking start is received, and cancels the sleep state and turns off the first transistor switch circuit 24 when a predetermined time limit has elapsed after the trigger signal is

received.

[0049]

In this way, the on-board unit 1 can notify the presence or absence of the parking violation while minimizing the power consumption of the CPU 21 while the engine of the vehicle V is in an OFF state.

[0050]

<Second Embodiment>

Hereinafter, a second embodiment will be described in detail with reference to FIGS. 6 and 7. The configuration of the on-board unit 1 according to the present embodiment is the same as the configuration of the first embodiment except for the points described below.

[0051]

(Functional Configuration of On-Board Unit)

FIG. 6 is a diagram showing a functional configuration of the on-board unit according to the second embodiment. As shown in FIG. 6, in the on-board unit 1 according to the present embodiment, the main unit 2 further includes a blinking circuit 27.

[0052]

The blinking circuit 27 is provided on the signal line 26 that connects the first transistor switch circuit 24 and the CPU 21. The blinking circuit 27 switches ON and OFF of the first transistor switch circuit 24 at a predetermined blinking pitch.

[0053]

FIG. 7 is a diagram showing an example of an LED display pattern according to the second embodiment. As shown in FIG. 7, when the parking time of the vehicle V is within the time limit, the on-board unit 1 blinks the LED1. That is, the on-board

unit 1 blinks the LED1 in step S112 of FIG. 5 and stops blinking (turns off) the LED1 in step S114.

[0054]

(Operation and Effect)

As described above, in the on-board unit 1 according to the present embodiment, the main unit 2 further includes the blinking circuit 27 provided on the signal line 26 that connects the first transistor switch circuit 24 and the self-holding circuit 22.

[0055]

In this manner, the on-board unit 1 can blink the LED1 until the parking time of the vehicle V exceeds the time limit. Depending on the environment of the parking zone or the like, there is a possibility that the blinking has better visibility, and thus the burden on the enforcement officer to check the LED1 can be further reduced.

[0056]

<Third Embodiment>

Hereinafter, a third embodiment will be described in detail with reference to FIGS. 8 to 10. The configuration of the on-board unit 1 according to the present embodiment is the same as the configuration of each of the above-described embodiments except for the following points.

[0057]

(Functional Configuration of On-Board Unit)

FIG. 8 is a diagram showing a functional configuration of the on-board unit according to the third embodiment. As shown in FIG. 8, in the on-board unit 1 according to the present embodiment, the signal line 26 that connects the first transistor switch circuit 24 and the self-holding circuit 22 includes a first signal line 26A and a second signal line 26B.

[0058]

Further, the blinking circuit 27 is provided on the first signal line 26A.

[0059]

(Process Example of On-Board Unit)

FIG. 9 is a flowchart showing an example of a process of the on-board unit according to the third embodiment. FIG. 9 shows an example of a process (parking time management process) of determining whether the parking is within the time limit and notifying of the determination result when the vehicle V is parked in the parking zone.

[0060]

First, the CPU 21 of the main unit 2 receives the trigger signal for the start of parking from the central computer system 6 (step S211). The process in step S211 is the same as the process in the first embodiment (step S111 in FIG. 5).

[0061]

When the trigger signal is received, the CPU 21 of the main unit 2 turns on the LED1, and starts the timer (step S212). Here, the CPU 21 of the main unit 2 keeps LED1 turned on by keeping the first transistor switch circuit 24 constantly on through the second signal line 26B.

[0062]

Next, the CPU 21 of the main unit 2 cancels the sleep state when the parking time of the vehicle V is a predetermined time before the time limit by the timer (step S213). The predetermined time may be set arbitrarily to, for example, 10 minutes.

[0063]

When the sleep state is canceled, the CPU 21 of the main unit 2 blinks the LED1 (step S214). Here, the CPU 21 of the main unit 2 blinks the LED1 by intermittently

turning on or turning off the first transistor switch circuit 24 through the first signal line 26A.

