US012388342B2

(12) **United States Patent**
Shinoda

(10) **Patent No.: US 12,388,342 B2**
(45) **Date of Patent: Aug. 12, 2025**

(54) **ELECTRONIC APPARATUS, DISPLAY DEVICE, AND VOLTAGE MANAGEMENT METHOD**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 466 days.

(21) Appl. No.: **17/788,180**

(22) PCT Filed: **Dec. 27, 2019**

(86) PCT No.: **PCT/JP2019/051395**
§ 371 (c)(1),
(2) Date: **Jun. 22, 2022**

(87) PCT Pub. No.: **WO2021/131015**
PCT Pub. Date: **Jul. 1, 2021**

(65) **Prior Publication Data**

US 2023/0017285 A1 Jan. 19, 2023

(51) **Int. Cl.**
H02M 1/00 (2007.01)
H02M 3/157 (2006.01)

(52) **U.S. Cl.**
CPC ***H02M 1/0006*** (2021.05); ***H02M 3/157*** (2013.01)

(58) **Field of Classification Search**
CPC G05F 1/00; G05F 1/10; G05F 1/12; G05F 1/46; G05F 1/455; G05F 1/45; G05F 1/445; G05F 1/66; G05F 1/40; G05F 1/42; G05F 1/44; G05F 1/462; G05F 1/52; G05F 1/56; G05F 3/10; G05F 3/16; G05F 3/18;
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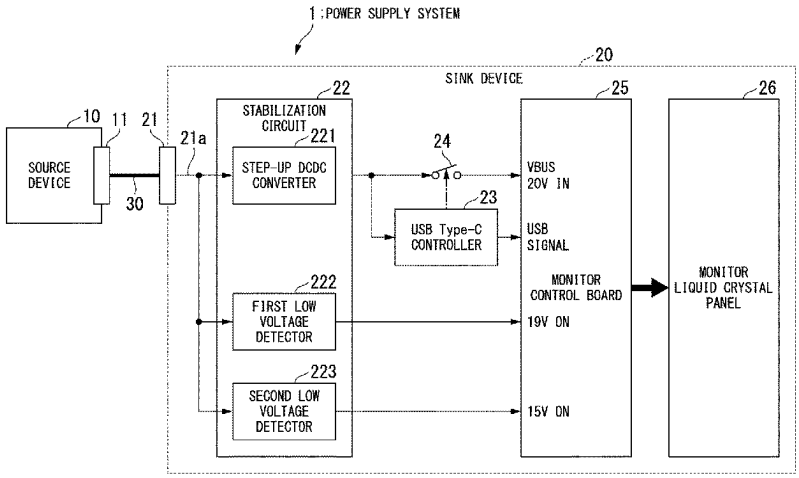
(57) **ABSTRACT**

A reference voltage generator configured to be supplied with a first voltage from an external device and to generate a reference voltage which is a voltage lower than a second voltage which is a voltage higher than the first voltage supplied from the external device on the basis of the second voltage through negotiation with the external device; a determiner configured to determine a magnitude relationship between the second voltage and the reference voltage; and an output configured to notify that a voltage has decreased when the second voltage is equal to or lower than the reference voltage on the basis of the result of determination are included.

9 Claims, 7 Drawing Sheets



(58) **Field of Classification Search**
CPC ... G05F 3/185; G05F 3/20; G05F 3/26; G05F 3/30; G05F 3/205; G05F 3/22; G05F 3/24; G05F 3/222; G05F 3/242; G05F 3/225; G05F 3/227; G05F 3/245; G05F 3/247; G05F 3/262; G05F 3/265; G05F 3/267; G05F 1/575; H02M 5/2573; H02M 1/081; H02M 5/293; H02M 7/12; H02M 3/10; H02M 3/125; H02M 3/13; H02M 3/135; H02M 3/145; H02M 3/15; H02M 3/155; H02M 3/156; H02M 3/157; H02M 3/158; H02M 1/346; H02M 3/1588; H02M 2003/1566; H02M 3/1582; H02M 3/1584; H02M 2003/1557; H02M 1/0032; H02M 1/4225; H02M 7/217; H02M 1/0025; H02M 1/0045; H02M 1/0009; H02M 1/08; H02M 1/088; H02M 1/0048; H05B 39/048; B23K 11/24; H04B 2215/069
See application file for complete search history.

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FIG. 1

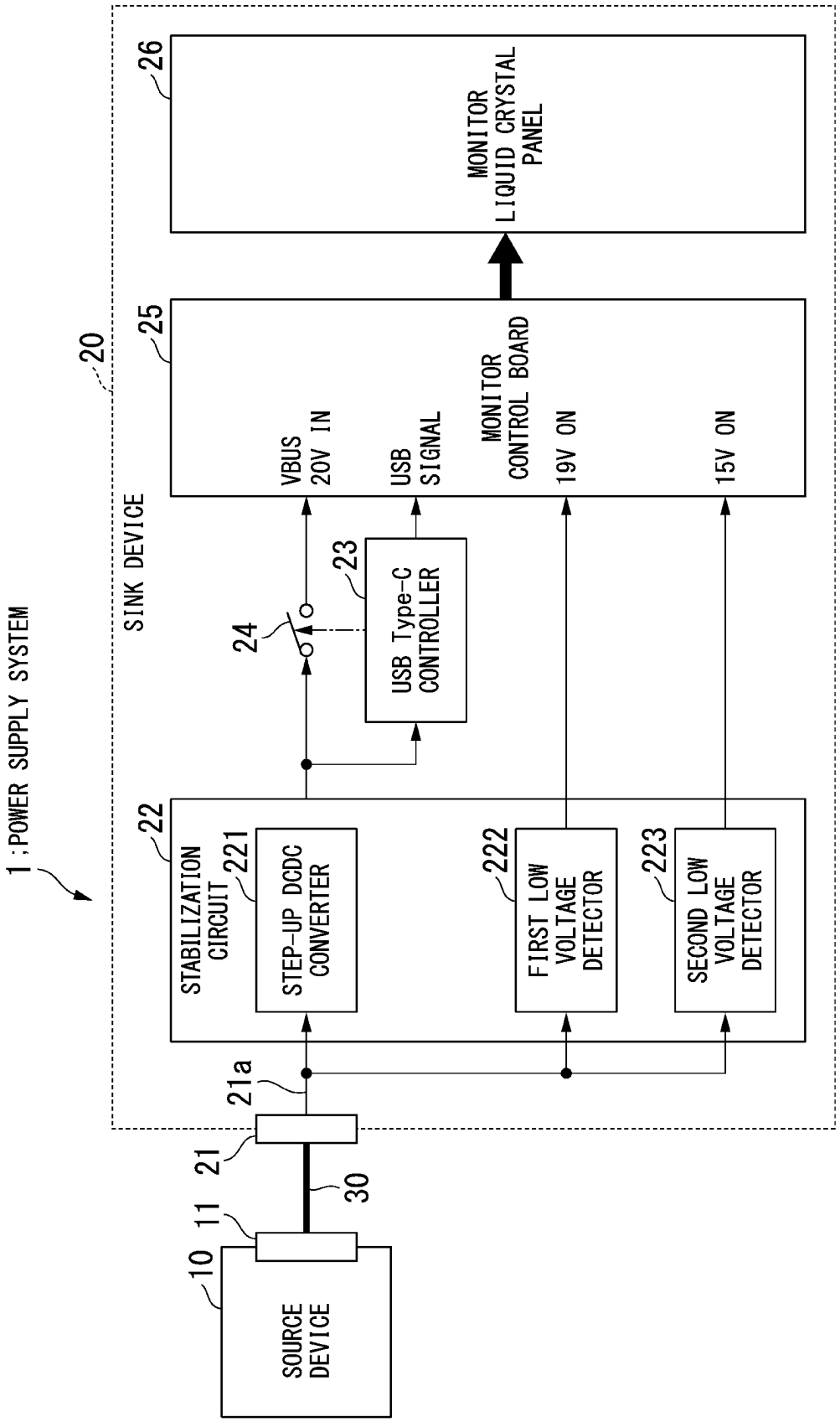

1 ; POWER SUPPLY SYSTEM
20
SINK DEVICE
SOURCE DEVICE
10
11
21
21a
30
22
STABILIZATION CIRCUIT
221
STEP-UP DCDC CONVERTER
222
FIRST LOW VOLTAGE DETECTOR
223
SECOND LOW VOLTAGE DETECTOR
23
USB Type-C CONTROLLER
24
25
MONITOR CONTROL BOARD
VBUS 20V IN
USB SIGNAL
19V ON
15V ON
26
MONITOR LIQUID CRYSTAL PANEL

FIG. 2

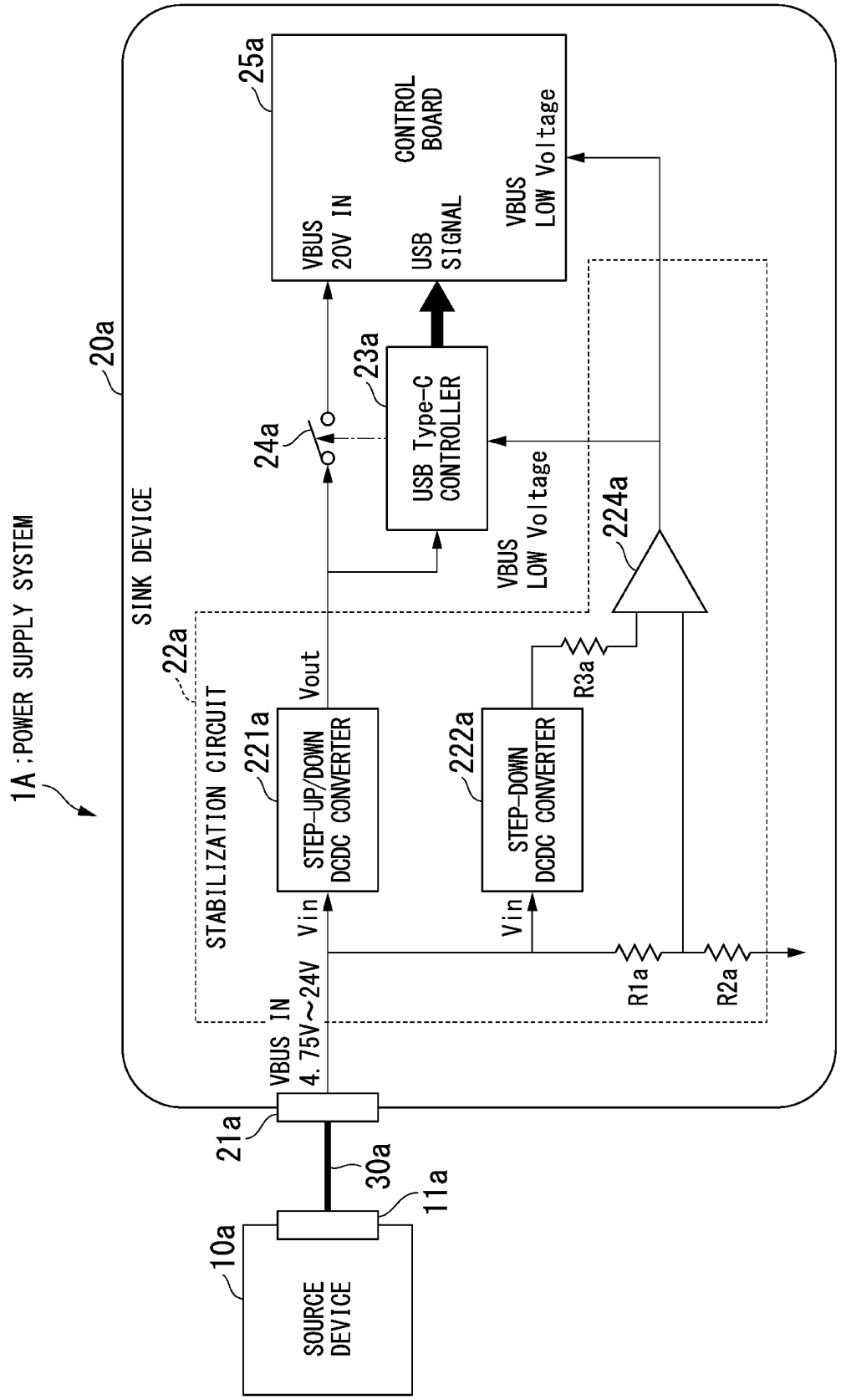

1A:POWER SUPPLY SYSTEM
20a
SINK DEVICE
25a
CONTROL BOARD
VBUS 20V IN
USB SIGNAL
VBUS LOW Voltage
23a
USB Type-C CONTROLLER
24a
VBUS LOW Voltage
224a
22a
STABILIZATION CIRCUIT
221a
STEP-UP/DOWN DCDC CONVERTER
Vout
222a
STEP-DOWN DCDC CONVERTER
R3a
Vin
Vin
R1a
R2a
VBUS IN 4.75V~24V
21a
30a
11a
10a
SOURCE DEVICE

