US 20150311729A1

(19) **United States**

(12) **Patent Application Publication**

Ono et al.

(10) **Pub. No.: US 2015/0311729 A1**

(43) **Pub. Date: Oct. 29, 2015**

(54) **CHARGING DEVICE**

(71) Applicant: **Renesas Electronics Corporation**, Kawasaki-shi (JP)

(72) Inventors: **Yoshiharu Ono**, Kanagawa (JP); **Tsutomu Tanaka**, Kanagawa (JP); **Mamoru Mochizuki**, Tokyo (JP); **Takashi Makita**, Kanagawa (JP)

(21) Appl. No.: **14/792,725**

(22) Filed: **Jul. 7, 2015**

Related U.S. Application Data

(63) Continuation of application No. 13/771,322, filed on Feb. 20, 2013.

(30) **Foreign Application Priority Data**

Mar. 19, 2012 (JP) 2012-062212

Publication Classification

(51) **Int. Cl.**

H02J 7/00 (2006.01)

G01R 31/36 (2006.01)

(52) **U.S. Cl.**

CPC ***H02J 7/007*** (2013.01); ***H02J 7/0052*** (2013.01); ***G01R 31/3627*** (2013.01); *H02J 2007/0062* (2013.01); *H02J 2007/0098* (2013.01)

(57) **ABSTRACT**

There is provided a charging device which can rapidly charge, with a single charger, portable devices of a plurality of charging specifications.

A plurality of available power indicating circuits included in a USB module **10** notify, through a data line, a portable device coupled to the charging device of a signal indicating suppliable amount of current. A CPU **4** obtains, from a portable device coupled thereto, information identifying the portable device, at the time of adjustment. A memory **6** has a table stored therein, for a plurality of portable devices, defining a correspondence between information identifying a portable device and an available power indicating circuit. Referring to the table based on the obtained information, the CPU **4** selects an available power indicating circuit and, at the time of actual operation, activates only the selected available power indicating circuit.