[0064]

In addition, when the LED1 is switched from being ON to blinking, the CPU 21 of the main unit 2 transitions to the sleep state again to suppress unnecessary power consumption (step S215).

[0065]

Then, the CPU 21 of the main unit 2 cancels the sleep state when the parking time of the vehicle V exceeds the time limit by the timer (step S216).

[0066]

When the sleep state is canceled, the CPU 21 of the main unit 2 turns off the LED1 (step S217), and transitions to the sleep state again (step S218). The processes in steps S217 and S218 are the same as the processes in the first embodiment (steps S114 and S115 in FIG. 5).

[0067]

FIG. 10 is a diagram showing an example of an LED display pattern according to the third embodiment. As a result of the process in FIG. 9, as shown in FIG. 10, when the parking time of the vehicle V is within the time limit and the remaining time is longer than a predetermined time (n minutes), the LED1 remains on. When the parking time is within the time limit but the remaining time is equal to or shorter than the predetermined time (n minutes), the LED1 blinks. When the parking time is outside the time limit, the LED1 is turned off. As described above, even when the parking time is within the time limit, by changing the display pattern of the LED1 in accordance with the remaining time, it is possible to allow the enforcement officer to easily ascertain whether the parking time is approaching the time limit. The

enforcement officer can efficiently enforce parking violations by, for example, closely monitoring the vehicle V for which the time limit is approaching (that is, LED1 is blinking). Further, other users can understand when the parking zone is likely to become available.

[0068]

(Operation and Effect)

As described above, in the on-board unit 1 according to the present embodiment, the signal line 26 includes the first signal line 26A provided with the blinking circuit 27, and the second signal line 26B not provided with the blinking circuit 27. In a case where the parking time of the vehicle V is within the time limit, the CPU 21 turns on the first transistor switch circuit 24 through the first signal line 26A when the remaining time until the time limit is equal to or shorter than the predetermined time, and turns on the first transistor switch circuit 24 through the second signal line 26B when the remaining time is longer than the predetermined time.

[0069]

In this way, the on-board unit 1 can change the display mode (turning on or blinking) of the LED1 in accordance with the remaining time until the time limit. As a result, the enforcement officer can easily understand whether the parking time is approaching the time limit. The enforcement officer can efficiently enforce parking violations, such as closely monitoring the vehicle V for which the time limit is approaching. Further, it is possible to allow other users to easily ascertain whether the parking zone will become available within the predetermined time, and the convenience can be improved.

[0070]

<Fourth Embodiment>

Hereinafter, a fourth embodiment will be described in detail with reference to FIGS. 11 and 12. The configuration of the on-board unit 1 according to the present embodiment is the same as the configuration of each of the above-described embodiments except for the following points.

[0071]

(Functional Configuration of On-Board Unit)

FIG. 11 is a diagram showing a functional configuration of an on-board unit according to the fourth embodiment. As shown in FIG. 11, in the on-board unit 1 according to the present embodiment, the blinking circuit 27 includes a first blinking circuit 27A provided in the first signal line 26A, and a second blinking circuit 27B provided in the second signal line 26B.

[0072]

The first blinking circuit 27A switches ON and OFF of the first transistor switch circuit 24 at a first blinking pitch (pitch 1). In addition, the second blinking circuit 27B switches ON and OFF of the first transistor switch circuit 24 at a second blinking pitch (pitch 2) different from the first blinking pitch. For example, the pitch 1 is slower than the pitch 2.

[0073]

FIG. 12 is a diagram showing an example of an LED display pattern according to the fourth embodiment. As shown in FIG. 12, when the parking time of the vehicle V is within the time limit and the remaining time is longer than the predetermined time (n minutes) (step S212 in FIG. 9), the LED1 blinks at the pitch 1 (low speed). In addition, when the parking time is within the time limit but the remaining time is equal to or shorter than the predetermined time (n minutes) (step S214 in FIG. 9), the LED1 blinks at the pitch 2 (high speed). As described above, even in a case where the parking

time is within the time limit, the blinking speed of the LED1 is changed in accordance with the remaining time, so that the enforcement officer can easily understand whether or not the time limit is approaching. The enforcement officer can efficiently crack down on illegal parking, such as closely monitoring the vehicle V for which the time limit is approaching. Further, it is possible to allow other users to predict when the parking zone is likely to become available.

