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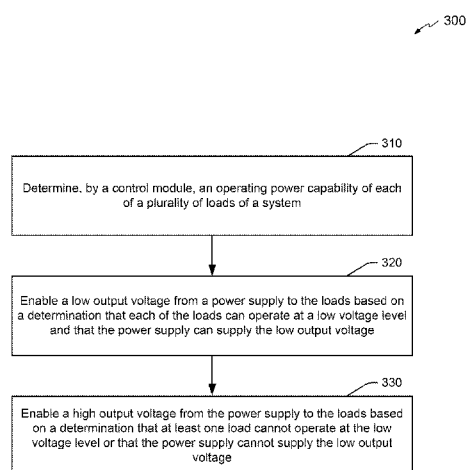
- (81) **Designated States** (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.
- (84) **Designated States** (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— as to the identity of the inventor (Rule 4.17(i))

[Continued on next page]

(54) **Title:** ENABLING LOW OUTPUT VOLTAGE TO LOADS



(57) **Abstract:** Example implementations relate to enabling a low output voltage to loads. For example, a system includes a power supply to supply power to a plurality of loads and a control module. The control module is to determine an operating power capability of each load and to enable a low output voltage from the power supply to the loads based on a determination that each load can operate at a low voltage level and that the power supply can supply the low output voltage.

FIG. 3



— *as to applicant's entitlement to apply for and be granted
a patent (Rule 4.17(ii))*

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— *with international search report (Art. 21(3))*

ENABLING A LOW OUTPUT VOLTAGE TO LOADS

BACKGROUND

[0001] Computing systems such as a server system can include a number of sub-systems or loads that receive power from a power supply for operation. A sub-system/load of the server can include memory modules, storage devices, input/output (I/O) devices, etc. A power supply converts mains alternating current (AC) power to low-voltage regulated direct current (DC) power to power the loads of the server. A server can receive a 12V output voltage from a power supply to power the loads.

BRIEF DESCRIPTION OF THE DRAWINGS

[0002] Some examples of the present application are described with respect to the following figures:

[0003] FIG. 1 is a block diagram of an example system including a control module for enabling a low output voltage to a plurality of loads of the system;

[0004] FIG. 2 is another block diagram of an example system including a control module for enabling a low output voltage to a plurality of loads of the system;

[0005] FIG. 3 is a flowchart of an example method for enabling a low output voltage to a plurality of loads of a system;

[0006] FIG. 4 is a flowchart of another example method for enabling a low output voltage to a plurality of loads of a system; and

[0007] FIG. 5 is a block diagram of a computer-readable storage medium having instructions executable to enable a low output voltage to a plurality of loads of a system.

DETAILED DESCRIPTION

[0008] Examples disclosed herein relate to enabling a low output voltage from a power supply to a plurality of loads of a system (e.g., a server system) to improve the power efficiency of the system. The described solutions can be implemented during run-time of the system and without powering down the system, by allowing dynamic power supply voltage output configuration where the power supply output can be allowed to safely change without powering down.

[0009] For example, to improve power efficiency, it may be desirable to operate the system at a lower voltage (e.g., 6V) compared to a conventional higher voltage (e.g., 12V). A control module can be provided and communicatively coupled to the loads of the system to receive communication regarding each load's ability to operate at the lower voltage, and communication regarding the power supply's ability to supply a low output voltage (e.g., operate in a dual mode and provide both a high output voltage and a low output voltage). The control module can enable the low output voltage from the power supply to the loads if it is determined that all the loads can operate at a low voltage and the power supply can supply the low output voltage. Accordingly, the power supply output voltage can be safely and dynamically changed without powering down the system.

[0010] In one example, a system includes a power supply to supply power to a plurality of loads and a control module. The control module is to determine an operating power capability of each load and to enable a low output voltage from the power supply to the loads based on a determination that each load can operate at a low voltage level and that the power supply can supply the low output voltage.

[0011] In another example, a method includes determining, by a control module, an operating power capability of each of a plurality of loads of a system. The method includes enabling a low output voltage from a power supply to the loads based on a determination that each of the loads can operate at a low voltage level and that the power supply can supply the low output voltage. The method also includes enabling a high output voltage from the power supply to the loads based on a determination that at least one load cannot operate at the low voltage level or that the power supply cannot supply the low output voltage.

[0012] In another example, a non-transitory computer-readable storage medium is encoded with instructions executable by a processor of system to determine an operating power capability of each of a plurality of loads and a power supply of the system. The instructions are executable to enable a low output voltage from the power supply to the load based on a determination that each load can operate at the low voltage level and that the power supply can supply the low output voltage. The instructions are also executable to enable a high output voltage from the power supply to the loads based on a determination that at least one load cannot operate at the low voltage level or that the power supply cannot supply the low output voltage.