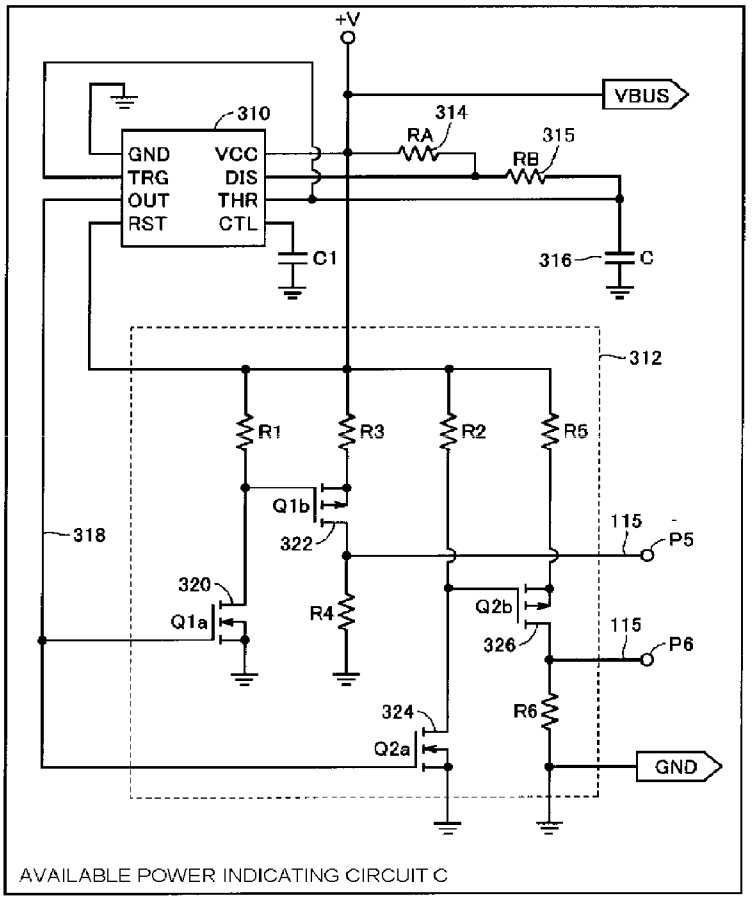


FIG. 1

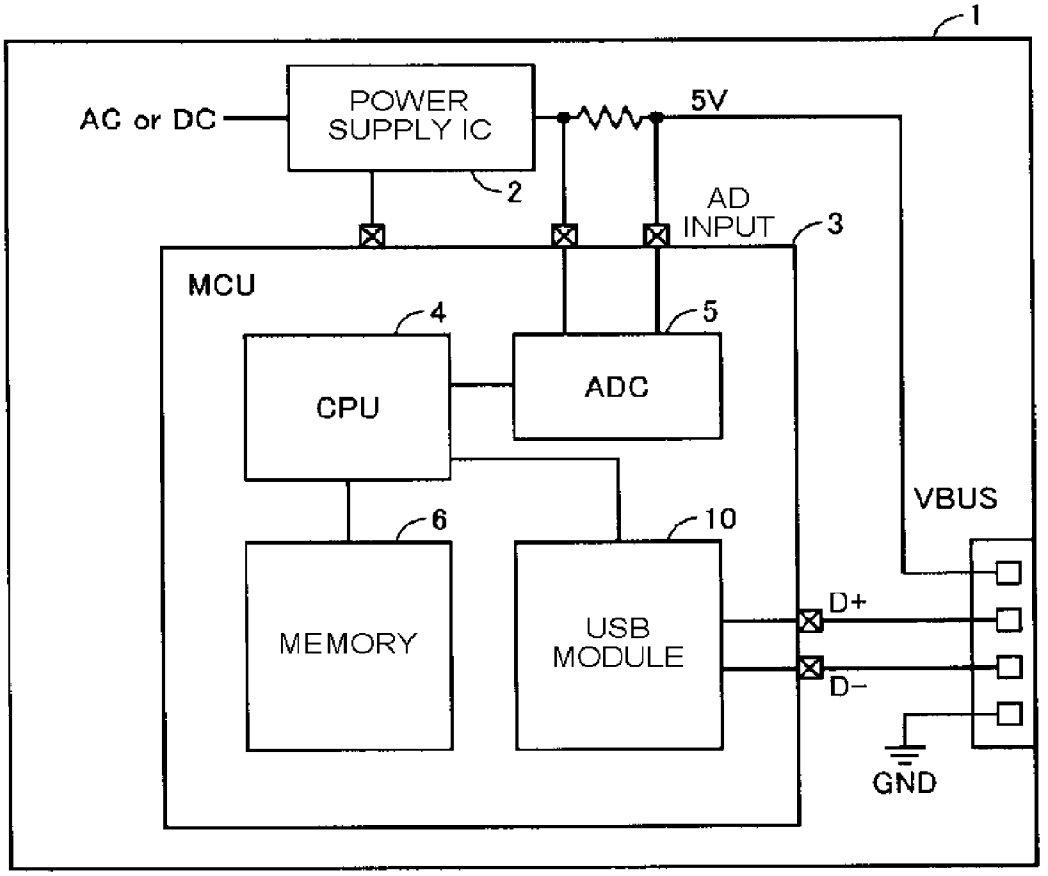

1
AC or DC
POWER SUPPLY IC
2
5V
AD INPUT
3
MCU
4
5
CPU
ADC
VBUS
6
10
MEMORY
USB MODULE
D+
D−
GND

FIG. 2

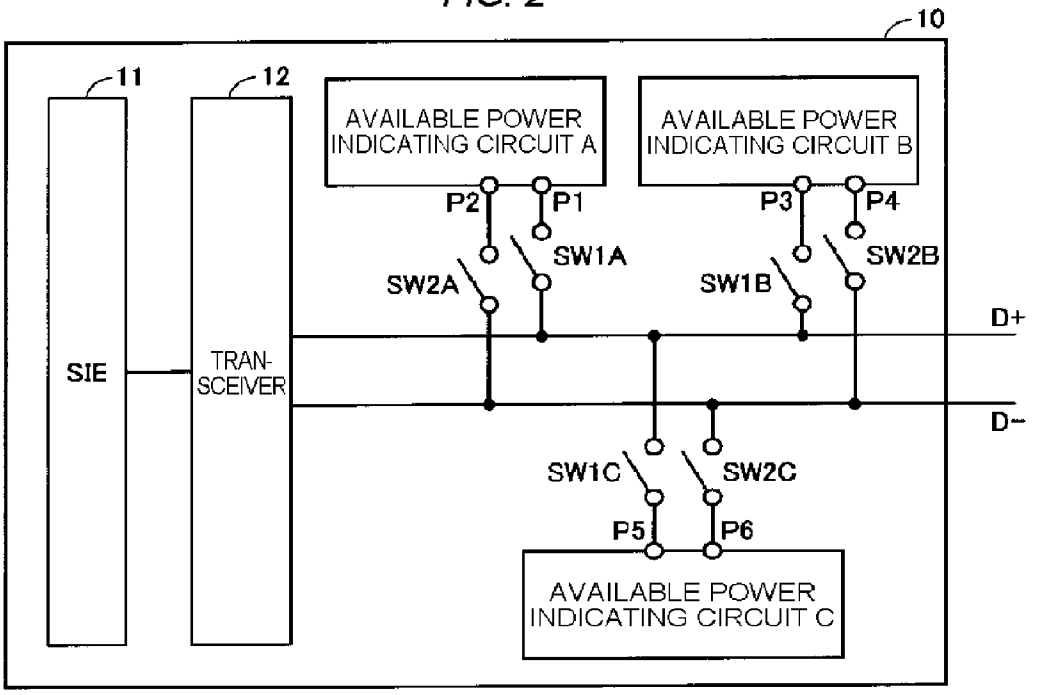

10
11
12
SIE
TRAN-
SCEIVER
AVAILABLE POWER
INDICATING CIRCUIT A
AVAILABLE POWER
INDICATING CIRCUIT B
AVAILABLE POWER
INDICATING CIRCUIT C
P1
P2
P3
P4
P5
P6
SW1A
SW2A
SW1B
SW2B
SW1C
SW2C
D+
D-

FIG. 3

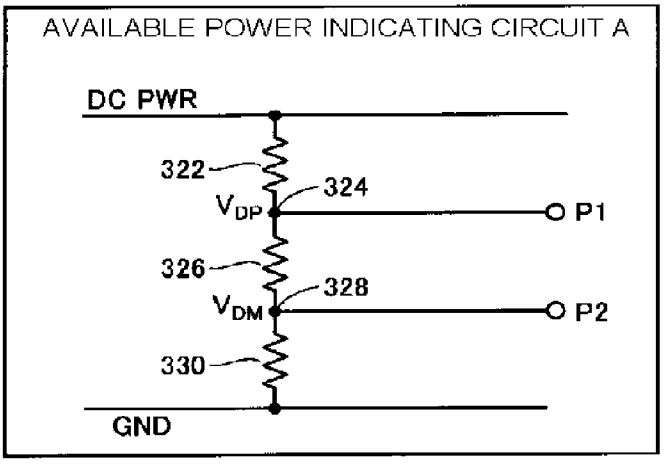

AVAILABLE POWER INDICATING CIRCUIT A
DC PWR
322
324
V_{DP}
P1
326
328
V_{DM}
P2
330
GND

FIG. 4

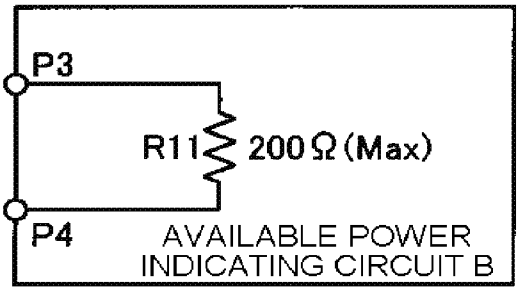
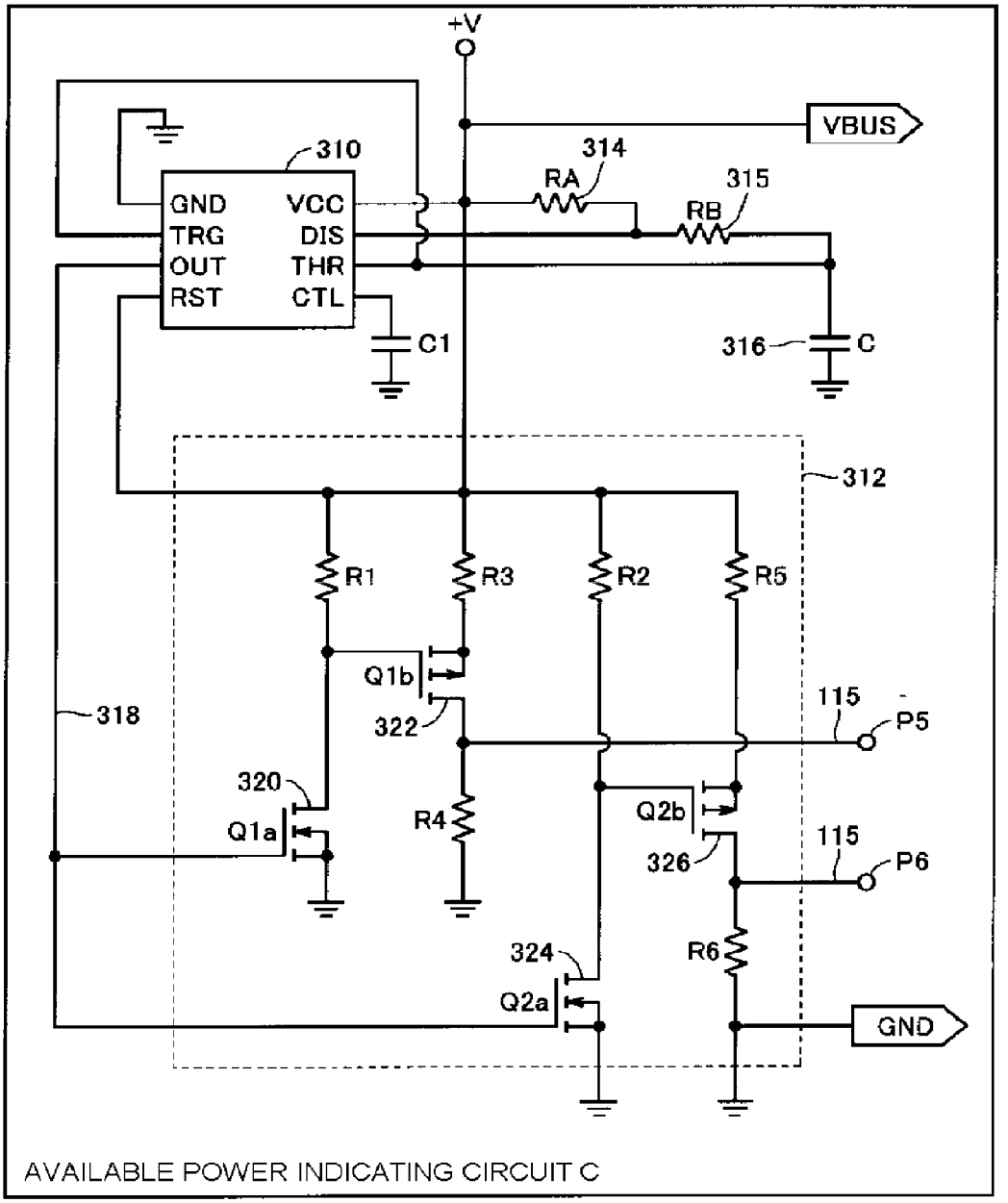