[0074]

(Operation and Effect)

As described above, in the on-board unit 1 according to the present embodiment, the blinking circuit 27 includes the first blinking circuit 27A and the second blinking circuit 27B having the blinking pitch different from the blinking pitch of the first blinking circuit 27A. The signal line 26 includes the first signal line 26A provided with the first blinking circuit 27A and the second signal line 26B provided with the second blinking circuit 27B. In a case where the parking time of the vehicle V is within the time limit, the CPU 21 turns on the first transistor switch circuit 24 through the first signal line 26A when the remaining time until the time limit is equal to or shorter than the predetermined time, and turns on the first transistor switch circuit 24 through the second signal line 26B when the remaining time is longer than the predetermined time.

[0075]

In this way, the on-board unit 1 can change the display mode (blinking pitch) of the LED1 in accordance with the remaining time until the time limit. As a result, the enforcement officer can easily understand whether the parking time is approaching the time limit. The enforcement officer can efficiently enforce parking violations, such as closely monitoring the vehicle V for which the time limit is approaching. Further, it is possible to allow other users to easily predict whether or not the parking zone will

become available within the predetermined time, and the convenience can be improved.

[0076]

The configuration of the third embodiment (FIG. 8) and the configuration of the present embodiment (FIG. 11) may be combined to have a configuration in which a signal line provided with the first blinking circuit 27A, a signal line provided with the second blinking circuit 27B, and a signal line not provided with the blinking circuit are provided. In this case, by changing the display pattern of the LED1, for example, turning on the LED1 when the remaining time exceeds 20 minutes, blinking the LED1 (pitch 1) when the remaining time is equal to or shorter than 20 minutes, and blinking the LED1 (pitch 2) when the remaining time is equal to or shorter than 10 minutes, it is possible to predict the remaining time until the time limit in more detail.

[0077]

Further, the blinking circuit 27 may include three or more blinking circuits. For example, when there are three blinking circuits, the blinking pitch of the LED1 may be changed in three stages of low speed, medium speed, and high speed to increase the number of contents that can be notified. In this case, by changing the display pattern of the LED1, for example, blinking the LED1 (low speed) when the remaining time exceeds 20 minutes, blinking the LED1 (medium speed) when the remaining time is equal to or shorter than 20 minutes, and blinking the LED1 (high speed) when the remaining time is equal to or shorter than 10 minutes, it is possible to predict the remaining time until the time limit in more detail.

[0078]

<Fifth Embodiment>

Hereinafter, a fifth embodiment will be described in detail with reference to FIGS. 13 and 14. The configuration of the on-board unit 1 according to the present

embodiment is the same as the configuration of each of the above-described embodiments except for the following points.

[0079]

(Functional Configuration of On-Board Unit)

FIG. 13 is a diagram showing a functional configuration of the on-board unit according to the fifth embodiment. As shown in FIG. 13, in the on-board unit 1 according to the present embodiment, the switch unit 23 of the main unit 2 includes a plurality of first transistor switch circuits 24A and 24B that superimpose first notification signals having different voltage levels. For example, the first transistor switch circuit 24A superimposes a first notification signal of 3.3 V, and the first transistor switch circuit 24B superimposes the first notification signal of 1.8 V. In addition, the antenna unit 3 includes a plurality of first light-emitting elements 32A and 32B respectively corresponding to the first transistor switch circuits 24A and 24B.