FIG. 3

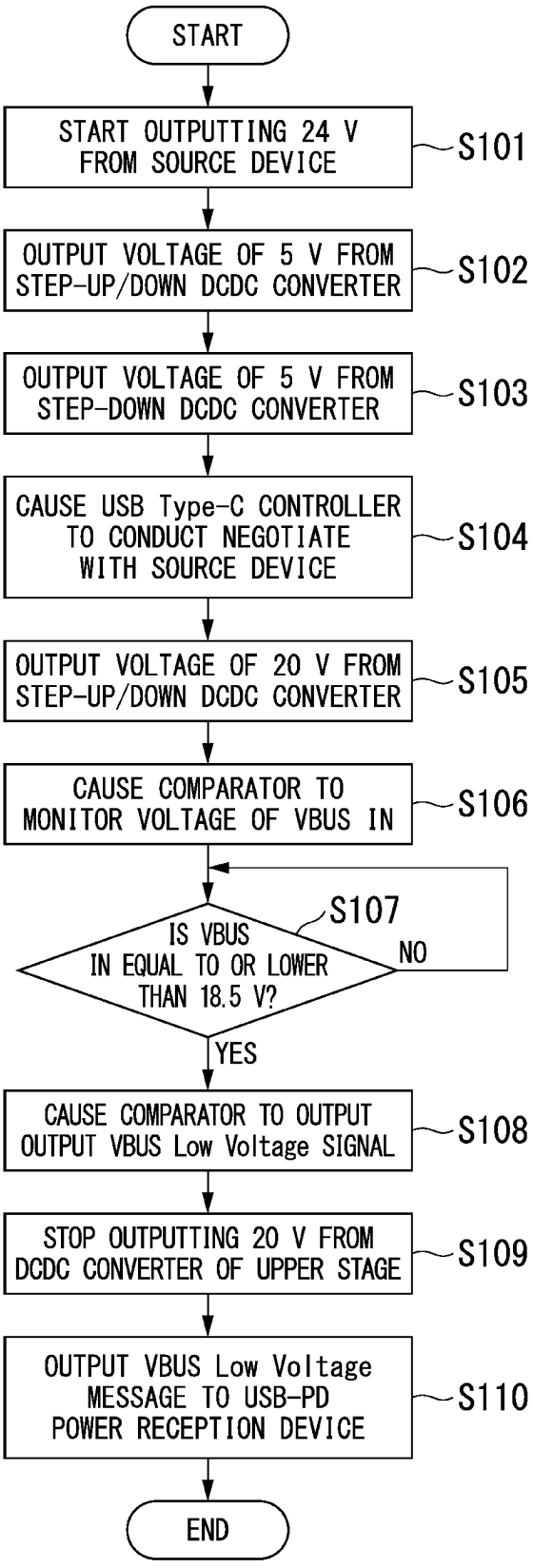

START
START OUTPUTTING 24 V FROM SOURCE DEVICE
S101
OUTPUT VOLTAGE OF 5 V FROM STEP-UP/DOWN DCDC CONVERTER
S102
OUTPUT VOLTAGE OF 5 V FROM STEP-DOWN DCDC CONVERTER
S103
CAUSE USB Type-C CONTROLLER TO CONDUCT NEGOTIATE WITH SOURCE DEVICE
S104
OUTPUT VOLTAGE OF 20 V FROM STEP-UP/DOWN DCDC CONVERTER
S105
CAUSE COMPARATOR TO MONITOR VOLTAGE OF VBUS IN
S106
S107
IS VBUS IN EQUAL TO OR LOWER THAN 18.5 V?
NO
YES
CAUSE COMPARATOR TO OUTPUT OUTPUT VBUS Low Voltage SIGNAL
S108
STOP OUTPUTTING 20 V FROM DCDC CONVERTER OF UPPER STAGE
S109
OUTPUT VBUS Low Voltage MESSAGE TO USB-PD POWER RECEPTION DEVICE
S110
END

FIG. 4

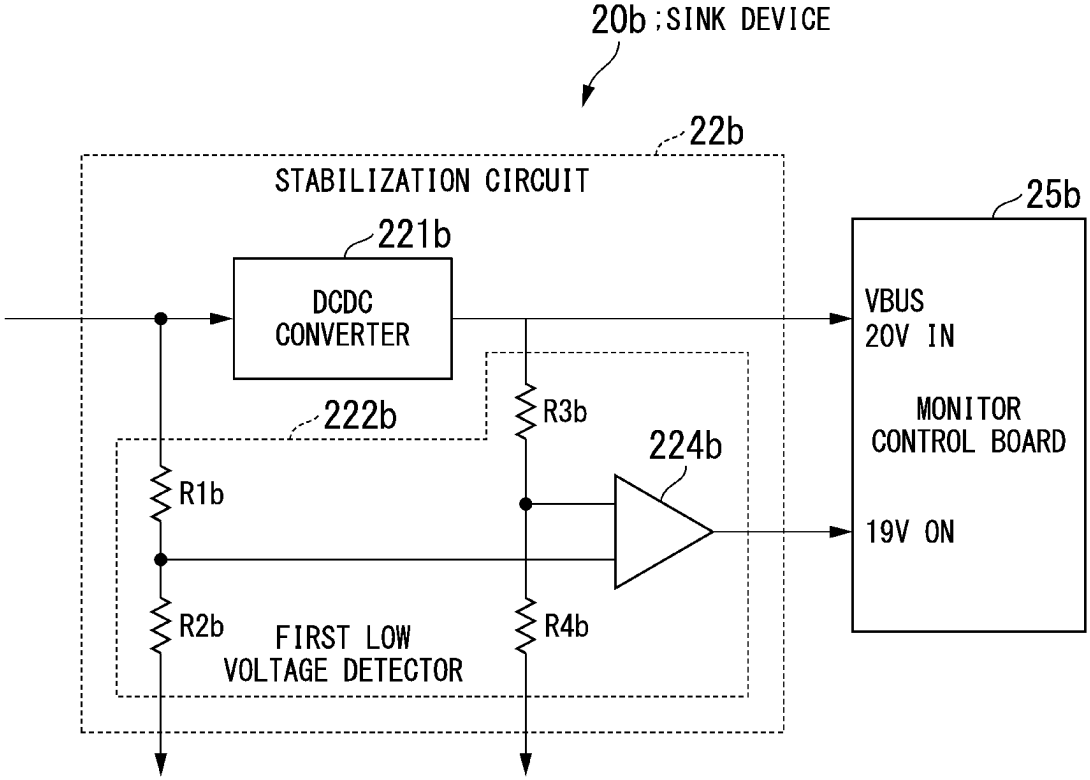

20b ;SINK DEVICE
22b
STABILIZATION CIRCUIT
221b
DCDC
CONVERTER
25b
VBUS
20V IN
MONITOR
CONTROL BOARD
19V ON
222b
R3b
224b
R1b
R2b
FIRST LOW
VOLTAGE DETECTOR
R4b

FIG. 5

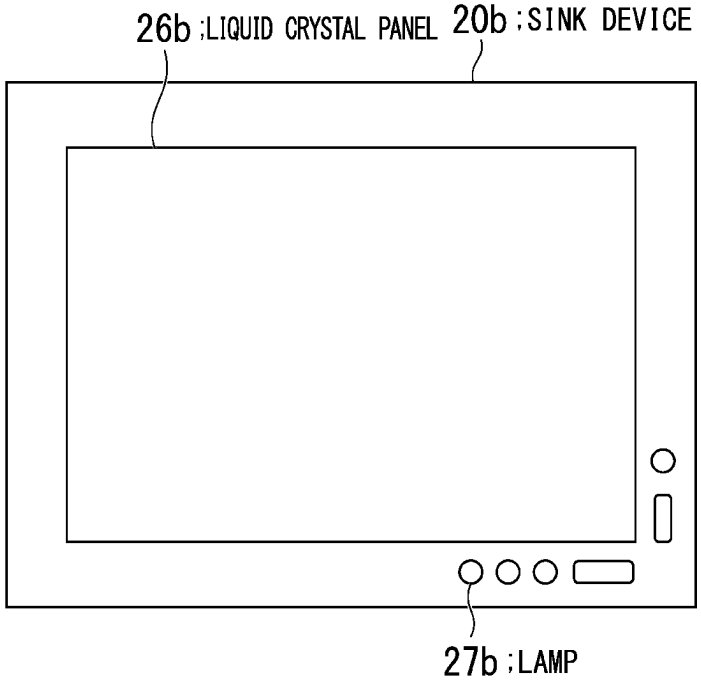

26b ;LIQUID CRYSTAL PANEL
20b ;SINK DEVICE
27b ;LAMP

FIG. 6

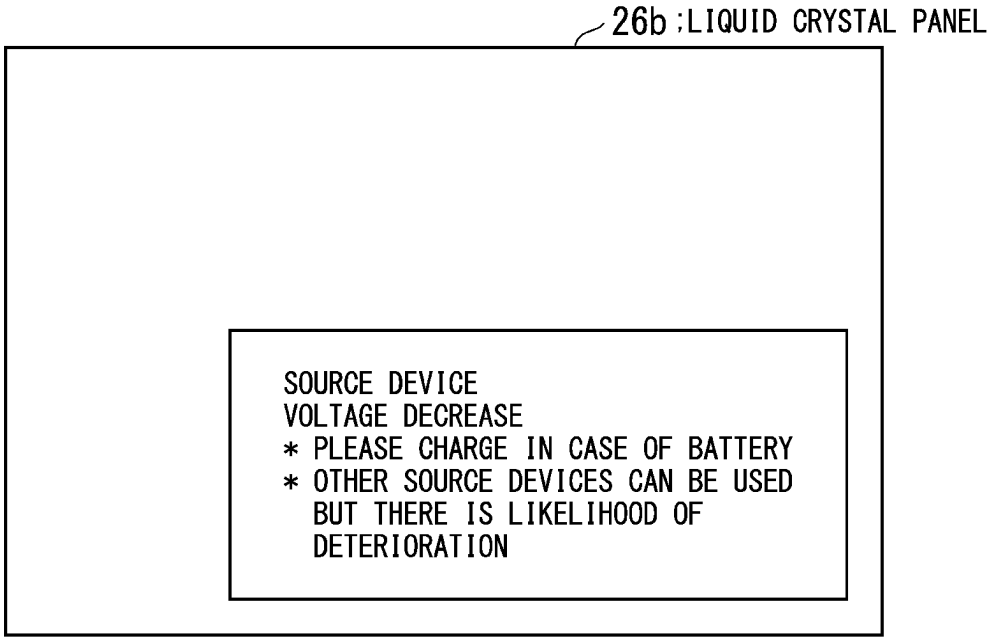

26b ;LIQUID CRYSTAL PANEL
SOURCE DEVICE
VOLTAGE DECREASE
* PLEASE CHARGE IN CASE OF BATTERY
* OTHER SOURCE DEVICES CAN BE USED
BUT THERE IS LIKELIHOOD OF
DETERIORATION