FIG. 5



AVAILABLE POWER INDICATING CIRCUIT C

FIG. 6A

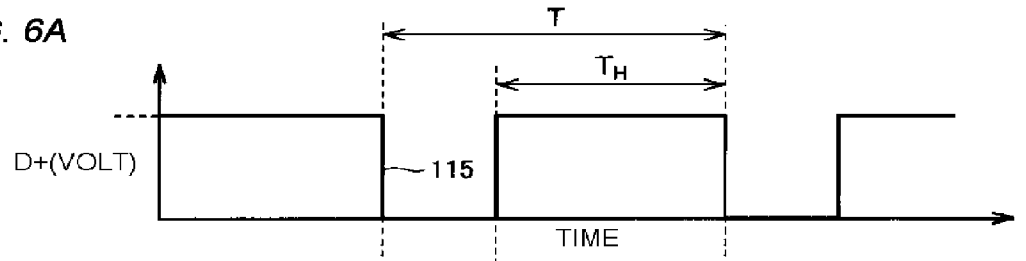


FIG. 6B

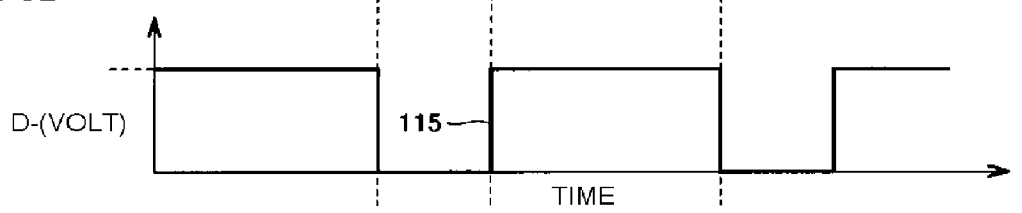


FIG. 7

V_ID	P_ID	AVAILABLE POWER INDICATING CIRCUIT	LIMIT VALUE OF CURRENT SUPPLY AMOUNT
0x****	0x****	A	1.0A
0x****	0x****	B	1.5A
·	·	·	·

FIG. 8

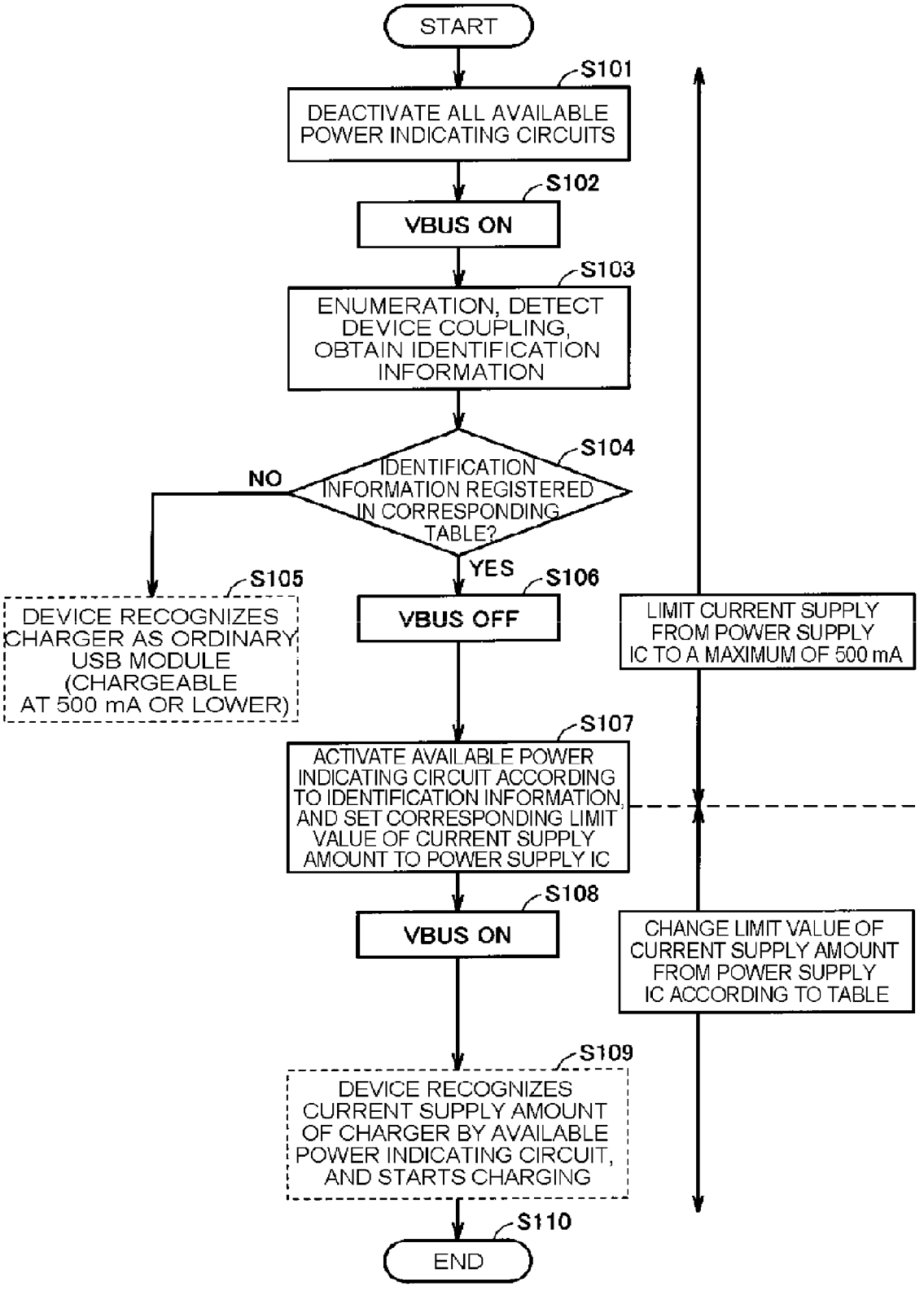

START
S101
DEACTIVATE ALL AVAILABLE POWER INDICATING CIRCUITS
S102
VBUS ON
S103
ENUMERATION, DETECT DEVICE COUPLING, OBTAIN IDENTIFICATION INFORMATION
S104
IDENTIFICATION INFORMATION REGISTERED IN CORRESPONDING TABLE?
NO
YES
S105
DEVICE RECOGNIZES CHARGER AS ORDINARY USB MODULE (CHARGEABLE AT 500 mA OR LOWER)
S106
VBUS OFF
LIMIT CURRENT SUPPLY FROM POWER SUPPLY IC TO A MAXIMUM OF 500 mA
S107
ACTIVATE AVAILABLE POWER INDICATING CIRCUIT ACCORDING TO IDENTIFICATION INFORMATION, AND SET CORRESPONDING LIMIT VALUE OF CURRENT SUPPLY AMOUNT TO POWER SUPPLY IC
S108
VBUS ON
CHANGE LIMIT VALUE OF CURRENT SUPPLY AMOUNT FROM POWER SUPPLY IC ACCORDING TO TABLE
S109
DEVICE RECOGNIZES CURRENT SUPPLY AMOUNT OF CHARGER BY AVAILABLE POWER INDICATING CIRCUIT, AND STARTS CHARGING
S110
END