[0080]

FIG. 14 is a diagram showing an example of an LED display pattern according to the fifth embodiment. As shown in FIG. 14, when the parking time of the vehicle V is within the time limit and the remaining time is longer than the predetermined time (n minutes) (step S212 in FIG. 9), the LED1A is turned on. When the parking time is within the time limit but the remaining time is equal to or shorter than the predetermined time (n minutes) (step S214 in FIG. 9), the LED1B is turned on. In this way, even when the parking time is within the time limit, the LED1A or the LED1B is switched and turned on in accordance with the remaining time, so that the enforcement officer can easily understand whether or not the time limit is approaching. The enforcement officer can efficiently crack down on illegal parking, such as closely monitoring the vehicle V for which the time limit is approaching. Furthermore, it is possible to allow

other users to predict when the parking zone is likely to become available.

[0081]

(Operation and Effect)

As described above, in the on-board unit 1 according to the present embodiment, the main unit 2 includes the plurality of first transistor switch circuits 24A and 24B that superimpose first notification signals having different voltage levels. The antenna unit 3 includes a plurality of first light-emitting elements 32A and 32B (LED1A and LED1B) respectively corresponding to the first transistor switch circuits 24A and 24B.

[0082]

In this way, the on-board unit 1 can switch and turn on the LED1A or the LED1B in accordance with the remaining time until the time limit. As a result, the enforcement officer can easily understand whether or not the time limit is approaching. The enforcement officer can efficiently crack down on illegal parking, such as closely monitoring the vehicle V for which the time limit is approaching. Further, it is possible to allow other users to easily predict whether or not the parking zone will become available within the predetermined time, and the convenience can be improved.

[0083]

The configuration of the second embodiment (FIG. 6) and the configuration of the present embodiment (FIG. 13) may be combined so that the blinking circuit 27 is provided in one or both of the first transistor switch circuits 24A and 24B, and one or both of LED1A and LED1B may be made capable of blinking. Further, the configuration of the third embodiment (FIG. 8) or the configuration of the fourth embodiment (FIG. 11) may be combined with the configuration of the present embodiment. That is, for one or both of the LED1A and the LED1B, turning on and blinking may be switchable, or the blinking pitch may be switchable. In this way, it is

possible to predict the time when the parking zone will become available in more detail.

[0084]

<Other Embodiments>

Although one embodiment has been described above in detail with reference to the accompanying drawings, the specific configuration is not limited to that described above, and various design changes and the like may be made. That is, in another embodiment, the order of the above-described processes may be changed as appropriate. In addition, some of the processes may be executed in parallel.

[0085]

<Supplementary Note>

The on-board unit and the method for controlling the on-board unit described in the above-described embodiments are understood as follows, for example.

[0086]

(1) A first aspect relates to an on-board unit 1 including: a main unit 2; and an antenna unit 3 connected to the main unit 2 by a coaxial cable 4, in which the main unit 2 includes a switch unit 23 including a first transistor switch circuit 24 configured to superimpose a first notification signal on a signal to be output to the antenna unit 3, and a CPU 21 configured to turn on the first transistor switch circuit 24 when a parking time of a vehicle V is within a time limit, and turn off the first transistor switch circuit 24 when the parking time is outside the time limit, and the antenna unit 3 includes a first light-emitting element 32 provided at a position visible from outside the vehicle V, and a voltage level determination unit 31 configured to turn on or turn off the first light-emitting element 32 based on a voltage level of the signal input from the main unit 2.

[0087]

In the related art, the enforcement officer of the parking zone needs to perform

time-consuming work of determining whether or not there is a parking violation by comparing the date and time described in the parking ticket with the current date and time. In addition, in the on-board unit in the related art, the LED provided in the antenna unit notifies the state to the occupant of the vehicle. Therefore, a person outside the vehicle cannot check the lighting state of the LED. On the other hand, the on-board unit 1 according to the present embodiment can easily allow a person outside the vehicle V to ascertain whether or not the vehicle V is parked beyond the time limit, with the above-described configuration. Therefore, it is possible to reduce the burden on the enforcement officer.