FIG. 7

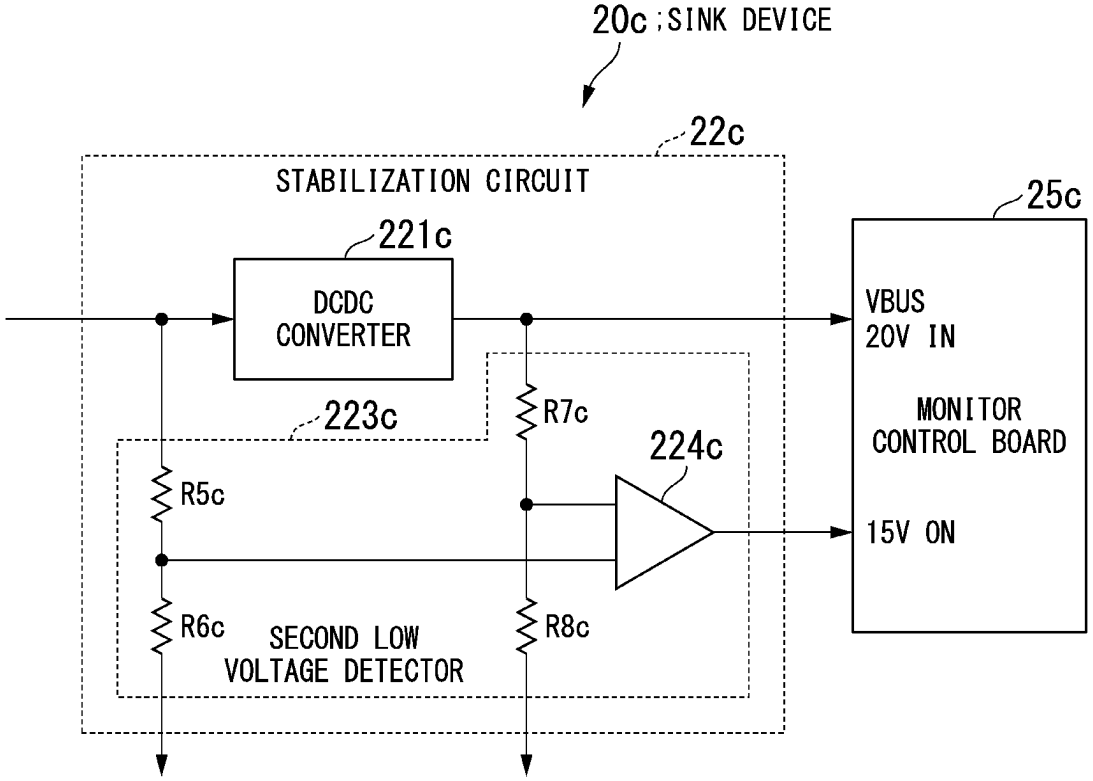

20c ;SINK DEVICE
22c
STABILIZATION CIRCUIT
221c
DCDC
CONVERTER
25c
VBUS
20V IN
MONITOR
CONTROL BOARD
15V ON
223c
R7c
224c
R5c
R6c
SECOND LOW
VOLTAGE DETECTOR
R8c

FIG. 8

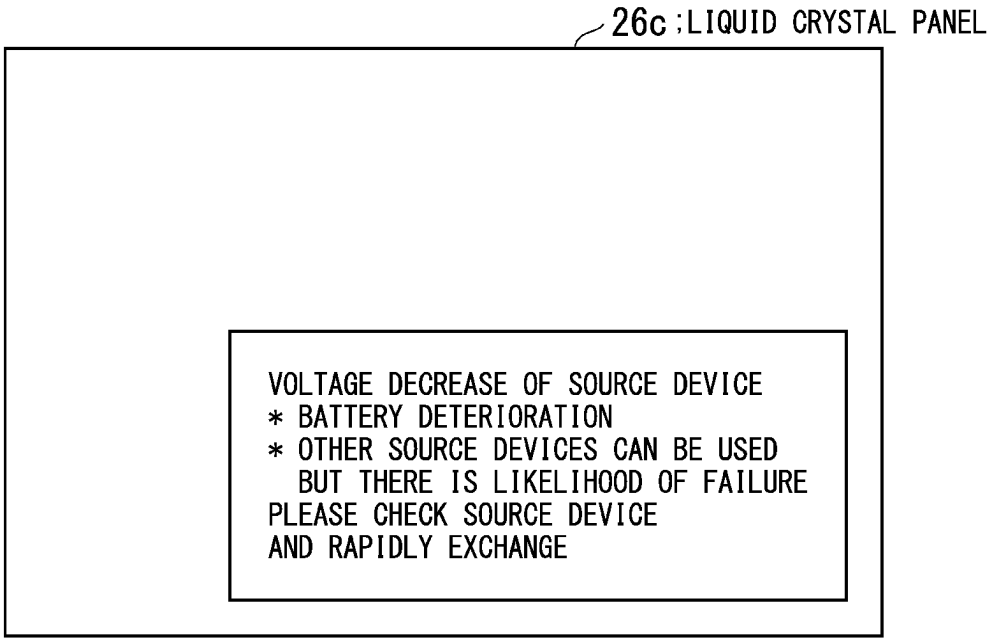

26c:LIQUID CRYSTAL PANEL
VOLTAGE DECREASE OF SOURCE DEVICE
* BATTERY DETERIORATION
* OTHER SOURCE DEVICES CAN BE USED
BUT THERE IS LIKELIHOOD OF FAILURE
PLEASE CHECK SOURCE DEVICE
AND RAPIDLY EXCHANGE

FIG. 9

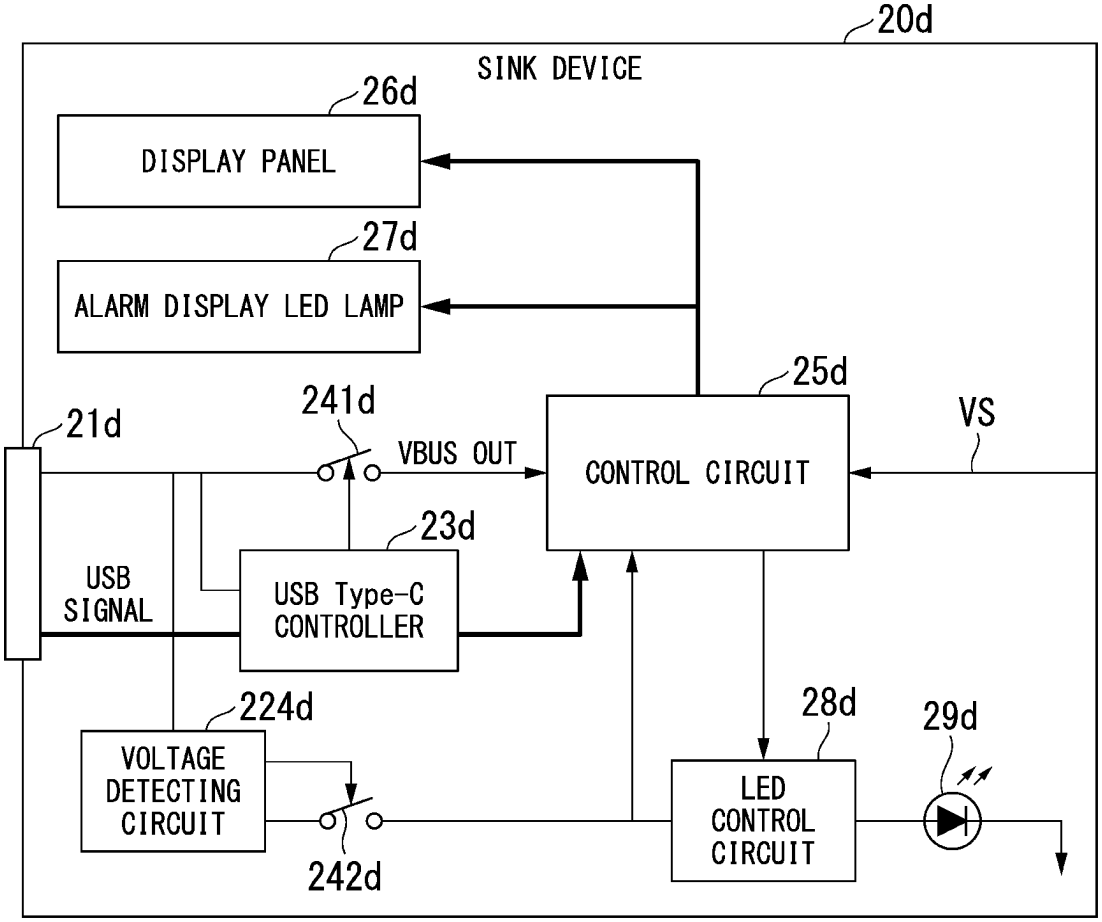
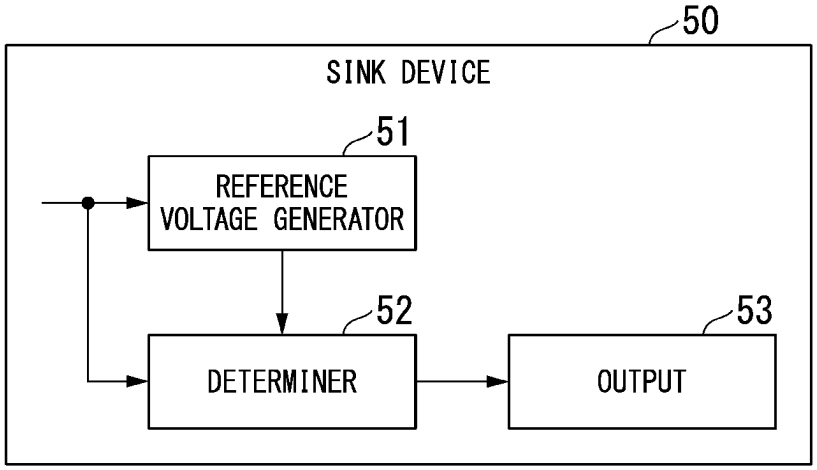

20d
SINK DEVICE
26d
DISPLAY PANEL
27d
ALARM DISPLAY LED LAMP
25d
241d
21d
VBUS OUT
CONTROL CIRCUIT
VS
23d
USB
SIGNAL
USB Type-C
CONTROLLER
224d
28d
29d
VOLTAGE
DETECTING
CIRCUIT
LED
CONTROL
CIRCUIT
242d

FIG. 10


50
SINK DEVICE
51
REFERENCE
VOLTAGE GENERATOR
52
53
DETERMINER
OUTPUT

ELECTRONIC APPARATUS, DISPLAY DEVICE, AND VOLTAGE MANAGEMENT METHOD

TECHNICAL FIELD

Some of the present invention relate to an electronic apparatus, a display device, and a voltage management method.