FIG. 9

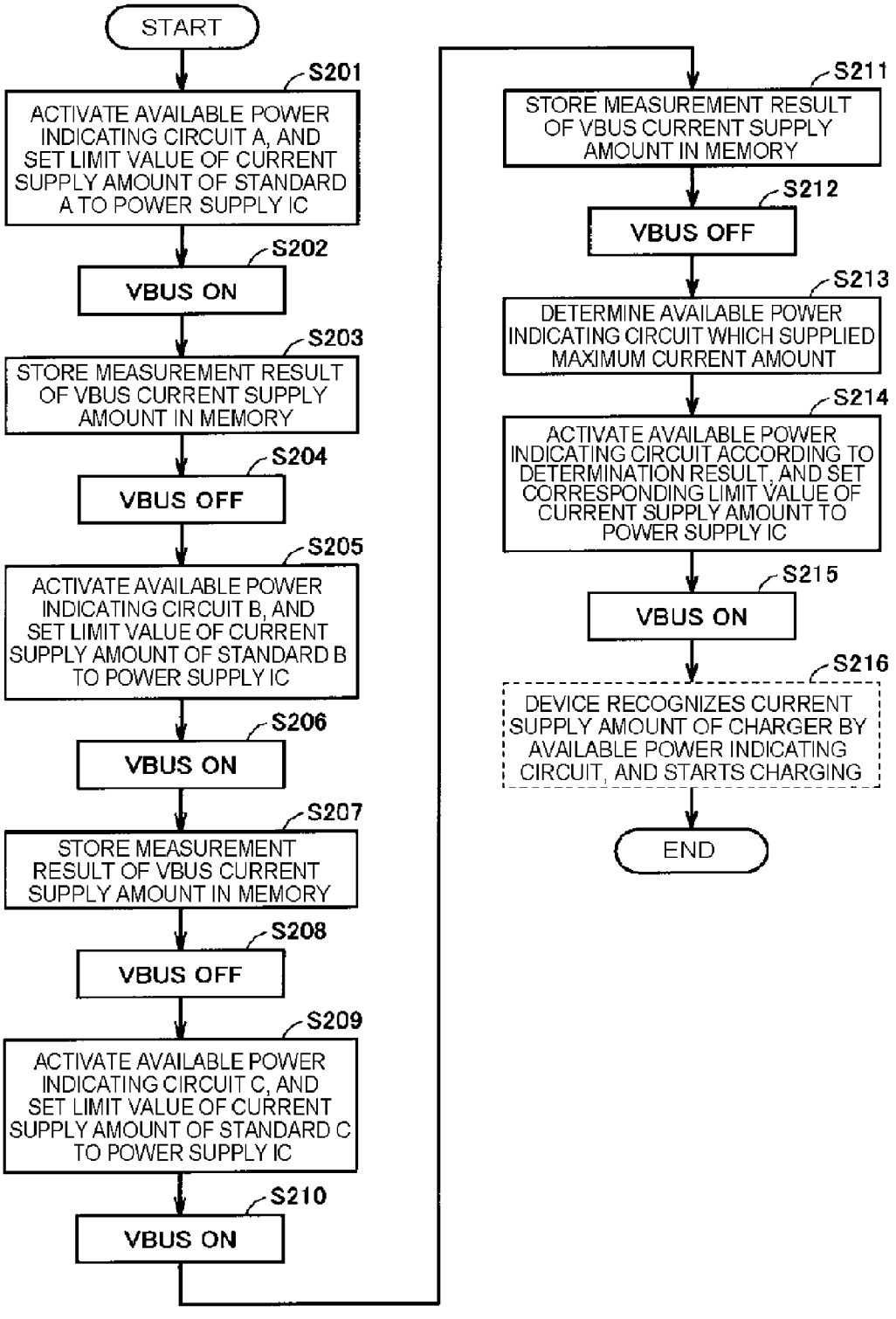

START
S201
ACTIVATE AVAILABLE POWER INDICATING CIRCUIT A, AND SET LIMIT VALUE OF CURRENT SUPPLY AMOUNT OF STANDARD A TO POWER SUPPLY IC
S202
VBUS ON
S203
STORE MEASUREMENT RESULT OF VBUS CURRENT SUPPLY AMOUNT IN MEMORY
S204
VBUS OFF
S205
ACTIVATE AVAILABLE POWER INDICATING CIRCUIT B, AND SET LIMIT VALUE OF CURRENT SUPPLY AMOUNT OF STANDARD B TO POWER SUPPLY IC
S206
VBUS ON
S207
STORE MEASUREMENT RESULT OF VBUS CURRENT SUPPLY AMOUNT IN MEMORY
S208
VBUS OFF
S209
ACTIVATE AVAILABLE POWER INDICATING CIRCUIT C, AND SET LIMIT VALUE OF CURRENT SUPPLY AMOUNT OF STANDARD C TO POWER SUPPLY IC
S210
VBUS ON
S211
STORE MEASUREMENT RESULT OF VBUS CURRENT SUPPLY AMOUNT IN MEMORY
S212
VBUS OFF
S213
DETERMINE AVAILABLE POWER INDICATING CIRCUIT WHICH SUPPLIED MAXIMUM CURRENT AMOUNT
S214
ACTIVATE AVAILABLE POWER INDICATING CIRCUIT ACCORDING TO DETERMINATION RESULT, AND SET CORRESPONDING LIMIT VALUE OF CURRENT SUPPLY AMOUNT TO POWER SUPPLY IC
S215
VBUS ON
S216
DEVICE RECOGNIZES CURRENT SUPPLY AMOUNT OF CHARGER BY AVAILABLE POWER INDICATING CIRCUIT, AND STARTS CHARGING
END

FIG. 10

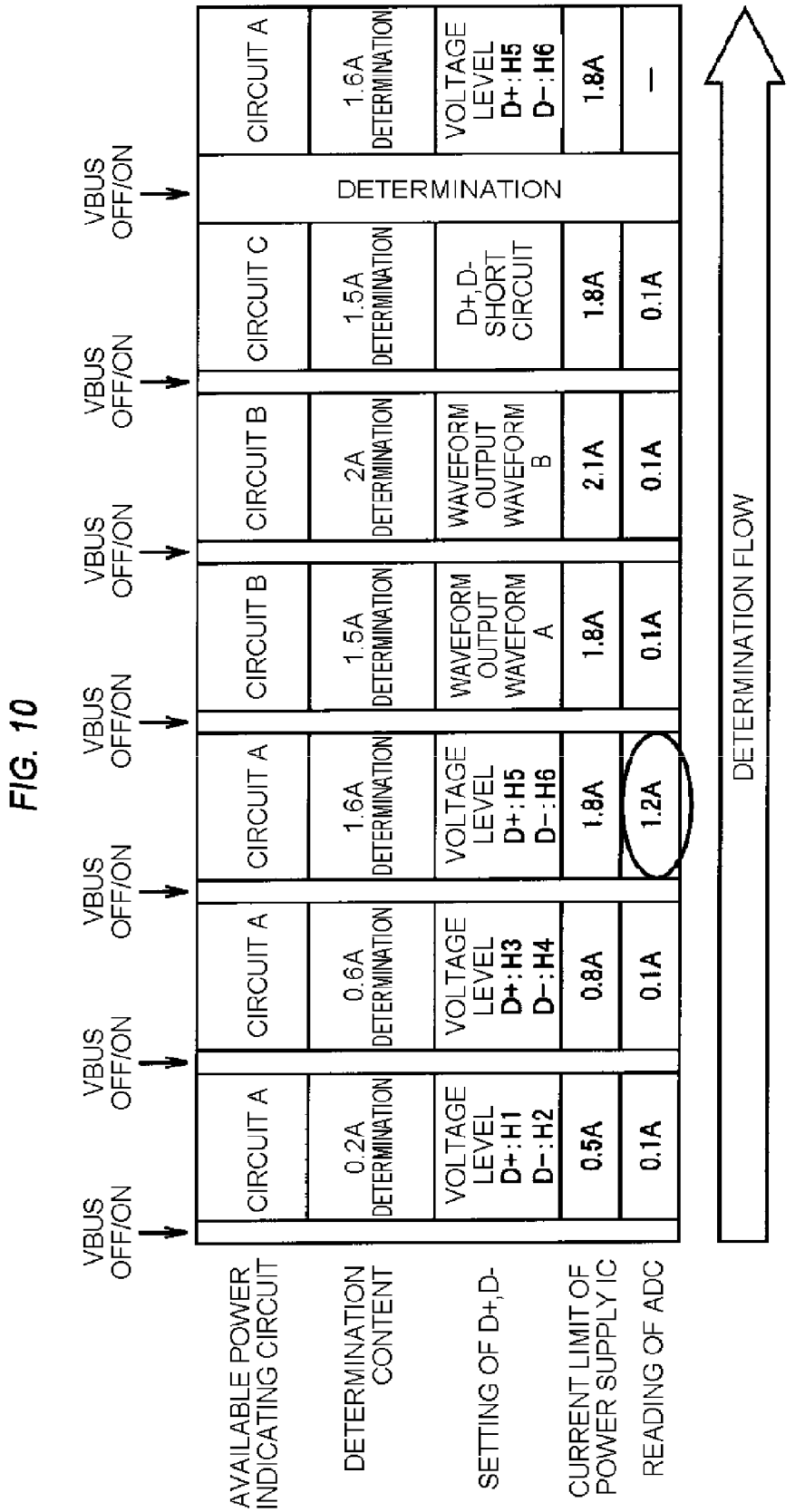
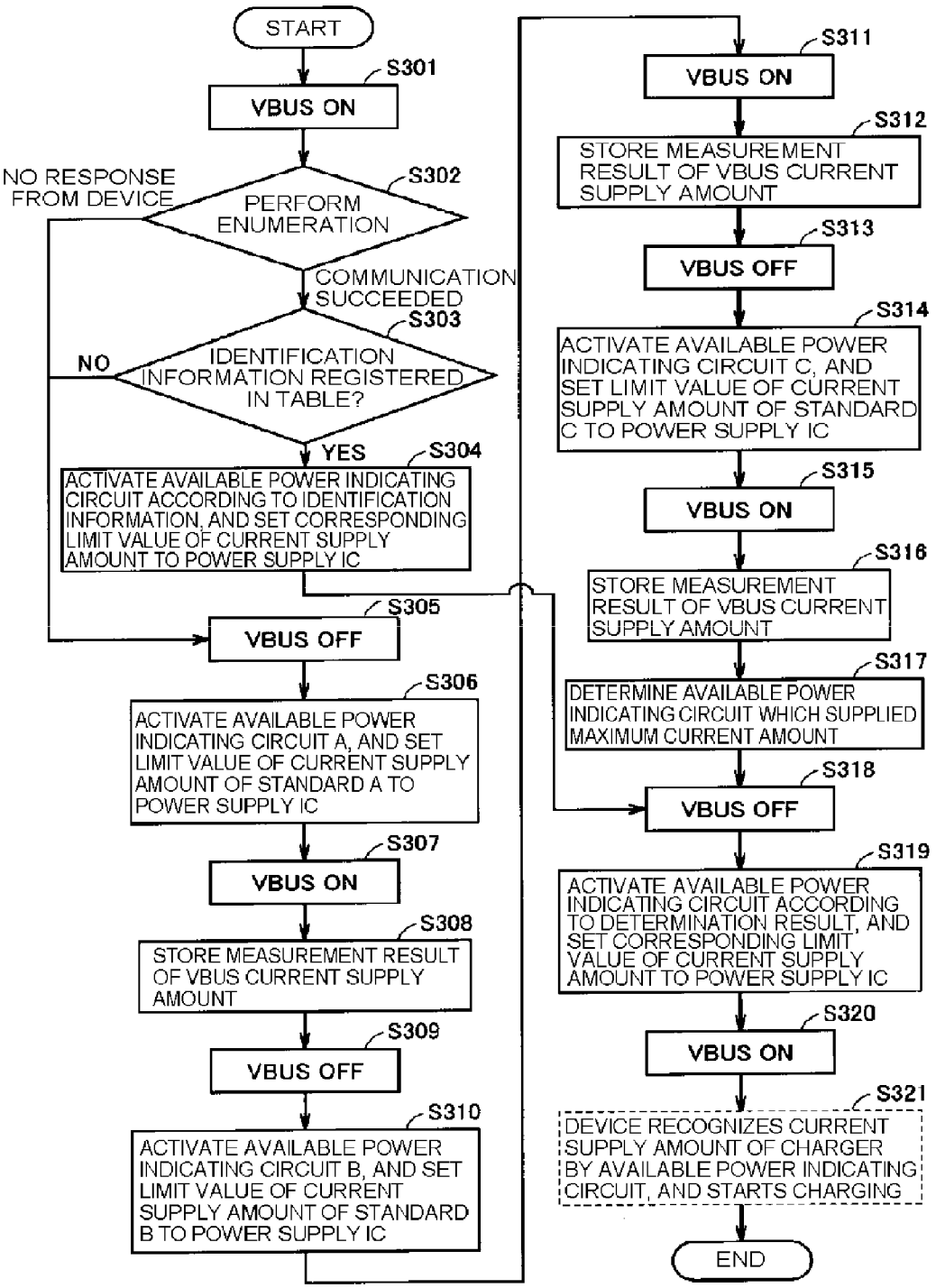