[0088]

(2) A second aspect relates to the on-board unit 1 according to the first aspect, in which the main unit 2 further includes a self-holding circuit 22 configured to maintain an ON state or an OFF state of the switch unit 23, and the switch unit 23, the CPU 21, and the self-holding circuit 22 are connected to a power supply B capable of supplying power even while an engine of the vehicle V is in an OFF state.

[0089]

In this way, the on-board unit 1 can switch between turning on and turning off the first light-emitting element 32 (LED1) even while the vehicle V is parked and the engine is turned off.

[0090]

(3) A third aspect relates to the on-board unit 1 according to the first or second aspect, in which the switch unit 23 further includes a second transistor switch circuit 25 configured to superimpose, on the signal to be output to the antenna unit 3, a second notification signal having a voltage level different from the voltage level of the first notification signal, the CPU 21 is configured to turn on the second transistor switch

circuit 25 when a state of the on-board unit 1 satisfies a predetermined condition, and turn off the second transistor switch circuit 25 when the state of the on-board unit 1 does not satisfy the condition or when an error has occurred, the antenna unit 3 further includes a second light-emitting element 33 provided at a position visible from inside the vehicle V, and the voltage level determination unit 31 is configured to turn on or turn off each of the first light-emitting element 32 and the second light-emitting element 33 based on the voltage level of the signal input from the main unit 2.

[0091]

In this way, the on-board unit 1 can notify the enforcement officer outside the vehicle V of the presence or absence of the parking violation, and can notify the occupant of the vehicle V of the state of the on-board unit 1. As a result, since one on-board unit 1 can be used for both the toll collection process and the parking time management process, the installation space can be reduced as compared with the introduction of individual on-board units. Further, it is possible to suppress an increase in introduction cost.

[0092]

(4) A fourth aspect relates to the on-board unit 1 according to any one of the first to third aspects, in which the CPU 21 is configured to turn on the first transistor switch circuit 24 and transition to a sleep state when receiving a trigger signal, defined in advance, indicating a parking start, and cancel the sleep state and turn off the first transistor switch circuit 24 when a predetermined time limit has elapsed after receiving the trigger signal.

[0093]

In this way, the on-board unit 1 can notify the presence or absence of the parking violation while minimizing the power consumption of the CPU 21 while the engine of

the vehicle V is in an OFF state.

[0094]

(5) A fifth aspect relates to the on-board unit 1 according to the second aspect, in which the main unit 2 further includes a blinking circuit 27 provided on a signal line 26 connecting the first transistor switch circuit 24 and the self-holding circuit 22.

[0095]

In this manner, the on-board unit 1 can blink the first light-emitting element 32 (LED1) until the parking time of the vehicle V exceeds the time limit. Depending on the environment of the parking zone or the like, there is a possibility that the blinking has better visibility, and thus it is possible to further reduce the burden on the enforcement officer to check the first light-emitting element 32 (LED1).

[0096]

(6) A sixth aspect relates to the on-board unit 1 according to the fifth aspect, in which the signal line 26 includes a first signal line 26A provided with the blinking circuit 27 and a second signal line 26B not provided with the blinking circuit 27, and the CPU 21 is configured to, in a case where the parking time of the vehicle V is within the time limit, turn on the first transistor switch circuit 24 through the first signal line 26A when a remaining time until the time limit is equal to or shorter than a predetermined time, and turn on the first transistor switch circuit 24 through the second signal line 26B when the remaining time is longer than the predetermined time.

[0097]

In this way, the on-board unit 1 can change the display mode (lighting or blinking) of the first light-emitting element 32 (LED1) in accordance with the remaining time until the time limit. As a result, the enforcement officer can easily understand whether or not the time limit is approaching. The enforcement officer can efficiently

crack down on illegal parking, such as closely monitoring the vehicle V for which the time limit is approaching. Furthermore, it is possible to allow other users to easily ascertain whether the parking zone will become available within the predetermined time, and the convenience can be improved.