BACKGROUND ART

In recent years, a technique in which a source device and a sink device are connected using a cable and electric power is supplied from the source device to the sink device has emerged. A cable corresponding to a standard of Universal Serial Bus (USB) Type-C can be used for connection between the source device and the sink device.

In USB Type-C, a function of supplying electric power is called USB power delivery (hereinafter referred to as USB Type-C PD).

Many batteries, AC adapters, and the like serving as source devices (a power supply side) corresponding to the standard of USB Type-C PD are on the market.

Examples of products (the power supply side) corresponding to the standard of USB Type-C PD include battery-driven devices, devices in which a VBUS power source is mounted in a source device, and AC adapters corresponding to USB PD.

A power supply device of USB PD is supplied with electric power from a source device corresponding to USB Type-C PD (such as an AC adapter, a battery, or a desktop PC) and requests necessary voltage and current through negotiation of USB Type-C, and electric power is supplied from the source device to a sink device.

In reception of electric power based on USB Type-C PD, the sink device can request 5 V, 9 V, 12 V, 15 V, and 20 V as VBUS voltages from the source device under the standard of USB Type-C PD and can conduct negotiation and be supplied with electric power as a result of the negotiation. In supply of electric power based on USB Type-C PD, the sink device can request the VBUS voltage in a range of equal to or less than a current value of 3 A when an output voltage is equal to or less than 15 V and request the VBUS voltage in a range of equal to or less than a current value of 5 A when the output voltage is 20 V.

For example, a display device is used as an example of the sink device.

When a source device and a display device are connected via a USB Type-C cable, a voltage of 5 V is supplied from the source device to the display device. A USB Type-C controller of the display device starts negotiation. When conditions of the negotiation from the display device to the source device have been satisfied, a switch between a VBUS IN line and a VBUS OUT line in the display device is turned on and electric power with a voltage of higher than 5 V is supplied to the constituents of the display device according to the result of negotiation via the VBUS OUT line. Accordingly, the sink device can operate.

At this time, since the negotiation operation is performed only once when a USB Type-C connector is inserted, outputting of the sink device (for example, displaying of a screen on the display device) is stopped when the voltage supplied from the source device such as a battery, an AC adapter, or a desktop PC decreases with long term use.

Here, since the negotiation of USB Type-C is performed only once as described above, there is a likelihood that a protection circuit (such as an overcurrent circuit) of the source device will operate in a state in which the switch between the VBUS IN line and the VBUS OUT line in the display device is turned on. In this case, the screen displayed on the display device is not displayed and the operation of the display device is stopped.

In this way, in the case in which certain failure in the source device, a decrease in battery voltage, or the like occurs, the device performing reception of electric power based on USB PD on the sink side stops its operation when it is not supplied with electric power from a device other than the source device (when it does not have a function of connection to an AC power source, or the like). Then, the screen on the display device such as the sink device is not displayed. In this case, since the screen on the display device is not displayed, there is a likelihood that a user will determine that failure has occurred in the sink device (the display device).

CITATION LIST

Patent Literature

Patent Literature 1
Japanese Unexamined Patent Application, First Publication No. 2019-023042

SUMMARY OF INVENTION

Technical Problem

A problem to be solved is that there is a likelihood that a user will recognize that failure occurs in a sink device even when failure occurs in a source device.

Solution to Problem

One aspect of the present invention is an electronic apparatus including: a reference voltage generator configured to be supplied with a first voltage from an external device and to generate a reference voltage which is a voltage lower than a second voltage which is a voltage higher than the first voltage supplied from the external device on the basis of the second voltage through negotiation with the external device; a determiner configured to determine a magnitude relationship between the second voltage and the reference voltage; and an output configured to notify that a voltage has decreased when the second voltage is equal to or lower than the reference voltage on the basis of the result of determination.

One aspect of the present invention is a voltage management method including: being supplied with a first voltage from an external device and generating a reference voltage which is a voltage lower than a second voltage which is a voltage higher than the first voltage supplied from the external device on the basis of the second voltage through negotiation with the external device; determining a magnitude relationship between the second voltage and the reference voltage; and notifying that a voltage has decreased when the second voltage is equal to or lower than the reference voltage on the basis of the result of determination.

Advantageous Effects of Invention

According to the aspect of the present invention, a likelihood of failure occurring in a source device is notified of when a voltage supplied from the source device has

decreased. Accordingly, it is possible to enable a user to understand that a device in which failure occurs is the source device.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a functional block diagram illustrating a configuration of a power supply system **1** according to an aspect of the present invention.

FIG. **2** is a block diagram schematically illustrating a configuration of a power supply system **1**A according to a second embodiment of the present invention.

FIG. **3** is a flowchart illustrating operations of a sink device **20***a* in the power supply system **1**A.

FIG. **4** is a block diagram schematically illustrating a configuration of a sink device **20***b* according to a third embodiment.

FIG. **5** is a diagram illustrating a front appearance of the sink device when the sink device **20***b* is a display device.

FIG. **6** is a diagram illustrating an example in which alarm information is output using a liquid crystal panel **26***b* of the sink device **20***b*.

FIG. **7** is a block diagram schematically illustrating a configuration of a sink device **20***c* according to a fourth embodiment.

FIG. **8** is a diagram illustrating an example in which alarm information is output using a liquid crystal panel **26***c* provided in the sink device **20***c*.

FIG. **9** is a block diagram schematically illustrating a configuration of a sink device **20***d* according to a fifth embodiment.

FIG. **10** is a block diagram schematically illustrating a configuration of a sink device **50** according to a sixth embodiment.

DESCRIPTION OF EMBODIMENTS

FIG. **1** is a functional block diagram illustrating a configuration of a power supply system **1** according to an aspect of the present invention.

In the power supply system **1**, a source device **10** and a sink device **20** are connected via a Universal Serial Bus (USB) Type-C cable **30**.

The source device **10** conducts negotiation with the sink device **20** and supplies electric power based on a result of the negotiation to the sink device **20**.

In USB Type-C, the function of supplying electric power is called USB power delivery (hereinafter referred to as USB Type-C PD). Electric power of a maximum of 100 W can be supplied and received using a USB Type-C cable.

In USB Type-C PD, an output voltage can be determined to be one voltage in a voltage range which can be supplied from the source device and in which maximum received/supplied power is 100 W on the basis of a result of negotiation between the source device and the sink device. Here, when the output voltage changes, a maximum output current may also change. For example, when supply power determined through negotiation is 60 W and the output voltage is set to a voltage in a range of 5 V to 20 V, a supply current value may be set to 3 A. When electric power in a range of 60 W to 100 W is determined as the supply power as the result of negotiation, the output current can be set to 3 A when the output voltage ranges from 5 V to 15 V, and the output current can be set to 5 A when the output voltage is set to 20 V.

The source device **10** can supply, for example, electric power of a maximum of 45 W, and can also cope with supply of electric power in a range of 45 W to 100 W. The source device **10** is a device based on the standard of USB Type-C PD. Accordingly, the source device **10** can supply electric power of equal to or higher than 45 W. In this case, the source device **10** can output an output voltage of 20 V. For example, one of a battery, an AC adapter, and a desktop PC can be used as the source device **10**.

The source device **10** includes a connector **11**. The connector **11** can be connected to one terminal of a USB Type-C cable **30**. The other terminal of the USB Type-C cable **30** is connected to a connector **21** provided in the sink device **20**. Accordingly, the source device **10** and the sink device **20** can be communicatively and electrically connected to each other via the USB Type-C cable **30**, and electric power can be supplied from the source device **10** to the sink device **20**.

The sink device **20** conducts negotiation with the source device **10** and requests a required output voltage from the source device **10** when electric power required by the sink device **20** is determined. The sink device **20** can request supply of electric power in a range of equal to or lower than 100 W and can request an output voltage of 20 V, for example, when negotiation has been conducted such that electric power of 100 W is supplied.

The sink device **20** includes a connector **21**, a stabilization circuit **22**, a USB Type-C controller **23**, a switch **24**, a monitor control board **25**, and a monitor liquid crystal panel **26**. The sink device **20** is, for example, a display device.

The connector **21** is connected to the other terminal of the USB Type-C cable **30**.

The stabilization circuit **22** includes a step-up DCDC converter **221**, a first low voltage detector **222**, and a second low voltage detector **223**.

The step-up DCDC converter **221** generates the same voltage as the voltage requested from the source device **10** through negotiation on the basis of the voltage supplied from an external device (the source device **10**). More specifically, the step-up DCDC converter **221** steps up a voltage VBUS IN which is supplied via the USB Type-C cable **30**. For example, the step-up DCDC converter **221** steps up the output voltage of 5 V supplied from the VBUS input line to 20 V. This output voltage 20 V is the same voltage as the voltage requested from the source device **10** through negotiation.

An input of the step-up DCDC converter **221** is connected to the VBUS input line of the USB Type-C cable **30** using the function of USB Type-C PD. The voltage supplied from the VBUS input line is, for example, an output voltage in a range of 4.75 V to 21 V according to the standard of USB Type-C PD.

An output of the step-up DCDC converter **221** is connected to the switch **24** and the USB Type-C controller **23**. The voltage output from the step-up DCDC converter **221** is, for example, an output voltage in a range of 19 V to 21 V according to the standard of USB Type-C PD when the output voltage is 20 V.

In this way, the step-up DCDC converter **221** is provided between the connector **21** and the USB Type-C controller **23**. Accordingly, even when the voltage VBUS IN is equal to or less than 20 V, the voltage VBUS OUT output from the step-up DCDC converter **221** can be supplied as a fixed voltage of 20 V by causing the step-up DCDC converter **221** to step up the voltage. As a result, since the VBUS supply voltage can be stably supplied at 20 V, it is possible to prevent an erroneous operation in controlling a power-supplied device of USB Type-C PD (the sink device **20**).

The first low voltage detector **222** is connected to the VBUS input line between the connector **21** and an input terminal of the step-up DCDC converter **221** and determines a magnitude relationship between the voltage of a BUS input line and a first voltage reference value. Since a minimum reference voltage when the output voltage is 20 V is defined as 19 V in the standard of USB Type-C PD, the minimum reference voltage can be used as the first voltage reference value. That is, the first voltage reference value is, for example, 19 V.

The first voltage reference value may be generated using a first reference voltage generating function of generating a first reference voltage lower than the voltage determined through negotiation. For example, as in an embodiment which will be described later, the first reference voltage generating function may be realized by a DCDC converter that generates the first reference voltage using the voltage of the VBUS input line input to the step-up DCDC converter **221** as an input and supplies the generated first reference voltage to the first low voltage detector **222**.

For example, as in an embodiment which will be described later, the first reference voltage generating function may generate the first reference voltage through resistive voltage division using resistors using the voltage of the VBUS input line input to the step-up DCDC converter **221** as an input and supply the generated first reference voltage to the first low voltage detector **222**.