VBUS OFF/ON
CIRCUIT A
0.2A DETERMINATION
VOLTAGE LEVEL D+:H1 D−:H2
0.5A
0.1A
VBUS OFF/ON
CIRCUIT A
0.6A DETERMINATION
VOLTAGE LEVEL D+:H3 D−:H4
0.8A
0.1A
VBUS OFF/ON
CIRCUIT A
1.6A DETERMINATION
VOLTAGE LEVEL D+:H5 D−:H6
1.8A
1.2A
VBUS OFF/ON
CIRCUIT B
1.5A DETERMINATION
WAVEFORM OUTPUT WAVEFORM A
1.8A
0.1A
VBUS OFF/ON
CIRCUIT B
2A DETERMINATION
WAVEFORM OUTPUT WAVEFORM B
2.1A
0.1A
VBUS OFF/ON
CIRCUIT C
1.5A DETERMINATION
D+,D- SHORT CIRCUIT
1.8A
0.1A
DETERMINATION
CIRCUIT A
1.6A DETERMINATION
VOLTAGE LEVEL D+:H5 D−:H6
1.8A
—
AVAILABLE POWER INDICATING CIRCUIT
DETERMINATION CONTENT
SETTING OF D+,D-
CURRENT LIMIT OF POWER SUPPLY IC
READING OF ADC
DETERMINATION FLOW

FIG. 11


START
S301
VBUS ON
S302
NO RESPONSE FROM DEVICE
PERFORM ENUMERATION
COMMUNICATION SUCCEEDED
S303
NO
IDENTIFICATION INFORMATION REGISTERED IN TABLE?
YES
S304
ACTIVATE AVAILABLE POWER INDICATING CIRCUIT ACCORDING TO IDENTIFICATION INFORMATION, AND SET CORRESPONDING LIMIT VALUE OF CURRENT SUPPLY AMOUNT TO POWER SUPPLY IC
S305
VBUS OFF
S306
ACTIVATE AVAILABLE POWER INDICATING CIRCUIT A, AND SET LIMIT VALUE OF CURRENT SUPPLY AMOUNT OF STANDARD A TO POWER SUPPLY IC
S307
VBUS ON
S308
STORE MEASUREMENT RESULT OF VBUS CURRENT SUPPLY AMOUNT
S309
VBUS OFF
S310
ACTIVATE AVAILABLE POWER INDICATING CIRCUIT B, AND SET LIMIT VALUE OF CURRENT SUPPLY AMOUNT OF STANDARD B TO POWER SUPPLY IC
S311
VBUS ON
S312
STORE MEASUREMENT RESULT OF VBUS CURRENT SUPPLY AMOUNT
S313
VBUS OFF
S314
ACTIVATE AVAILABLE POWER INDICATING CIRCUIT C, AND SET LIMIT VALUE OF CURRENT SUPPLY AMOUNT OF STANDARD C TO POWER SUPPLY IC
S315
VBUS ON
S316
STORE MEASUREMENT RESULT OF VBUS CURRENT SUPPLY AMOUNT
S317
DETERMINE AVAILABLE POWER INDICATING CIRCUIT WHICH SUPPLIED MAXIMUM CURRENT AMOUNT
S318
VBUS OFF
S319
ACTIVATE AVAILABLE POWER INDICATING CIRCUIT ACCORDING TO DETERMINATION RESULT, AND SET CORRESPONDING LIMIT VALUE OF CURRENT SUPPLY AMOUNT TO POWER SUPPLY IC
S320
VBUS ON
S321
DEVICE RECOGNIZES CURRENT SUPPLY AMOUNT OF CHARGER BY AVAILABLE POWER INDICATING CIRCUIT, AND STARTS CHARGING
END

CHARGING DEVICE

CROSS-REFERENCE TO RELATED APPLICATION

[0001] The disclosure of Japanese Patent Application No. 2012-062212 filed on Mar. 19, 2012 including the specification, drawings and abstract is incorporated herein by reference in its entirety.

BACKGROUND

[0002] The present invention relates to a charging device, for example, a charging device which charges a portable device via a universal serial bus.

[0003] In recent years, charging of portable devices via a USB has been becoming common. With USB2.0, the maximum current that can be taken out from a port is defined as 500 mA, and there is a problem in which it takes a while to charge a high-capacity secondary battery.

[0004] To address such problems, there is proposed a mechanism which can determine the power supply ability of the USB charger (host) side and obtain a current exceeding 500 mA from a charger having sufficient power supply ability (Japanese Patent No. 4695220 (Patent Document 1), Japanese Patent No. 4664362 (Patent Document 2), U.S. Pat. No. 7,581,119 B2 (Patent Document 3), Japanese Patent No. 3811704 (Patent Document 4), U.S. Pat. No. 7,170,259 B2 (Patent Document 5), Japanese Patent Laid-Open No 2005-6497 (Patent Document 6), and Battery Charging v1.2 Specification, Internet <URL: http://www.usb.org/developers/devclass_docs> (Non-Patent Document 1), for example).

SUMMARY

[0005] However, there exist currently various standards, and thus rapid charging of many portable devices becomes possible only by dedicated chargers.

[0006] The other problems and new feature will become clear from the descriptions in the specification and accompanying drawings.

[0007] A charging device according to an embodiment includes a plurality of available power indicating circuits which notify, through a data line, a portable device coupled to the charging device of a signal indicating suppliable amount of current. A control unit obtains, from a portable device coupled thereto, information identifying the portable device, at the time of adjustment. A storage unit has a table stored therein, for a plurality of portable devices, defining a correspondence between information identifying a portable device and an available power indicating circuit. Referring to the table based on the obtained information, the control unit selects an available power indicating circuit and, at the time of actual operation, activates only the selected available power indicating circuit.