[0098]

(7) According to a seventh aspect, the blinking circuit 27 includes a first blinking circuit 27A and a second blinking circuit 27B having a blinking pitch different from a blinking pitch of the first blinking circuit 27A, the signal line 26 includes a first signal line 26A provided with the first blinking circuit 27A and a second signal line 26B provided with the second blinking circuit 27B, and the CPU 21 is configured to, in a case where the parking time of the vehicle V is within the time limit, turn on the first transistor switch circuit 24 through the first signal line 26A when a remaining time until the time limit is equal to or shorter than a predetermined time, and turn on the first transistor switch circuit 24 through the second signal line 26B when the remaining time is longer than the predetermined time.

[0099]

In this manner, the on-board unit 1 can change the display mode (blinking pitch) of the first light-emitting element 32 (LED1) in accordance with the remaining time until the time limit. As a result, the enforcement officer can easily understand whether or not the time limit is approaching. The enforcement officer can efficiently crack down on illegal parking, such as closely monitoring the vehicle V for which the time limit is approaching. Further, it is possible to allow other users to easily predict whether or not the parking zone will become available within the predetermined time, and the convenience can be improved.

[0100]

(8) An eighth aspect relates to the on-board unit 1 according to any one of the first to seventh aspects, in which the main unit 2 includes a plurality of the first transistor switch circuits 24A and 24B configured to superimpose respective first notification signals having different voltage levels, and the antenna unit 3 includes a plurality of the first light-emitting elements 32A and 32B respectively corresponding to the plurality of first transistor switch circuits 24A and 24B.

[0101]

In this way, the on-board unit 1 can switch and turn on the first light-emitting element 32A (LED1A) or the first light-emitting element 32B (LED1B) in accordance with the remaining time until the time limit. As a result, the enforcement officer can easily understand whether or not the time limit is approaching. The enforcement officer can efficiently crack down on illegal parking, such as closely monitoring the vehicle V for which the time limit is approaching. Further, it is possible to allow other users to easily predict whether or not the parking zone will become available within the predetermined time, and the convenience can be improved.

[0102]

(9) A ninth aspect relates to a method for controlling an on-board unit 1 including a main unit 2 including a switch unit 23 including a first transistor switch circuit 24 configured to superimpose a first notification signal on a signal to be output to an antenna unit 3, and the antenna unit 3 connected to the main unit 2 by a coaxial cable 4 and including a first light-emitting element 32 provided at a position visible from outside a vehicle V, the method including: a step of, by the main unit 2, turning on the first transistor switch circuit 24 when a parking time of the vehicle V is within a time limit, and turning off the first transistor switch circuit 24 when the parking time is outside the time limit; and a step of, by the antenna unit 3, turning on or turning off the

first light-emitting element 32 based on a voltage level of the signal input from the main unit 2.

[Industrial Applicability]

[0103]

According to the above aspects, it is possible to perform the state display visible from outside the vehicle.

[Reference Signs List]

[0104]

100: parking system

1: on-board unit

2: main unit

20: power supply circuit

21: CPU

22: self-holding circuit

23: switch unit

24, 24A, 24B: first transistor switch circuit

25: second transistor switch circuit

26: signal line

26A: first signal line

26B: second signal line

27: blinking circuit

27A: first blinking circuit

27B: second blinking circuit

3: antenna unit

31: voltage level determination unit

32, 32A, 32B: first light-emitting element (LED1, LED1A, LED1B)

33: second light-emitting element

4: coaxial cable

5: roadside unit

6: central computer system

7: terminal device

B: power supply

V: vehicle

Claims

[Claim 1]

An on-board unit comprising:

a main unit; and

an antenna unit connected to the main unit by a coaxial cable,

wherein the main unit includes

a switch unit including a first transistor switch circuit configured to superimpose a first notification signal on a signal to be output to the antenna unit, and

a CPU configured to turn on the first transistor switch circuit when a parking time of a vehicle is within a time limit, and turn off the first transistor switch circuit when the parking time is outside the time limit, and

the antenna unit includes

a first light-emitting element provided at a position visible from outside the vehicle, and

a voltage level determination unit configured to turn on or turn off the first light-emitting element based on a voltage level of the signal input from the main unit,

wherein the main unit further includes a self-holding circuit configured to maintain an ON state or an OFF state of the switch unit, and

the switch unit, the CPU, and the self-holding circuit are connected to a power supply capable of supplying power even while an engine of the vehicle is in an OFF state.