The first low voltage detector **222** determines whether the voltage VBUS IN supplied from the VBUS input line is equal to or less than 19 V and outputs a signal indicating that the voltage VBUS IN is equal to or less than 19 V to the monitor control board **25** when the voltage VBUS IN is equal to or less than 19 V. By causing the first low voltage detector **222** to output the signal based on the result of determination, the monitor control board **25** can cause the monitor liquid crystal panel **26** to display that a residual capacity of a battery in the source device has decreased or that the source device has deteriorated.

For example, the monitor control board **25** may display that a residual capacity of a battery has decreased when the source device is a device that supplies electric power using the battery and display that an abnormality has occurred in a voltage output from the source device when the source device is an AC adapter or a desktop PC.

Accordingly, it is possible to display an alarm indicating that there is a likelihood that an abnormality has not occurred in the function of the sink device **20** but an abnormality has occurred in the source device **10** through microcomputer control or the like.

The second low voltage detector **223** is connected to the VBUS input line between the connector **21** and the input terminal of the step-up DCDC converter **221** and determines a magnitude relationship between the voltage of the BUS input line and a second voltage reference value. The second voltage reference value is, for example, 15 V.

The second voltage reference value may be generated using a second reference voltage generating function of generating a second reference voltage lower than the first reference voltage. For example, as in an embodiment which will be described later, the second reference voltage generating function may be realized by a DCDC converter that generates the second reference voltage using the voltage of the VBUS input line input to the step-up DCDC converter **221** as an input and supplies the generated second reference voltage to the second low voltage detector **223**.

For example, as in an embodiment which will be described later, the second reference voltage generating function may generate the second reference voltage through resistive voltage division using resistors using the voltage of the VBUS input line input to the step-up DCDC converter **221** as an input and supply the generated second reference voltage to the second low voltage detector **223**.

The second low voltage detector **223** determines whether the voltage VBUS IN supplied from the VBUS input line is equal to or less than 15 V and outputs a signal indicating that the voltage VBUS IN is equal to or less than 15 V to the monitor control board **25** when the voltage VBUS IN is equal to or less than 15 V. By causing the second low voltage detector **223** to output the signal based on the result of determination, the monitor control board **25** can cause the monitor liquid crystal panel **26** to display that the residual capacity of the battery in the source device has decreased or that the source device has deteriorated.

The monitor control board **25** may cause the monitor liquid crystal panel **26** to display a message of battery exhaustion or the like as on-screen display (OSD) for a predetermined time (for example, 1 minute) and cut off supply of electric power to the monitor liquid crystal panel **26** or stop the operation of the sink device **20** through a power supply management function after the predetermined time has elapsed.

In this way, since the first low voltage detector **222** and the second low voltage detector **223** are provided and various types of information are output when the voltage supplied from the source device **10** is equal to or less than a predetermined voltage, a user can understand that an abnormality has not occurred in the sink device **20** but an abnormality has occurred in the source device **10** by ascertaining details of the output information.

When the source device **10** is connected via the connector **21**, the USB Type-C controller **23** detects that the source device **10** is connected via the connector **21**, conducts negotiation with the source device **10**, and requests electric power or a voltage in a range of electric power with which the source device **10** and the sink device **20** can cope.

The USB Type-C controller **23** receives an input of a voltage output from the step-up DCDC converter **221** and acquires a VBUS signal superimposed on the voltage by performing filtering or the like thereon. The USB Type-C controller **23** can conduct negotiation with reference to the VBUS signal.

When negotiation has been established (ended), the USB Type-C controller **23** supplies the voltage output from the step-up DCDC converter **221** to the monitor control board **25** by turning on the switch **24**.

The USB Type-C controller **23** can monitor the voltage supplied from the step-up DCDC converter **221** and stop supply of the voltage to the monitor control board **25** by turning off the switch **24** when it is determined as a result of monitoring that an abnormality has occurred in the supplied voltage.

Here, since the USB Type-C controller **23** monitors the voltage and a fixed voltage is output from the step-up DCDC converter **221**, it is possible to curb cases in which it is determined that the voltage is equal to or less than a predetermined voltage. Accordingly, even when a certain amount of fluctuation occurs in the voltage supplied from the source device **10**, a fixed voltage can be continuously supplied to the monitor control board **25** and thus it is possible to prevent the USB Type-C controller **23** from turning off the switch **24** by detecting that the voltage is a low voltage.

The switch **24** switches between an on state and an off state on the basis of a signal output from the USB Type-C

controller **23**. The voltage output from the step-up DCDC converter **221** is supplied to the monitor control board **25** when the switch **24** switches to the on state, and the voltage output from the step-up DCDC converter **221** is not supplied to the monitor control board **25** when the switch **24** switches to the off state.

The monitor control board **25** detects whether negotiation has been established on the basis of a USB signal USB SIGNAL output from the USB Type-C controller **23**. The USB signal USB SIGNAL can be used as a signal indicating a result of determination of whether negotiation has been established.

The monitor control board **25** displays various types of information on the monitor liquid crystal panel **26** according to the signal output from the first low voltage detector **222** or the second low voltage detector **223**. Accordingly, when the voltage output from the source device **10** has decreased, it is possible to notify the sink device **20** that an abnormality has occurred in the source device **10** by outputting an alarm from the sink device. When a signal output from the second low voltage detector **223** is acquired and the source device is a device using a battery or the like, the monitor control board **25** displays an alarm for notifying of battery exhaustion or the like. The monitor control board **25** can notify of an alarm indicating battery exhaustion or the like, for example, in a plurality of steps. The plurality of steps may be three steps.

The monitor liquid crystal panel **26** is a liquid crystal display panel and displays various types of information according to a signal from the monitor control board **25**.

In this embodiment, an example in which the stabilization circuit **22** of the sink device **20** includes the step-up DCDC converter **221**, the first low voltage detector **222**, and the second low voltage detector **223** has been described above, but a configuration in which the stabilization circuit **22** includes the step-up DCDC converter **221** but does not include the first low voltage detector **222** and the second low voltage detector **223** may be employed. That is, the stabilization circuit **22** does not monitor a low voltage using the first low voltage detector **222** and the second low voltage detector **223**, but since the step-up DCDC converter **221** is provided, the stabilization circuit **22** can supply the voltage VBUS OUT output from the step-up DCDC converter **221** to be a fixed voltage of 20 V by causing the step-up DCDC converter **221** to step up the voltage even when the voltage VBUS IN supplied from the source device **10** becomes equal to or less than 20 V after negotiation for requesting the voltage of 20 V has been established. Accordingly, since the monitor control board **25** can be supplied with a voltage of less fluctuation, it is possible to continuously operate the sink device **20**.

A power supply system **1**A according to a second embodiment will be described below.

FIG. **2** is a block diagram schematically illustrating a configuration of the power supply system **1**A according to the second embodiment. In the power supply system **1**A, a source device **10***a* and a sink device **20***a* are connected via a USB Type-C cable **30***a*. The power supply system **1**A shares some functions with the power supply system **1** illustrated in FIG. **1**.

The source device **10***a* has functions shared with the source device **10**, but is different therefrom in a function of outputting an output voltage in a range of rated output of 21 V to 24 V. For example, a device such as a battery, an AC adapter, or a desktop PC can be used as the source device **10***a*.

The sink device **20***a* shares some functions of the sink device **20** and thus differences will be mainly described. The sink device **20***a* requests an output voltage of 20 V after negotiation.

The sink device **20***a* includes a connector **21***a*, a stabilization circuit **22***a*, a USB Type-C controller **23***a*, a switch **24***a*, and a control board **25***a*.

The stabilization circuit **22***a* includes a step-up/down DCDC converter **221***a*, a step-down DCDC converter **222***a*, a comparator **224***a*, a resistor R**1***a*, a resistor R**2***a*, and a resistor R**3***a*.

The step-up/down DCDC converter **221***a* shares some functions of the step-up DCDC converter **221** and thus different functions will be described.

An input of the step-up/down DCDC converter **221***a* is connected to a VBUS input line of a USB Type-C cable **30***a* using a function of USB Type-C PD. An output of the step-up/down DCDC converter **221***a* is connected to the switch **24***a* and the USB Type-C controller **23***a*.

The step-up/down DCDC converter **221***a* has a function of converting a voltage supplied from the source device **10***a*, an input voltage Vin supplied from the VBUS input line ranges from 4.75 V to 30 V, and the step-up/down DCDC converter **221***a* can convert the output voltage Vout to 5 V or 20 V and output the converted voltage.

In this way, the step-up DCDC converter **221** is provided between the connector **21***a* and the USB Type-C controller **23***a*. Accordingly, by causing the step-up/down DCDC converter **221***a* to step up or down a voltage even when an output voltage in a range of 21 V to 24 V is supplied from the source device **10***a*, it is possible to curb fluctuation of a voltage such that the voltage VBUS OUT output from the step-up/down DCDC converter **221***a* is one voltage of 5 V and 20 V and to supply the voltage. As a result, since the VBUS supply voltage can be stably supplied at 5 V or 20 V, it is possible to prevent an erroneous operation in controlling a power-supplied device (the sink device **20***a*) of USB Type-C PD.

The step-down DCDC converter **222***a* has a function of converting a voltage supplied from an external device (the source device **10***a*), an input voltage Vin supplied from the VBUS input line ranges from 4.75 V to 30 V, and the step-down DCDC converter **222***a* can convert the input voltage Vin to an output voltage Vout (for example, 5 V) by stepping down the input voltage Vin and output the converted voltage. The step-down DCDC converter **222***a* may convert the input voltage Vin to the output voltage Vout of 5 V by stepping up the input voltage and output the converted voltage when the input voltage Vin is lower than 5 V.

The input of the step-down DCDC converter **222***a* is connected to the VBUS input line between the connector **21***a* and the input terminal of the step-up/down DCDC converter **221***a*. The output of the step-down DCDC converter **222***a* is connected to one terminal of the resistor R**3***a*. Here, since the resistor R**3***a* is connected to the comparator **224***a*, the step-down DCDC converter **222***a* has a function of supplying a reference power for monitoring the voltage supplied from the source device **10***a* to the comparator **224***a* via the resistor R**3***a*.

One terminal of the resistor R**1***a* is connected to the VBUS input line between the connector **21***a* and the input terminal of the step-up/down DCDC converter **221***a*. The other terminal of the resistor R**1***a* is connected to one terminal of the resistor R**2***a*.

One terminal of the resistor R2*a* is connected to the other terminal of the resistor R1*a*. The other terminal of the resistor R2*a* is connected to the ground.

One terminal of the resistor R3*a* is connected to the output of the step-down DCDC converter **222***a*. The other terminal of the resistor R3*a* is connected to a first terminal of the comparator **224***a*.

The first terminal of the comparator **224***a* is connected to the other terminal of the resistor R3*a*. A second terminal of the comparator **224***a* is connected to a connection point between the resistor R1*a* and the resistor R2*a*.

Here, since the resistor R1*a* and the resistor R2*a* are connected in series and one terminal of the resistor R1*a* is connected to the VBUS input line, the resistors serve as a resistor that detects the voltage VBUS IN. Since the second terminal of the comparator **224***a* is connected to the connection point between the resistor R1*a* and the resistor R2*a*, a voltage based on a division ratio of the resistor R1*a* and the resistor R2*a* is input to the comparator **224***a* via the second terminal. Here, resistance values of the resistor R1*a* and the resistor R2*a* are set such that a voltage between the resistor R1*a* and the resistor R2*a* is 5 V when a voltage of 18.5 V is input from the VBUS input line. In this way, the voltage based on the resistive voltage division using the resistor R1*a* and the resistor R2*a* is input to the second terminal of the comparator **224***a*.