[0008] According to the embodiment described above, a single charger can rapidly charge portable devices of a plurality of charging specifications.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] FIG. **1** shows a configuration of a charger of an embodiment;

[0010] FIG. **2** shows a configuration of a USB module **10**;

[0011] FIG. **3** shows a configuration of an available power indicating circuit A;

[0012] FIG. **4** shows a configuration of an available power indicating circuit B;

[0013] FIG. **5** shows a configuration of an available power indicating circuit C;

[0014] FIGS. **6**A and **6**B each show an exemplary charger configuration signal **115** simultaneously transmitted over data lines D+ and D−;

[0015] FIG. **7** shows an exemplary table;

[0016] FIG. **8** is a flow chart representing an operation procedure of a first embodiment;

[0017] FIG. **9** is a flow chart representing an operation procedure of a second embodiment;

[0018] FIG. **10** shows an exemplary determination procedure according to an exemplary variation of the second embodiment; and

[0019] FIG. **11** shows a flow chart of a third embodiment.

DETAILED DESCRIPTION

[0020] An embodiment of the present invention will be described below, referring to the drawings.

First Embodiment

[0021] FIG. **1** shows a configuration of a charger of the present embodiment.

[0022] Referring to FIG. **1**, the charger **1** includes a power supply IC (Integrated Circuit) **2** and an MCU (Micro Control Unit) **3**.

[0023] The power supply IC**2** supplies current to a portable device coupled through a voltage bus VBUS.

[0024] The MCU **3** includes a CPU (Central Processing Unit) **4**, an ADC (Analog to Digital Converter) **5**, a memory **7**, and a USB (Universal Serial Bus) module **10**.

[0025] FIG. **2** shows a configuration of the USB module **10**. The USB module **10** has an SIE (Serial Interface Engine) **11**, a transceiver **12**, an available power indicating circuit A, an available power indicating circuit B, an available power indicating circuit C, and switches SW**1**A, SW**2**A, SW**1**B, SW**2**B, SW**1**C, and SW**2**C.

[0026] The SIE **11** is a logical circuit which processes details of a low level USB protocol. The transceiver **12** processes the physical transmission and reception function of the USB.

[0027] The available power indicating circuits A, B, and C notify, through a data line, a portable device coupled to the charging device of a signal indicating suppliable amount of current.

[0028] FIG. **3** shows a configuration of the available power indicating circuit A. Referring to FIG. **3**, the available power indicating circuit A includes resistors **322**, **326**, and **330**. DC PWR (e.g., 5.0V) is voltage-divided by the resistors **322**, **326**, and **330**. A voltage VDP which has been voltage-divided from a node **324** is output to a terminal P**1**. The terminal P**1** is coupled to the data line D+ via a switch SW**1**A. A voltage VDM which has been voltage-divided from a node **328** is output to a terminal P**2**. The terminal P**2** is coupled to the data line D− via a switch SW**2**A. By the voltages VDP and VDM, the portable device coupled thereto recognizes the current supply ability of a charger **1**.

[0029] FIG. **4** shows a configuration of an available power indicating circuit B. The available power indicating circuit B corresponds to a Dedicated Charging Port (referred to as DCP, in the following) in the "Battery Charging Specifica-

tion" which is the power supply specifications of the USB. DCP is a port having a current supply ability of 1.5 A at the maximum.

[0030] As shown in FIG. **4**, terminals P**3** and P**4** are coupled by a resistor R**11** (e.g., a maximum of 200Ω) between. The portable device applies a voltage to the data line D+. The available power indicating circuit B receives a voltage from the terminal P**3** coupled to the data line D+. The voltage received by the resistor R**11** is reduced and output from the terminal P**4** to the data line D−. The coupled side of the portable device recognizes the current supply ability of charger **1**, in accordance with the magnitude of the voltage in the data line D−. That is, the portable device recognizes that the current supply ability of the charger **1** is 1.5 A, when the magnitude of the voltage over the data line D− is equal to or larger than a predetermined value. In comparison, the Standard downstream port (SDP in the following) having a current supply ability of 500 mA in the "Battery Charging Specification" has no mechanism of returning the voltage which has been received from the terminal coupled over the data line D+ to the data line −. Therefore, the portable device recognizes that the current supply ability of the charger **1** is 500 mA, when the magnitude of the voltage over the data line D− is equal to or less than a predetermined value.

[0031] FIG. **5** shows a configuration of the available power indicating circuit C. As shown in FIG. **5**, the available power indicating circuit C is equivalent to a signal generator **114** described in Patent Document 6.

[0032] The available power indicating circuit C has a digital timer **310**, a switching circuit **312**, and RC circuits **314** to **316**.

[0033] The available power indicating circuit C operates as follows. The frequency and the duty cycle of a charger configuration signal **115** can be adjusted by selecting the values of resistors and capacitors in the RC circuits **314** to **316**.

[0034] The digital timer **310** may be a standard timer IC, for example. The timer **310** generates a timer output signal **318** which may be subject to tuning by changing the values of resistors and capacitors in the RC circuits **314** to **316**. The RC circuits **314** to **316** are coupled between the discharge (DIS) input and the threshold (THR) input of the timer **310**.

[0035] The timer output signal **318** is coupled as an input of two transistor pairs **320** and **322**, and **324** and **326** in the switching circuit **312**. The switching circuit **312** adjusts the peak voltage and impedance output from terminals P**5** and P**6** to the data lines D+ and D−.

[0036] FIGS. **6**A and **6**B each show an exemplary charger configuration signal **115** simultaneously transmitted over data lines D+ and D−. FIG. **6**A has the charger configuration signal **115** over the data line D+ plotted along the time axis. FIG. **6**B has the charger configuration signal **115** over the data line D− plotted along the time axis.

[0037] The charger configuration signal **115** is a periodic digital signal having a constant frequency (1/T) and a constant duty cycle (TH/T). The frequency (1/T) and the duty cycle (TH/T) of the charger configuration signal **115** are set to indicate the current supply ability of the charger **1**. Using the constant frequency (1/T) and the constant duty cycle (TH/T), the coupled side of the portable device recognizes the current supply ability of the charger **1**.

[0038] Referring to FIG. **1** again, a memory **6** stores, for a plurality of portable devices, a table defining the correspondence between the information identifying a portable device and an available power indicating circuit and the limit value for the current supply amount (maximum current supply amount).

[0039] FIG. **7** shows an exemplary table. A vender ID (V_ID) and a product ID (P_ID) are used as information identifying a portable device.

[0040] A CPU **4** obtains, from a portable device coupled thereto, information identifying the portable device when performing enumeration which is an adjustment stage. Enumeration is a procedure for identifying a portable device whose host (charger **1**) is coupled to a USB. During enumeration, the portable device reports its configuration to the host (charger **1**). At the time of recognizing the configuration of the portable device, the host (charger **1**) is allowed to use the portable device.

[0041] Referring to the table based on the obtained information, the CPU **4** selects an available power indicating circuit and, at the time of actual operation, activates only the selected available power indicating circuit, and also turns on only a switch coupled to the activated available power indicating circuit. In addition, referring to the table, the CPU **4** sets, in the power supply IC**2**, a limit value for the amount of current to be supplied corresponding to the obtained identification information.

[0042] (Operation)

[0043] FIG. **8** is a flow chart representing an operation procedure of the first embodiment.

[0044] First, the CPU **4** deactivates all the available power indicating circuits A, B, and C, and turns off all the switches SW**1**A, SW**2**A, SW**1**B, SW**2**B, SW**1**C, and SW**2**C coupled to the available power indicating circuits A, B, and C (step S**101**).

[0045] Next, the CPU **4** causes the power supply IC**2** to supply current to the portable device through the voltage bus VBUS (step S**102**).

[0046] Subsequently, the CPU **4** performs enumeration, detects existence of coupling of the portable device through the SIE **11**, and obtains information identifying the portable device (vendor ID, product ID) (step S**103**).

[0047] When the obtained information identifying the portable device is not registered in the table (NO at step S**104**), the portable device being coupled recognizes the charger **1** as an ordinary USB module and charges it with 500 mA or lower (step S**105**).