[Claim 2]

The on-board unit according to claim 1,

wherein the switch unit further includes a second transistor switch circuit configured to superimpose, on the signal to be output to the antenna unit, a second notification signal having a voltage level different from the voltage level of the first notification signal,

the CPU is configured to turn on the second transistor switch circuit when a state of the on-board unit satisfies a predetermined condition, and turn off the second transistor switch circuit when the state of the on-board unit does not satisfy the condition or when an error has occurred,

the antenna unit further includes a second light-emitting element provided at a position visible from inside the vehicle, and

the voltage level determination unit is configured to turn on or turn off each of the first light-emitting element and the second light-emitting element based on the voltage level of the signal input from the main unit.

[Claim 3]

The on-board unit according to claim 1 or 2,

wherein the CPU is configured to

turn on the first transistor switch circuit and transition to a sleep state when receiving a trigger signal, defined in advance, indicating a parking start, and

cancel the sleep state and turn off the first transistor switch circuit when a predetermined time limit has elapsed after receiving the trigger signal.

[Claim 4]

The on-board unit according to claim 1,

wherein the main unit further includes a blinking circuit provided on a signal

line connecting the first transistor switch circuit and the self-holding circuit.

[Claim 5]

The on-board unit according to claim 4,

wherein the signal line includes a first signal line provided with the blinking circuit and a second signal line not provided with the blinking circuit, and

the CPU is configured to, in a case where the parking time of the vehicle is within the time limit, turn on the first transistor switch circuit through the first signal line when a remaining time until the time limit is equal to or shorter than a predetermined time, and turn on the first transistor switch circuit through the second signal line when the remaining time is longer than the predetermined time.

[Claim 6]

The on-board unit according to claim 4,

wherein the blinking circuit includes a first blinking circuit and a second blinking circuit having a blinking pitch different from a blinking pitch of the first blinking circuit,

the signal line includes a first signal line provided with the first blinking circuit and a second signal line provided with the second blinking circuit, and

the CPU is configured to, in a case where the parking time of the vehicle is within the time limit, turn on the first transistor switch circuit through the first signal line when a remaining time until the time limit is equal to or shorter than a predetermined time, and turn on the first transistor switch circuit through the second signal line when the remaining time is longer than the predetermined time.

[Claim 7]

The on-board unit according to any one of claims 1 to 7,

wherein the main unit includes a plurality of the first transistor switch circuits configured to superimpose respective first notification signals having different voltage levels, and

the antenna unit includes a plurality of the first light-emitting elements respectively corresponding to the plurality of first transistor switch circuits.

[Claim 8]

A method for controlling an on-board unit including;

a main unit including a switch unit including a first transistor switch circuit configured to superimpose a first notification signal on a signal to be output to an antenna unit, a CPU and a self-holding circuit, and

the antenna unit connected to the main unit by a coaxial cable and including a first light-emitting element provided at a position visible from outside a vehicle, the method comprising:

a step of, by the CPU of the main unit, turning on the first transistor switch circuit when a parking time of the vehicle is within a time limit, and turning off the first transistor switch circuit when the parking time is outside the time limit;

a step of, by the antenna unit, turning on or turning off the first light-emitting element based on a voltage level of the signal input from the main unit; and

a step of, by the self-holding circuit of the main unit, maintaining an ON state or an OFF state of the switch unit.

wherein the switch unit, the CPU, and the self-holding circuit are connected to a power supply capable of supplying power even while an engine of the vehicle is in an

OFF state.