The comparator **224***a* compares a voltage input to the second terminal with the output voltage (5 V) of the step-down DCDC converter **222***a* input to the first terminal of the comparator **224***a* via the resistor R3*a*.

When the voltage input via the second terminal is equal to or less than 5 V (the voltage of the VBUS input line is 18.5 V) on the basis of the result of comparison, the comparator **224***a* sets the comparator output to ON and outputs a VBUS Low Voltage signal to the USB Type-C controller **23***a* and the monitor control board **25***a*. The comparator **224***a* can notify that the output voltage of the source device **10***a* has decreased by outputting the VBUS Low Voltage signal.

The USB Type-C controller **23***a* shares some functions with the USB Type-C controller **23**.

When the source device **10***a* is connected via the connector **21***a*, the USB Type-C controller **23***a* detects that the source device **10***a* is connected via the connector **21***a*, conducts negotiation with the source device **10***a*, and requests electric power or a voltage in a range of electric power with which the source device **10***a* and the sink device **20***a* can cope.

The USB Type-C controller **23***a* receives the voltage output from the step-up/down DCDC converter **221***a* and acquires a VBUS signal superimposed on the voltage by performing filtering or the like. The USB Type-C controller **23***a* can conduct negotiation with reference to the VBUS signal.

When negotiation has been established (ended), the USB Type-C controller **23***a* supplies the voltage output from the step-up/down DCDC converter **221***a* to the monitor control board **25***a* by turning on the switch **24***a*.

The USB Type-C controller **23***a* monitors the voltage supplied from the step-up/down DCDC converter **221***a* and stops supply of a voltage to the monitor control board **25***a* by turning off the switch **24***a* when an abnormality has occurred in the supplied voltage.

Here, the USB Type-C controller **23***a* monitors the voltage output from the step-up/down DCDC converter **221***a*, but a fixed voltage (20 V) is output from the step-up/down DCDC converter **221***a* and thus it is possible to decrease the number of times it is determined that the output voltage is equal to or less than a predetermined voltage on the basis of the result of monitoring. Accordingly, even when the voltage supplied from the source device **10***a* fluctuates more or less, a fixed voltage can be continuously supplied to the monitor control board **25***a* and thus it is possible to decrease the number of times the USB Type-C controller **23***a* detects a low voltage and turns off the switch **24**.

The switch **24***a* switches between an on state and an off state on the basis of a signal output from the USB Type-C controller **23***a*. The voltage output from the step-up/down DCDC converter **221***a* is supplied to the control board **25***a* when the switch **24***a* switches to the on state, and the voltage output from the step-up/down DCDC converter **221***a* is not supplied to the control board **25***a* when the switch **24***a* switches to the off state.

The control board **25***a* receives the voltage supplied from the step-up/down DCDC converter **221***a* via the switch **24***a* and performs its operation. When the VBUS Low Voltage signal output from the comparator **224***a* is acquired, the control board **25***a* detects that the voltage output from the source device **10***a* has decreased to equal to or less than a predetermined voltage (18.5 V). Accordingly, necessary control can be performed. For example, when it is detected that the voltage has decreased to equal to or less than the predetermined voltage, the control board **25***a* outputs an alarm signal to a device in a subsequent stage.

The control board **25***a* receives the SUB SIGNL output from the USB Type-C controller **23***a*.

The operation of the sink device **20***a* in the power supply system **1**A will be described below with reference to the flowchart illustrated in FIG. **3**.

When the source device **10***a* is powered on and a voltage of 24 V is output from the source device **10***a* (Step S**101**), the step-up/down DCDC converter **221***a* converts the voltage supplied from the source device **10***a* to 5 V and outputs the converted voltage to the USB Type-C controller **23***a* (Step S**102**). On the other hand, the step-down DCDC converter **222***a* converts the voltage supplied from the source device **10***a* to 5 V and outputs the converted voltage to the first terminal of the comparator **224***a* via the resistor R3*a* (Step S**103**).

When the voltage of 5 V is supplied from the step-up/down DCDC converter **221***a*, the USB Type-C controller **23***a* conducts negotiation with the source device **10***a* (Step S**104**). The USB Type-C controller **23***a* requests supply of a voltage of 20 V by conducting negotiation with the source device **10***a*. Then, the source device **10***a* receives the request and supplies the voltage of 20 V to the sink device **20***a*.

When the negotiation has been ended, the step-up/down DCDC converter **221***a* converts the voltage supplied from the source device **10***a* to 20 V and outputs the converted voltage to the USB Type-C controller **23***a* (Step S**105**). The USB Type-C controller **23***a* turns on the switch **24***a* when the voltage of 20 V is supplied. Accordingly, the voltage of 20 V is supplied to the control board **25***a*. The control board **25***a* controls the constituents of the sink device **20***a*.

On the other hand, the comparator **224***a* starts monitoring the voltage supplied from the VBUS input line (Step S**106**). The comparator **224***a* compares the voltage of 5 V output from the step-down DCDC converter **222***a* with a voltage obtained by dividing the voltage supplied from the VBUS input line (the voltage of VBUS IN) using the resistor R1*a* and the resistor R2*a* and determines whether the voltage of VBUS IN is equal to or less than a reference voltage (18.5 V) (Step S**107**).

When the voltage of VBUS IN is greater than the reference voltage (18.5 V) (Step S**107**: NO), the comparator **224***a*

continues to determine whether the voltage of VBUS IN is equal to or less than the reference voltage (18.5 V).

When the voltage of VBUS IN is equal to or less than the reference voltage (18.5 V) (Step S**107**: YES), the comparator **224***a* turns on the output of the comparator and outputs the VBUS Low Voltage signal to the USB Type-C controller **23***a* and the control board **25***a* (Step S**108**).

When the VBUS Low Voltage signal is input from the comparator **224***a*, the USB Type-C controller **23***a* stops outputting the voltage of 20 V from the step-up/down DCDC converter **221***a* by stopping conversion of electric power in the step-up/down DCDC converter **221***a* (Step S**109**).

The control board **25***a* outputs a VBUS Low Voltage message to a device in a stage (for example, a display device) subsequent to the control board **25***a* in the sink device **20***a* (Step S**110**). Accordingly, it is possible to display the VBUS Low Voltage message.

A third embodiment will be described below.

FIG. **4** is a block diagram schematically illustrating a configuration of a sink device **20***b* according to the third embodiment.

Similarly to the sink device according to the first or second embodiment, the sink device **20***b* is electrically connected to a source device via a USB Type-C cable and can be supplied with electric power from the source device by conducting negotiation with the source device.

The sink device **20***b* includes a stabilization circuit **22***b* and a monitor control board **25***b*.

The stabilization circuit **22***b* includes a DCDC converter **221***b* and a first low voltage detector **222***b*.

The DCDC converter **221***b* steps up or down a voltage VBUS IN supplied from the source device via the USB Type-C cable. For example, the voltage supplied from the source device to the DCDC converter **221***b* via the VBUS input line is an output voltage in a range of 4.75 V to 21 V based on the USB Type-C PD standard.

The output of the DCDC converter **221***b* is connected to the monitor control board **25***b* and one terminal of the resistor R**3***a*. The voltage output from the DCDC converter **221***b* is, for example, an output voltage in a range of 19 V to 21 V based on the USB Type-C PD standard.

The DCDC converter **221***b* converts the output voltage in the range of 4.75 V to 21 V supplied from the source device to an output voltage in the range of 19 V to 21 V and outputs the converted voltage to a subsequent stage (for example, the monitor control board **25***b*).

In this way, the DCDC converter **221***b* can supply a fixed voltage of 20 V as the voltage VBUS OUT output from the DCDC converter **221***b* by converting the voltage even when the voltage VBUS IN is equal to or less than 20 V. Accordingly, since 20 V can be stably supplied as the voltage VBUS, it is possible to prevent an erroneous control operation of a device supplied with electric power (the sink device **20***b*) based on the USB Type-C PD standard.

The first low voltage detector **222***b* determines whether the voltage supplied from the source device is equal to or less than a first voltage reference value and outputs the result of determination to the monitor control board **25***b*. The first voltage reference value is, for example, 20 V.

The first low voltage detector **222***b* includes a resistor Rib, a resistor R**2***b*, a resistor R**3***b*, a resistor R**4***b*, and a comparator **224***b*.

One terminal of the resistor R**1***b* is connected to the VBUS input line. The other terminal of the resistor R**1***b* is connected to one terminal of the resistor R**2***b*.

One terminal of the resistor R**2***b* is connected to the other terminal of the resistor R**1***b*. The other terminal of the resistor R**2***b* is connected to the ground.

One terminal of the resistor R**3***b* is connected to an output of the DCDC converter **221***b*. The other terminal of the resistor R**3***b* is connected to one terminal of the resistor R**4***b*.

One terminal of the resistor R**4***b* is connected to the other terminal of the resistor R**3***b*. The other terminal of the resistor R**4***b* is connected to the ground.

A first terminal of the comparator **224***b* is connected to a connection point between the resistor R**3***b* and the resistor R**4***b*. A second terminal of the comparator **224***b* is connected to a connection point between the resistor R**1***a* and the resistor R**2***a*.

Here, since the resistor R**3***b* and the resistor R**4***b* are connected in series and the first terminal of the comparator **224***b* is connected to the connection point between the resistor R**3***b* and the resistor R**4***b*, a voltage based on a voltage division ratio of the resistor R**3***b* and the resistor R**4***b* is input as a reference voltage from the first terminal. Here, the output voltage of the DCDC converter **221***b* is used as the reference voltage for the DCDC converter **221***b* to stably output the output voltage 20 V.

Resistance values of the resistor R**3***b* and the resistor R**4***b* are set such that a voltage between the resistor R**3***b* and the resistor R**4***b* is 5 V when a voltage of 20 V is input from the output of the DCDC converter **221***b*. In this way, the voltage based on the resistive voltage division using the resistor R**3***b* and the resistor R**4***b* is input to the first terminal of the comparator **224***b*.

Resistance values of the resistor R**1***b* and the resistor R**2***b* are set such that a voltage between the resistor R**1***b* and the resistor R**2***b* is 5 V when a voltage of 19 V is input from the VBUS input line. In this way, the voltage based on the resistive voltage division using the resistor R**1***b* and the resistor R**2***b* is input to the second terminal of the comparator **224***b*.

The comparator **224***b* uses the voltage (5 V) input to the first terminal of the comparator **224***b* as the reference voltage and compares the voltage input to the second terminal of the comparator **224***b* with the reference voltage.

The comparator **224***b* turns on the output of the comparator and outputs a 19 V ON signal to the monitor control board **25***b* when the voltage input via the second terminal is equal to or less than 5 V (the VBUS input line 19 V) on the basis of the result of comparison between the voltage input to the first terminal and the voltage input to the second terminal. The comparator **224***b* can notify the monitor control board **25***b* that the output voltage of the source device has decreased by outputting the 19 V ON signal. When the 19 V ON signal is input, the monitor control board **25***b* outputs alarm information indicating that the output voltage of the source device has decreased using an output device.

The alarm information can be output by the monitor control board **25***b* using any method of notifying a user of the sink device **20***b* of the alarm information. For example, the method of notification may employ a lamp provided in the sink device **20***b* or may employ a liquid crystal panel when the liquid crystal panel is provided in the sink device **20***b*.