[0048] When the obtained information identifying the portable device is registered in the table (YES at step S**104**), the CPU **4** causes the power supply IC**2** to terminate supply of current through the voltage bus VBUS (step S**106**).

[0049] Referring to the table at the time of actual operation, the CPU **4** activates an available power indicating circuit corresponding to the obtained identification information, and turns on the switch coupled to the available power indicating circuit corresponding to the obtained identification information. In addition, referring to the table, the CPU **4** sets, in the power supply IC**2**, a limit value for the amount of current to be supplied corresponding to the obtained identification information (step S**107**).

[0050] Next, the CPU **4** causes the power supply IC**2** to supply current to the portable device through the voltage bus VBUS (step S**108**).

[0051] Subsequently, the portable device coupled thereto recognizes the current supply amount of the charger, in accordance with the activated available power indicating circuit, and performs charging (step S**109**).

[0052] According to the present embodiment, as has been described above, knowing the type of the portable device coupled thereto allows activation of an available power indicating circuit suited to the type, causing the portable device coupled thereto to recognize the current supply amount of the charger. As a result, according to the present embodiment, a single charger can support a plurality of charging specifications, allowing rapid charging of portable device coupled thereto.

Second Embodiment

[0053] The second embodiment differs from the first embodiment in the following points.

[0054] The ADC**5** measures the amount of current supplied to the portable device through a voltage bus (VBUS).

[0055] The CPU **4** activates available power indicating circuits one by one at the time of adjustment, causes the ADC**5** to measure the amount of current supplied to the portable device coupled through the voltage bus (VBUS), and stores the measurement result in the memory **6**.

[0056] Referring to the memory **6**, the CPU **4** selects an available power indicating circuit exhibiting the maximum current supply amount and, at the time of actual operation, activates only the selected available power indicating circuit, and also turns on only the switch coupled to the activated available power indicating circuit. In addition, the CPU **4** sets, in the power supply IC**2**, a limit value for the amount of current to be supplied corresponding to the available power indicating circuit to be activated.

[0057] FIG. **9** is a flow chart representing an operation procedure of the second embodiment. Referring to FIG. **9**, the CPU **4** first activates only the available power indicating circuit A, turns on the switches SW**1**A and SW**2**A coupled to the available power indicating circuit A, and turns off the remaining switches SW**1**B, SW**2**B, SW**1**C, and SW**2**C. The CPU **4** sets, in the power supply IC**2**, a limit value for the current supply amount corresponding to the available power indicating circuit A (corresponding to the standard A) (step S**201**).

[0058] Next, the CPU **4** causes the power supply IC**2** to supply current to the portable device through the voltage bus VBUS (step S**202**).

[0059] Subsequently, the ADC**5** measures, for a certain time period, the amount of current supplied through the voltage bus VBUS. The CPU **4** stores, in the memory **6**, the maximum amount of current detected in the ADC**5** (step S**203**).

[0060] Then, the CPU **4** causes the power supply IC**2** to terminate supply of current through the voltage bus VBUS (step S**204**).

[0061] Next, the CPU **4** activates only the available power indicating circuit B, turns on the switches SW**1**B and SW**2**B coupled to the available power indicating circuit B, and turns off the remaining switches SW**1**A, SW**2**A, SW**1**C, and SW**2**C. The CPU **4** sets, in the power supply IC**2**, a limit value for the current supply amount corresponding to the available power indicating circuit B (corresponding to the standard B) (step S**205**).

[0062] Subsequently, the CPU **4** causes the power supply IC**2** to supply current to the portable device through the voltage bus VBUS (step S**206**).

[0063] Then, the ADC**5** measures, for a certain time period, the amount of current supplied through the voltage bus VBUS. The CPU **4** stores, in the memory **6**, the maximum amount of current detected in the ADC**5** (step S**207**).

[0064] Subsequently, the CPU **4** causes the power supply IC**2** to terminate supply of current through the voltage bus VBUS (step S**208**).

[0065] Then, the CPU **4** activates only the available power indicating circuit C, turns on the switches SW**1**C and SW**2**C coupled to the available power indicating circuit C, and turns off the remaining switches SW**1**A, SW**2**A, SW**1**B, and SW**2**B. The CPU **4** sets, in the power supply IC**2**, a limit value for the current supply amount corresponding to the available power indicating circuit C (corresponding to the standard C) (step S**209**).

[0066] Next, the CPU **4** causes the power supply IC**2** to supply current to the portable device through the voltage bus VBUS (step S**210**).

[0067] Subsequently, the ADC**5** measures, for a certain time period, the amount of current supplied through the voltage bus VBUS. The CPU **4** stores, in the memory **6**, the maximum amount of current detected in the ADC**5** (step S**211**).

[0068] Then, the CPU **4** causes the power supply IC**2** to terminate supply of current through the voltage bus VBUS (step S**212**).

[0069] Next, referring to data stored in the memory, the CPU **4** selects the available power indicating circuit which has supplied the maximum amount of current (step S**213**).

[0070] Subsequently, the CPU **4** activates the selected available power indicating circuit at the time of actual operation, and turns on the switch coupled to the selected available power indicating circuit. In addition, the CPU **4** sets, in the power supply IC**2**, a limit value for the current supply amount corresponding to selected available power indicating circuit (step S**214**).

[0071] Then, the CPU **4** causes the power supply IC**2** to supply current to the portable device through the voltage bus VBUS (step S**215**).

[0072] Next, the portable device coupled thereto recognizes the current supply amount of the charger in accordance with the activated available power indicating circuit, and performs charging (step S**216**).

[0073] According to the present embodiment, as has been described above, an available power indicating circuit can be selected so that the current available at the portable device is maximized. As a result, a single charger can support a plurality of charging specifications, allowing rapid charging of portable device coupled thereto. In addition, a limit value for the amount of current to be supplied from the power supply IC can be set in accordance with the portable device.

Exemplary Variation of the Second Embodiment

[0074] In this exemplary variation, the CPU **4** sets one or more limit values for the amount of current to be supplied through the voltage bus (VBUS), in accordance with the available power indicating circuit to be activated at the time of adjustment. The CPU **4** causes the ADC**5** to measure, for a certain time period, the amount of current to be supplied to the portable device through the voltage bus VBUS under respective limit values, and stores the maximum value of the measured amount of current in the memory **6**.

[0075] Referring to the memory **6**, the CPU **4** selects an available power indicating circuit exhibiting the maximum current supply amount and a limit value for the amount of current to be supplied, activates only the selected available

power indicating circuit at the time of actual operation, and sets, in the power supply IC2, the limit value for the amount of current to be supplied.

[0076] FIG. **10** shows an exemplary determination procedure according to an exemplary variation of the second embodiment. First, the available power indicating circuit A is selected, and the limit value for the current supply amount of the power supply IC2 is set to 0.5 A. At this time, the maximum value within a certain time period of the amount of current supplied to the portable device through the voltage bus VBUS is measured to be 0.1 A. Next, the limit value for the current supply amount of the power supply IC2 is changed to 0.8 A. At this time, the maximum value within a certain time period of the amount of current supplied to the portable device through the voltage bus VBUS is measured to be 0.1 A. Next, the limit value for the current supply amount of the power supply IC2 is changed to 1.8 A. At this time, the maximum value within a certain time period of the amount of current supplied to the portable device through the voltage bus VBUS is measured to be 1.2 A.

[0077] Next, the available power indicating circuit B is selected, and the limit value for the current supply amount of the power supply IC2 is set to 1.8 A. At this time, the maximum value within a certain time period of the amount of current supplied to the portable device through the voltage bus VBUS is measured to be 0.1 A. Next, the limit value for the current supply amount of the power supply IC2 is changed to 2.1 A. At this time, the maximum value within a certain time period of the amount of current supplied to the portable device through the voltage bus VBUS is measured to be 0.1 A.

[0078] Subsequently, the available power indicating circuit C is selected, and the limit value for the current supply amount of the power supply IC2 is set to 1.8 A. At this time, the maximum value within a certain time period of the amount of current supplied to the portable device through the voltage bus VBUS is measured to be 0.1 A.

[0079] As a result of the above, in the case where the available power indicating circuit is A and the limit value for the current supply amount of the power supply IC2 is 1.8 A, the maximum value within a certain time period of the amount of current supplied to the portable device through the voltage bus VBUS is maximized. Therefore, at the time of actual operation, only the available power indicating circuit A is activated, and 1.8 A is set, in the power supply IC, as the limit value for the amount of current supplied.