[0013] Referring now to the figures, FIG. 1 is a block diagram of an example system including a control module for enabling a low output voltage to a plurality of loads of the system. System 100 can be any type of computing system such as a portable computer or communication device, a standalone server computer, a blade server, etc. System 100 can include a control module 102, a power supply 104, and a plurality of loads 106. System 100 can include additional components other than those depicted in FIG. 1, such as embedded firmware and hardware components. For example, system 100 can include a central processing unit (CPU), display, other hardware, software application, (I/O) ports, peripheral devices, etc.

[0014] Control module 102 can include one or more CPUs or cores thereof, microprocessors, hardware state machines, graphic processing units (GPUs), field-programmable gate arrays (FPGAs), or other electronic circuitry, which may be integrated in a single device or distributed across devices. In some examples, control module 102 may include one or more “lights-out” modules that may be powered on and operational when other modules or components of the system 100 are not powered on or are not operational. Control module 102 can be responsible for managing some or all of the functionalities of the system 100, including enabling a low output voltage from a power supply to the system 100.

[0015] Power supply 104 can be any device capable of providing electrical energy to the loads 106 of the system 100, for example by converting electrical energy from one form to another to make the energy compatible with the requirements of the loads 106. Power supply 104 can provide energy (i.e., power) to the loads 106 by converting an alternating current (AC) energy to a lower-voltage, regulated direct current (DC) energy for use by the loads 106. In some examples,

power supply 104 can provide a DC energy source to a DC output to the loads 106. Accordingly, power supply 104 can provide an output voltage to power the loads 106. In some examples, the power supply unit 104 can be internal to the system 100, as depicted in FIG. 1. In other examples, power supply 104 can be external to the system 100.

[0016] Loads 106 can be sub-systems of the system 100 that consume power or that depend upon the power supply 106 for power. Loads 106 can include CPU, memory, storage devices (e.g., hard disk drives (HDDs)), I/O devices, fans, motherboards, baseboard management control (BMC), or any other components of the system 100.

[0017] During operation of the system 100, for example during run-time, control module 102 can determine the operating power capability of each of the loads 106. For example, each load 106 can communicate its ability to operate at a low voltage level (e.g., 6V, 5V, or 3.3V, etc.) compared to a high voltage level (e.g., 12V) to the control module 102. Further, the power supply 104 can communicate its ability to supply a low output voltage (e.g., 6V, 5V, 3.3V, etc.) as well as a high output voltage (e.g., 12V) to the loads 106.

[0018] In response to determining that each load 106 can operate at the low voltage level and that the power supply 104 can supply the low output voltage, control module 102 can enable the low output voltage from the power supply 104 to the loads 106, thereby improving the power efficiency of the system 100. In certain examples, the low output voltage can be enabled without powering down the system 100. As such, a dynamic power supply voltage output change (i.e., from the high output voltage to the low output voltage) can be safely implemented without powering down the system 100. In some examples, if it is determined that at least one load 106 cannot operate at the low voltage level or that the power supply 104 cannot supply the low output voltage, control module 102 will enable the high output voltage from the power supply 104 to the loads 106.

[0019] FIG. 2 is another block diagram of an example system including a control module for enabling a low output voltage to a plurality of loads of the system. In the example of FIG. 2, control module 102 includes a register 220 to store a plurality of bits representing each load 106 and the power supply 104. In some examples, control

module 102 can be implemented as an FPGA device to execute logic for determining when to enable a low output voltage from the power supply 104 to the loads 106. In such examples, control module 102 can function as a power aggregator to collect information regarding the operating power capabilities of each load 106 and the power supply 104 and logically determine if the low output voltage from the power supply can be enabled.

[0020] Control module 102 can set each bit corresponding to the loads 106 and power supply 104 to a logical '1' or a logical '0' depending operating capability of the loads 106 and power supply 104, where the loads 106 include loads that depend on the power supply 104. For example, if a load 106 is able to operate at the low voltage level, the bit corresponding to the load is set to '1.' If however, a load is 106 is unable to operate at the low voltage level, the bit corresponding to the load is set to '0.' Similarly, a bit corresponding to the power supply 104 is set to '1' if the power supply 104 is able to supply the low output voltage, and set to '0' if the power supply 104 is unable to supply the low output voltage.

[0021] When all bits are set in the register 220, control module 102 can implement logical bit-wise "AND" to determine whether or not to enable the low output voltage from the power supply 104 to the loads 106. When all bits align, where the result of the bit-wise "AND" function is '1,' the low output voltage is enabled and the power supply 104 is allowed to reduce the output voltage (i.e., supply the low output voltage) to the loads 106. However, if at least one bit is set to '0' indicating that at least one load 106 is unable to operate at the low voltage level, or the power supply 104 is unable to supply the low output voltage, then the output of the logical "AND" would be '0' and the control module 102 will not enable the low output voltage from the power supply 104. Instead, the high output voltage will be enabled from the power supply 104.

[0022] FIG. 3 is a flowchart of an example method for enabling a low output voltage to a plurality of loads of a system. Although execution of method 300 is described below with reference to system 100 of FIGS. 1 and 2, other suitable devices for execution of method 300 can be used. Method 300 can be implemented in the form of executable instructions stored on a computer-readable storage medium, such as computer-readable storage medium 520 of FIG. 5, and/or in the form of electronic circuitry.