FIG. **5** is a diagram illustrating a front appearance of a sink device when the sink device **20***b* is a display device. The sink device **20***b* is, for example, a display device that operates by being supplied with electric power based on the USB Type-C PD standard and does not have a function of

being supplied with electric power from an external device (an AC power supply) other than the source device.

A plurality of lamps or switches are provided on a front surface of the sink device **20***b*. For example, one lamp **27***b* of the plurality of lamps serves as a power supply lamp. A power supply lamp which is provided in a general display device can be used as the lamp **27***b*. The control board **25***b* may use the power supply lamp as the lamp **27***b* or may use another lamp. The lamp **27***b* may be a light emitting diode (LED).

When it is connected to a source device via a USB Type-C cable, the sink device **20***b* transitions to a power save mode and the sink device **20***b* conducts negotiation. When negotiation has been established, the sink device **20***b* turns on the power supply.

Here, when it is detected that a source device has been connected via the USB Type-C cable, the control board **25***b* turns on the lamp **27***b* in a first color (for example, red). Accordingly, it is possible to display a standby mode. Then, negotiation is performed, and the control board **25***b* turns on the lamp **27***b* in a second color (for example, blue) which is a color different from the first color when the negotiation has been established. The control board **25***b* operates a liquid crystal panel **26***b* to display an image signal. On the other hand, when negotiation has not been established or when a 19 V ON signal is input from the stabilization circuit **22***b* (the comparator **224***b*), the control board **25***b* detects that the voltage output from the source device is less than the first reference voltage (for example, 19 V) and causes the lamp **27***b* to flicker in the first color.

In this way, it is possible to notify that the voltage supplied from the source device is less than the first reference voltage using a lamp provided in the sink device **20***b*. Accordingly, a user can understand that an abnormality has occurred in the sourced device instead of the sink device by ascertaining the lighting state of the lamp **27***b* even when the voltage supplied from the source device decreases and the image signal is not displayed on the liquid crystal panel **26***b*.

FIG. **6** is a diagram illustrating an example in which alarm information is output using the liquid crystal panel **26***b* of the sink device **20***b*. When a 19 V ON signal is input from the stabilization circuit **22***b* (the comparators **224***b*) and it is detected that the voltage output from the source device is less than the first reference voltage (for example, 19 V), the sink device **20***b* may display alarm information on the liquid crystal panel **26***b* instead of causing the lamp **27***b* to flicker in the first color. In this case, when the 19 V ON signal is input, the control board **25***b* displays alarm information as a message on an on-screen display (OSD). This message includes, for example, a message indicating that the output voltage of the source device has decreased, a message indicting that charging of the source device is prompted or a message indicting that a residual capacity of a battery of the source device has decreased when the source device is a battery-driven device, or a message indicating that the source device has deteriorated. Accordingly, a user can ascertain whether the source device is being charged or an abnormality has occurred in the source device. Here, since alarm information is displayed on the OSD, it is also possible to continuously display an image signal.

A fourth embodiment will be described below.

FIG. **7** is a block diagram schematically illustrating a configuration of a sink device **20***c* according to the fourth embodiment.

The sink device **20***c* has the functions shared by the sink device **20***b* according to the third embodiment and is different therefrom in that the reference voltage used for determination is a second reference voltage and in an operation after the 19 V ON signal has been input. Differences will be mainly described below.

Similarly to the sink device according to the first or second embodiment, the sink device **20***c* is electrically connected to the source device via the USB Type-C cable and can be supplied with electric power from the source device by conduct negotiation.

The sink device **20***c* includes a stabilization circuit **22***c* and a monitor control board **25***c*.

The stabilization circuit **22***c* includes a DCDC converter **221***c* and a second low voltage detector **223***c*.

The DCDC converter **221***c* steps up or down a voltage VUS IN (for example, any output voltage in the range of 4.75 V to 21 V) supplied from the source device via the USB Type-C cable.

The output of the DCDC converter **221***c* is connected to a monitor control board **25***c* and one terminal of a resistor R**7***a*. The voltage output from the DCDC converter **221***c* is, for example, any output voltage in the range of 19 V to 21 V based on the USB Type-C PD standard.

The DCDC converter **221***c* converts the output voltage in the range of 4.75 V to 21 V supplied from the source device to one output voltage in the range of 19 V to 21 V and outputs the converted voltage to a subsequent stage (for example, the monitor control board **25***c*).

In this way, the DCDC converter **221***c* can supply a fixed voltage of 20 V as the voltage VBUS OUT output from the DCDC converter **221***c* by converting the voltage even when the voltage VBUS IN is equal to or less than 20 V. Accordingly, since the VBUS supply voltage can be stably supplied at 20 V, it is possible to prevent an erroneous operation in controlling a power-supplied device (the sink device **20***b*) of USB Type-C PD.

The second low voltage detector **223***c* determines whether the voltage supplied from the source device is equal to or less than a second voltage reference voltage and outputs the result of determination to the monitor control board **25***c*. The second voltage reference value is, for example, 15 V.

The second low voltage detector **223***c* includes a resistor R**5***c*, a resistor R**6***c*, a resistor R**7***c*, a resistor R**8***c*, and a comparator **224***c*.

One terminal of the resistor R**5***c* is connected to the VBUS input line. The other terminal of the resistor R**5***c* is connected to one terminal of the resistor R**6***c*.

One terminal of the resistor R**6***c* is connected to the other terminal of the resistor R**5***c*. The other terminal of the resistor R**6***c* is connected to the ground.

One terminal of the resistor R**7***c* is connected to the output of the DCDC converter **221***c*. The other terminal of the resistor R**7***c* is connected to one terminal of the resistor R**8***c*.

One terminal of the resistor R**8***c* is connected to the other terminal of the resistor R**7***c*. The other terminal of the resistor R**8***c* is connected to the ground.

A first terminal of the comparator **224***c* is connected to a connection point between the resistor R**7***c* and the resistor R**8***c*. A second terminal of the comparator **224***c* is connected to a connection point between the resistor R**5***c* and the resistor R**6***c*.

Here, since the resistor R**7***c* and the resistor R**8***c* are connected in series and the first terminal of the comparator **224***c* is connected to the connection point between the resistor R**7***c* and the resistor R**8***c*, a voltage based on a voltage division ratio of the resistor R**7***c* and the resistor R**8***c* is input as a reference voltage from the first terminal. Here, the output voltage of the DCDC converter **221***c* is used as

the reference voltage for the DCDC converter **221***b* to stably output the output voltage 20 V.

Resistance values of the resistor R7*c* and the resistor R8*c* are set such that a voltage between the resistor R7*c* and the resistor R8*c* is 5 V when a voltage of 20 V is input from the output of the DCDC converter **221***c*. In this way, the voltage based on the resistive voltage division using the resistor R7*c* and the resistor R8*c* is input to the first terminal of the comparator **224***c*.

Resistance values of the resistor R5*c* and the resistor R6*c* are set such that a voltage between the resistor R5*c* and the resistor R6*c* is 5 V when a voltage of 15 V is input from the VBUS input line. In this way, the voltage based on the resistive voltage division using the resistor R5*c* and the resistor R6*c* is input to the second terminal of the comparator **224***c*.

The comparator **224***c* uses the voltage (5 V) input to the first terminal of the comparator **224***c* as the reference voltage and compares the voltage input to the second terminal of the comparator **224***c* with the reference voltage.

The comparator **224***c* turns on the output of the comparator and outputs a 15 V ON signal to the monitor control board **25***c* when the voltage input via the second terminal is equal to or less than 5 V (the VBUS input line 15 V) on the basis of the result of comparison between the voltage input to the first terminal and the voltage input to the second terminal. The comparator **224***c* can notify the monitor control board **25***c* that the output voltage of the source device has decreased by outputting the 15 V ON signal. When the 15 V ON signal is input, the monitor control board **25***c* outputs alarm information indicating that the output voltage of the source device has decreased using an output device.

The alarm information can be output by the monitor control board **25***c* using any method of notifying a user of the sink device **20***c* of the alarm information. For example, the method of notification may employ a lamp provided in the sink device **20***c* or may employ a liquid crystal panel when the liquid crystal panel is provided in the sink device **20***c*.

FIG. **8** is a diagram illustrating an example in which alarm information is output using the liquid crystal panel **26***c* of the sink device **20***c*. When a 15 V ON signal is input from the stabilization circuit **22***c* (the comparators **224***c*), the sink device **20***c* detects that the voltage output from the source device is less than the second reference voltage (for example, 15 V) and displays alarm information on the liquid crystal panel **26***c*. In this case, when the 15 V ON signal is input, the control board **25***c* displays alarm information as a message on an OSD. This message may include, for example, a message indicating that the output voltage of the source device has decreased and a message indicting that a battery has deteriorated or a message indicating that the source device has deteriorated when the source device is a battery-driven device.

When the 15 V ON signal is output from the comparator **224***c*, there is a likelihood of deterioration, failure, or the like of the source device and there is also a likelihood that an erroneous operation has been performed or an image signal displayed on the liquid crystal panel has not been displayed because electric power supplied to the liquid crystal panel has also decreased. Therefore, the monitor control board **25***c* displays a message based on the OSD for a predetermined time (for example, 1 minute) and then stops supply of electric power to the liquid crystal panel. In this way, by notifying that an image signal is not displayed using a message or the like in advance, a user can understand that there is a likelihood that an abnormality has not occurred in the sink device **20***c* but an abnormality has occurred in the source device.

In the fourth embodiment, since the DCDC converter **221***c* is provided, it is possible to stably supply electric power of 20 V to the liquid crystal panel. Accordingly, for example, even when a display device with power specifications in which necessary electric power is defined as 45 W or greater is applied as the sink device **20***c*, it is possible to prevent an image signal displayed on a screen from disappearing suddenly or to prevent the sink device from operating erroneously.

A sink device **20***d* according to a fifth embodiment will be described below.

FIG. **9** is a block diagram schematically illustrating a configuration of a sink device **20***d* according to the fifth embodiment. The sink device **20***d* can notify of a decrease in voltage of VBUS and an abnormal voltage by adding an LED or the like even when the sink device **20***d* is not a display device such as a monitor.

The sink device **20***d* includes a connector **21***d*, a voltage detecting circuit **224***d*, a USB Type-C controller **23***d*, a switch **241***d*, a switch **242***d*, a control circuit **25***d*, a display panel **26***d*, an alarm display LED lamp **27***d*, an LED control circuit **28***d*, and an LED lamp **29***d*.

The connector **21***d* can be connected to an external device which is a source device via a USB Type-C cable.

The voltage detecting circuit **224***d* detects a voltage supplied to the VBUS input line connected to the connector **21***d* and determines whether the detected voltage is equal to or greater than a third reference voltage. The voltage detecting circuit **224***d* turns off the switch **242***d* when the detected voltage is equal to or greater than the third reference voltage, and turns on the switch **242***d* to supply a VBUS STANDBY signal to the control circuit **25***d* when the detected voltage is less than the third reference voltage. As the third reference voltage, a lower-limit voltage (standard value) at the time of supply of 20 V in the USB Type-C PD standard can be used, for example, 18.5 V can be used.