Third Embodiment

[0080] The third embodiment is a combination of the selection of an available power indicating circuit by the first embodiment and the selection of an available power indicating circuit by the second embodiment.

[0081] FIG. **11** shows a flow chart of the third embodiment. Referring to FIG. **11**, the CPU **4** first causes the power supply IC2 to supply current to the portable device through the voltage bus VBUS (step S**301**).

[0082] Next, the CPU **4** performs enumeration. When there is no response from the portable device, the process flow proceeds to step S**305**.

[0083] When there is a response from the portable device, information identifying the portable device coupled thereto (vendor ID, product ID) is obtained. When the obtained identification information is not registered in the table (No at step S**303**), the process flow proceeds to step S**305**.

[0084] When the obtained identification information is registered in the table (YEs at step S**303**), the CPU **4** specifies an available power indicating circuit corresponding to the obtained identification information, referring to the table (step S**304**).

[0085] Next, the CPU **4** causes the power supply IC2 to terminate supply of current through the voltage bus VBUS (step S**318**).

[0086] The CPU **4** activates the specified available power indicating circuit at the time of actual operation, and turns on the switch coupled to the specified available power indicating circuit. In addition, referring to the table, the CPU **4** sets, in the power supply IC2, a limit value for the current supply amount corresponding to the obtained identification information (step S**319**).

[0087] Subsequently, the CPU **4** causes the power supply IC2 to supply current to a portable device through the voltage bus VBUS (step S**320**).

[0088] Next, the portable device coupled thereto recognizes the current supply amount of the charger in accordance with the activated available power indicating circuit, and performs charging (step S**321**).

[0089] In contrast, when there is no response from the portable device at step S**302** and identification information (vendor ID, product ID) obtained at step S**303** is not registered in the table, the following process is performed.

[0090] The CPU **4** causes the power supply IC2 to terminate supply of current through the voltage bus VBUS (step S**305**).

[0091] Next, the CPU **4** activates only the available power indicating circuit A, turns on the switches SW1A and SW2A coupled to the available power indicating circuit A, and turns off the remaining switches SW1B, SW2B, SW1C, and SW2C. The CPU **4** sets, in the power supply IC2, a limit value for the current supply amount corresponding to the available power indicating circuit A (step S**306**).

[0092] Subsequently, the CPU **4** causes the power supply IC2 to supply current to the portable device through the voltage bus VBUS (step S**307**).

[0093] Next, the ADC**5** measures, for a certain time period, the amount of current supplied through the voltage bus VBUS. The CPU **4** stores, in the memory **6**, the maximum amount of current detected in the ADC**5** (step S**308**).

[0094] Subsequently, the CPU **4** causes the power supply IC2 to terminate supply of current through the voltage bus VBUS (step S**309**).

[0095] Then, the CPU **4** activates only the available power indicating circuit B, turns on the switches SW1B and SW2B coupled to the available power indicating circuit B, and turns off the remaining switches SW1A, SW2A, SW1C, and SW2C. The CPU **4** sets, in the power supply IC2, the maximum amount of current corresponding to the available power indicating circuit B (step S**310**).

[0096] Next, the CPU **4** causes the power supply IC2 to supply current to the portable device through the voltage bus VBUS (step S**311**).

[0097] Subsequently, the ADC**5** measures, for a certain time period, the amount of current supplied through the voltage bus VBUS. The CPU **4** stores, in the memory **6**, the maximum amount of current detected in the ADC**5** (step S**312**).

[0098] Then, the CPU **4** causes the power supply IC2 to terminate supply of current through the voltage bus VBUS (step S**313**).

[0099] Subsequently, the CPU **4** activates only the available power indicating circuit C, turns on the switches SW**1**C and SW**2**C coupled to the available power indicating circuit C, and turns off the remaining switches SW**1**A, SW**2**A, SW**1**B, and SW**2**B. The CPU **4** sets, in the power supply IC**2**, the maximum of the current supply amount corresponding to the available power indicating circuit C (step S**314**).

[0100] Next, the CPU **4** causes the power supply IC**2** to supply current to the portable device through the voltage bus VBUS (step S**315**).

[0101] Then, the ADC**5** measures, for a certain time period, the amount of current supplied through the voltage bus VBUS. The CPU **4** stores, in the memory **6**, the maximum amount of current detected in the ADC**5** (step S**316**).

[0102] Next, referring to data stored in the memory, the CPU **4** selects the available power indicating circuit which has supplied the maximum amount of current (step S**317**).

[0103] Subsequently, the CPU **4** causes the power supply IC**2** to terminate supply of current through the voltage bus VBUS (step S**318**).

[0104] Then, the CPU **4** activates the selected available power indicating circuit at the time of actual operation, and turns on the switch coupled to the selected available power indicating circuit. In addition, the CPU **4** sets, as the current limit value of the power supply IC**2**, the amount of maximum current of the selected available power indicating circuit (step S**319**).

[0105] Next, the CPU **4** causes the power supply IC**2** to supply current to the portable device through the voltage bus VBUS (step S**320**).

[0106] Subsequently, the portable device coupled thereto recognizes the current supply amount of the charger in accordance with the activated available power indicating circuit, and performs charging (step S**321**).

[0107] According to the present embodiment, as has been described above, an available power indicating circuit can be selected using identification information when the identification information from the portable device is available, and an available power indicating circuit can be selected so that current available in the portable device side is maximized when identification information from the portable device is not available. As a result, a single charger can support a plurality of charging specifications, allowing rapid charging of portable device coupled thereto.

[0108] Although the invention made by the inventors has been specifically described above based on embodiments, it is needless to say that the present invention is not limited to the embodiments and various modifications are possible within a scope not departing from the gist of the invention.

1-5. (canceled)

6. A method for charging a portable device via a universal serial bus of a charging device, the method comprising:

supplying current to a portable device from a power supply of the charging device through a voltage bus (VBUS);

measuring the amount of current supplied to the portable device though the voltage bus (VBUS);

notifying the portable device coupled to the charging device of a signal indicating suppliable amount of current;

obtaining information identifying the portable device at a control unit coupled to the portable device;

selecting an available power indicating circuit based on the obtained information by referring to a previously stored table which defines, for a plurality of portable devices, correspondence between information identifying the portable devices and available power indicating circuits, and

activating only the selected available power indicating circuit at a time of actual operation,

wherein, when the control unit does not obtain from a portable device coupled thereto information identifying the portable device, or when an available power indicating circuit corresponding to information identifying the portable device is not defined in the table, the control unit activates the available power indicating circuits one by one, causes a measurement unit to measure the amount of current supplied to the portable device through a voltage bus (VBUS), stores a measurement result in a storage unit, selects, by referring to the storage unit, an available power indicating circuit exhibiting a maximum current supply amount, and activates only the selected available power indicating circuit at a time of actual operation.

7. The charging method according to claim **6**, further comprising setting, in the power supply unit, a limit value for the amount of current supplied through the voltage bus (VBUS) in accordance with an available power indicating circuit to be activated.

8. The charging device according to claim **6**, further comprising:

setting one or more limit values for the amount of current supplied through the voltage bus (VBUS) in accordance with an available power indicating circuit to be activated at a time of adjustment;

measuring the amount of current to be supplied to the portable device under respective limit values;

storing a measurement result in the storage unit;

selecting an available power indicating circuit exhibiting the maximum current supply amount and a limit value for amount of current to be supplied;

activating only the selected available power indicating circuit at a time of actual operation; and

setting, in the power supply unit, the limit value for the amount of current to be supplied.

9. A method for charging a portable device via a universal serial bus of a charging device, the method comprising:

supplying current to a portable device coupled through a voltage bus (VBUS);

measuring the amount of current supplied to the portable device through the voltage bus (VBUS);

notifying the portable device coupled to the charging device of a signal indicating suppliable amount of current, the notifying being done through a data line by a plurality of available power indicating circuits, each circuit having different current supplying ability;

at the time of adjustment, activating through a control unit the available power indicating circuits one by one, measuring the amount of current supplied to the portable device, and storing in a storage unit a measurement result;

selecting, by referring to the storage unit, an available power indicating circuit exhibiting a maximum current supply amount; and

activating only the selected available power indicating circuit at a time of actual operation,

wherein, at the time of adjustment, the control unit does not obtain from a portable device information identifying the portable device.

* * * * *