The USB Type-C controller **23***d* conducts negotiation when it is detected that the source device is connected to the connector **21***d*, turns on the switch **241***d* when negotiation is established and a voltage requested through the negotiation is supplied to the VBUS input line, and turns off the switch **241***d* when a voltage lower than the voltage requested through the negotiation is supplied to the VBUS input line.

A signal indicating the result of negotiation is output to the USB Type-C controller **23***d*.

The switch **241***d* switches between an on state and an off state on the basis of a signal from the USB Type-C controller **23***d*.

The switch **242***d* switches between an on state and an off state on the basis of the result of determination from the voltage detecting circuit **224***d*.

The control circuit **25***d* acquires a signal indicating the result of negotiation supplied from the USB Type-C controller **23***d* and operates by receiving a voltage supplied from the VBUS input line. When the VBUS STANDBY signal is input, the control circuit **25***d* transitions to a standby state and turns on or flickers the alarm display LED lamp **27***d*.

The control circuit **25***d* receives an image signal VS supplied from an external device and displays the image signal VS on the display panel **26***d*.

The control circuit **25***d* outputs a state signal indicating whether it is in a standby state or an active state to the LED control circuit **28***d*.

The display panel **26***d* is, for example, a liquid crystal panel and displays an image signal.

The alarm display LED lamp **27***d* includes one or more LED lamps and operates in accordance with an operation signal from the control circuit **25***d*.

The LED control circuit **28***d* turns on or off the LED lamp **29***d* in a mode corresponding to a state signal output from the control circuit **25***d*.

The LED lamp **29***d* is turned on or off according to an operation signal output from the LED control circuit **28***d*. The LED lamp **29***d* may be turned on in a color corresponding to the operation signal or may flicker.

With this configuration, the USB Type-C controller **23***d* conducts negotiation with a source device when it is detected that the source device is connected to the connector **21***d*. Then, the USB Type-C controller **23***d* turns on the switch **241***d* when the negotiation has been established. Accordingly, a voltage from the source device is supplied to the control circuit **25***d*, and the control circuit **25***d* operates. When its operation is started, the control circuit **25***d* transitions to the active state and displays the image signal VS on the display panel **26***d*. The control circuit **25***d* outputs a state signal indicating the active state to the LED control circuit **28***d*. Since the input state signal indicates the active state, the LED control circuit **28***d* turns on the LED lamp **29***d* in a color corresponding to the active state. Accordingly, a user can see an image signal displayed on the display panel **26***d* and understand that the sink device **20***d* is in the active state by ascertaining the turn-on state of the LED lamp **29***d*. In the active state, the control circuit **25***d* may notify that electric power is normally supplied from the source device by turning off the alarm display LED lamp **27***d* or turn on the alarm display LED lamp **27***d* in a color indicating that electric power is normally supplied.

Then, the USB Type-C controller **23***d* monitors whether the voltage supplied to the VBUS input line is equal to or greater than a predetermined voltage, continues to display an image signal when the voltage is equal to or greater than the predetermined voltage, and turns off the switch **241***d* when the voltage is less than the predetermined voltage. When the switch **241***d* is turned off, supply of a voltage from the VBUS input line to the control circuit **25***d* is stopped. When supply of electric power from the VBUS input line is stopped, the control circuit **25***d* stops displaying an image signal using the alarm display LED lamp **27***d*.

On the other hand, the voltage detecting circuit **224***d* detects a voltage supplied to the VBUS input line and determines whether the detected voltage is equal to or greater than the third reference voltage. The voltage detecting circuit **224***d* turns off the switch **242***d* when the detected voltage is equal to or greater than the third reference voltage, and turns on the switch **242***d* when the detected voltage is less than the third reference voltage. When the switch **242***d* is turned on, a STANDBY signal is supplied to the control circuit **25***d*.

Here, since supply of electric power from the VBUS input line is stopped, the control circuit **25***d* cannot drive the function of displaying an image signal, but can receive electric power capable of operating the alarm display LED lamp **27***d* or outputting a state signal to the LED control circuit **28***d* from the USB Type-C controller **23***d*. Accordingly, when the STANDVY signal is input, the control circuit **25***d* transitions to the standby state using the electric power acquired from the USB Type-C controller **23***d*. The control circuit **25***d* turns on the alarm display LED lamp **27***d* in a color indicating that an abnormality has occurred in the source device and outputs a state signal indicating the standby state to the LED control circuit **28***d*. Since the input state signal indicates the standby state, the LED control circuit **28***d* turns on the LED lamp **29***d* in a color corresponding to the standby state. Accordingly, even when displaying an image signal on the display panel **26***d* is stopped, a user can understand that the sink device **20***d* transitions to the standby state by ascertaining the turn-on state of the alarm display LED lamp **27***d* or the turn-on state of the LED lamp **29***d*. As a result, the user can understand that there is a likelihood that an abnormality has not occurred in the sink device **20***d* but an abnormality has occurred in the source device.

A sink device **50** according to a sixth embodiment will be described below.

FIG. **10** is a block diagram schematically illustrating a configuration of the sink device **50** according to the sixth embodiment.

The sink device **50** is an electronic apparatus that operates using electric power supplied from a source device.

The sink device **50** includes a reference voltage generator **51**, a determiner **52**, and an output **53**.

The reference voltage generator **51** is supplied with a first voltage from an external device and generates a reference voltage which is a voltage lower than a second voltage higher than a first voltage supplied from the external device on the basis of the second voltage when negotiation with the external device has been conducted.

The function of generating the second voltage from the first voltage may be provided in the sink device **50** or may be connected to the outside of the sink device **50**.

The determiner **52** determines a magnitude relationship between the second voltage and the reference voltage.

The output **53** notifies that the voltage has decreased when the second voltage is equal to or less than the reference voltage on the basis of the result of determination.

According to this embodiment, since it is notified that the voltage has decreased, it is possible to understand that there is a likelihood that an abnormality has not occurred in the sink device **50** but an abnormality has occurred in the source device.

In the aforementioned embodiments, the sink device may not be a display device as long as it is an electronic apparatus. For example, the electronic apparatus may be a projector.

Operation management may be performed by recording a program for realizing the functions of the processing units illustrated in FIG. **1** on a computer-readable recording medium and causing a computer system to read and execute the program recorded on the recording medium. The "computer system" mentioned herein may include an operating system (OS) or hardware such as peripherals.

The "computer system" includes an home page provision environment (or display environment) as long as it uses the WWW system.

The "computer-readable recording medium" may be a portable medium such as a flexible disk, a magneto-optical disc, a ROM, or a CD-ROM or a storage unit such as a hard disk incorporated in a computer system. The "computer-readable recording medium" may include a medium that holds a program for a predetermined time such as a volatile memory in a computer system serving as a server or a client. The program may be a program for realizing some of the aforementioned functions or may be a program which can realize the aforementioned functions in combination with another program stored in advance in the computer system. The program may be stored in a predetermined server, and

the program may be delivered (downloaded or the like) via a communication line in response to a request from another device.

While embodiments of the present invention have been described above in detail with reference to the drawings, the specific configuration is not limited to the embodiments, and includes designs or the like without departing from the gist of the present invention.

REFERENCE SIGNS LIST

1, **1**A . . . Power supply system
10, **10***a* . . . Source device
11, **21**, **21***a*, **21***d* . . . Connector
20, **20***a*, **20***b*, **20***c*, **20***d*, **20***e* . . . Sink device
22, **22***a*, **22***b*, **22***c* . . . Stabilizer circuit
23, **23***a*, **23***d* . . . USB Type-C controller
24, **24***a* . . . Switch
25*d* . . . Control circuit
25, **25***a*, **25***b*, **25***c*, **25***d* . . . Control circuit
26, **26***b*, **26***c*, **26***d* . . . Display panel
27*b* . . . Lamp
27*d* . . . Alarm display LED lamp
28*d* . . . LED control circuit
29*d* . . . LED lamp
30, **30***a* . . . USB Type-C cable
50 . . . Sink device
51 . . . Reference voltage generator
52 . . . Determiner
53 . . . Output
221 . . . Step-up DCDC converter
221*a* . . . Step-up/down DCDC converter
221*b*, **221***c* . . . DCDC converter
222 . . . First low voltage detector
222*a* . . . Step-down DCDC converter
222*b* . . . First low voltage detector
223 . . . Second low voltage detector
223*c* . . . Second low voltage detector
224 . . . Voltage detecting circuit
224*a*, **224***b*, **224***c* . . . Comparator
224*d* . . . Voltage detecting circuit
241*d* . . . Switch
242*d* . . . Switch

The invention claimed is:

1. An electronic apparatus comprising:
a reference voltage generator configured to
perform, with an external device, a negotiation for requesting a second voltage which is higher than a first voltage when the electronic apparatus receives the first voltage from the external device, and
generate a reference voltage which is lower than the second voltage on a basis of the second voltage;
a determiner configured to determine a magnitude relationship between the second voltage and the reference voltage; and
an output configured to notify that the second voltage is decreasing when the second voltage is equal to or lower than the reference voltage on a basis of a result of determination.

2. The electronic apparatus according to claim **1**,
wherein the reference voltage generator comprises:
a first reference voltage generator configured to generate a first reference voltage lower than a voltage determined through the negotiation; and
a second reference voltage generator configured to generate a second reference voltage lower than the first reference voltage,
wherein the determiner comprises:
a first determiner configured to determine a magnitude relationship between the second voltage and the first reference voltage; and
a second determiner configured to determine a magnitude relationship between the second voltage and the second reference voltage, and
wherein the output comprises:
a first output configured to output a result indicating that the second voltage is equal to or lower than the first reference voltage on a basis of a result of determination from the first determiner; and
a second output configured to output a result indicating that the second voltage is equal to or lower than the second reference voltage on a basis of a result of determination from the first determiner.

3. The electronic apparatus according to claim **2**,
wherein the second output is configured to output a message indicating that a residual capacity of a battery provided in the external device decreases.

4. The electronic apparatus according to claim **2**, the electronic apparatus further comprising:
a power supply managing unit configured to cut off supply of electric power to a monitor provided in the electronic apparatus on a basis of an output of the second output.

5. The electronic apparatus according to claim **1**,
wherein the reference voltage generator comprises:
a first DCDC converter configured to generate a reference voltage by stepping down the second voltage supplied from the external device.

6. The electronic apparatus according to claim **1**, the electronic apparatus further comprising:
a second DCDC converter configured to generate a third voltage which is requested from the external device through the negotiation from a voltage supplied from the external device,
wherein the reference voltage generator generates the reference voltage from the voltage output from second DCDC converter.

7. The electronic apparatus according to claim **1**,
wherein the output employs one of a lamp and a display panel.

8. A display device comprising:
a reference voltage generator configured to
perform, with an external device, a negotiation for requesting a second voltage which is higher than a first voltage when the electronic apparatus receives the first voltage from the external device, and
generate a reference voltage which is lower than the second voltage on a basis of the second voltage;
a determiner configured to determine a magnitude relationship between the second voltage and the reference voltage; and
an output configured to notify that the second voltage is decreasing when the second voltage is equal to or lower than the reference voltage on a basis of a result of determination.

9. A voltage management method comprising:
performing, with an external device, a negotiation for requesting a second voltage which is higher than a first voltage when the electronic apparatus receives the first voltage from the external device;
generating a reference voltage which is lower than the second voltage on a basis of the second voltage;
determining a magnitude relationship between the second voltage and the reference voltage; and

notifying that the second voltage is decreasing when the second voltage is equal to or lower than the reference voltage on a basis of a result of determination.

* * * * *