[0023] Method 300 includes determining, by a control module, an operating power capability of each of a plurality of loads of a system, at 310. For example, control module 102 can be communicatively coupled to the loads 106 and receive information regarding each load's ability to operate at a low voltage level. In some examples, control module 102 can also receive communication regarding the ability of the power supply 104 to supply a low output voltage. In certain examples, power supply 104 may be able to operate in a dual mode to supply both a high output voltage (e.g., 12V) and a low output voltage less than the high output voltage (e.g., voltages less than 12V).

[0024] Method 300 includes enabling a low output voltage from a power supply to the loads based on a determination that each of the loads can operate at a low voltage level and that the power supply can supply the low output voltage, at 320. For example, control module 102 can enable a low output voltage from the power supply 104 to the loads 106 if each of the loads 106 can operate at the low voltage level and the power supply 104 can supply the low output voltage. In some examples, the low output voltage can be enabled without powering down the system 100.

[0025] Method 300 includes enabling a high output voltage from the power supply to the loads based on a determination that at least one load cannot operate at the low voltage level or that the power supply cannot supply the low output voltage, at 330. For example, control module 102 can enable the high output voltage from the power supply 104 to the loads 106 if at least one load 106 is unable to operate at the low voltage level or the power supply 104 does not support the low output voltage. In some examples, the method 300 of FIG. 3 includes additional steps in addition to and/or in lieu of those depicted in FIG. 3.

[0026] FIG. 4 is a flowchart of another example method for enabling a low output voltage to a plurality of loads of a system. Although execution of method 400 is described below with reference to system 100 of FIGS. 1 and 2, other suitable devices for execution of method 400 can be used. Method 400 can be implemented in the form of executable instructions stored on a computer-readable storage medium, such as computer-readable storage medium 520 of FIG. 5, and/or in the form of electronic circuitry.

[0027] Method 400 includes storing a plurality of bits in a register, each bit corresponding to each load and the power supply, respectively, and each bit indicating whether each load can operate at the low voltage level and whether the power supply can supply the low output voltage, at 410. For example, control module 102 can store the bits in the register 220 to indicate the operating capabilities of the loads 106 and the power supply, where '1' indicates an ability of a load 106 to operate at the low voltage level and '0' indicates an inability of a load 106 to operate at the low voltage level, and where a '1' indicate an ability of the power supply 104 to provide a low output voltage and '0' indicates an inability of the power supply 104 to provide the low output voltage.

[0028] Method 400 includes determining if each load can operate at the low voltage level, at 420. For example, this determination can be made based on the logical value corresponding to each load 106 stored in the register 220. If it is determined that each load can operate at the low voltage level, at 420, method 400 includes determining if the power supply can provide the low output voltage, at 430. For example, this determination can be made based on the logical value corresponding to the power supply 104 stored in the register 220. If it is determined that the power supply can provide the low output voltage, at 430, method 400 includes enabling the low output voltage, at 440.

[0029] However, if it is determined that at least one load 106 cannot operate at the low voltage level, at 420, method 400 includes enabling the high output voltage, at 450. If it is determined that the power supply cannot provide the low output voltage, at 430, method 400 includes enabling the high output voltage, at 450. In some examples, the method 400 of FIG. 4 includes additional steps in addition to and/or in lieu of those depicted in FIG. 4.

[0030] FIG. 5 is a block diagram of a computer-readable storage medium having instructions executable to enable a low output voltage to a plurality of loads of a system. System 500 includes a processor 540 and a computer-readable storage medium 520.

[0031] Processor 540 can be one or more central processing units (CPUs), microprocessors, and/or other hardware devices suitable for retrieval and execution of instructions stored in computer-readable storage medium 520. Processor 540 may

fetch, decode, and execute instructions 522 and 524 to enable a low output voltage to a plurality of loads, as described below. As an alternative or in addition to retrieving and executing instructions, processor 540 may include one or more electronic circuits comprising a number of electronic components for performing the functionality of one or more of instructions 522 and 524.

[0032] Computer-readable storage medium 520 may be any electronic, magnetic, optical, or other physical storage device that stores executable instructions. Thus, computer-readable storage medium 520 may be, for example, random access memory (RAM), content addressable memory (CAM), ternary content addressable memory (TCAM), an electrically-erasable programmable read-only memory (EEPROM), flash memory, a storage drive, an optical disc, and the like. As described in detail below, computer-readable storage medium 520 may be encoded with executable instructions for enabling a low output voltage to a plurality of loads of the system 500.

[0033] Operating power capability determining instructions 522 include instructions to determine an operating power capability of each of a plurality of loads and a power supply of the system. For example, it can be determined whether or not each load 106 can operate at a low voltage level and whether or not the power supply 104 can supply a low output voltage.

[0034] Output power enabling instructions 524 include instructions to enable a low output voltage from the power supply to the loads based on a determination that each load can operate at the low voltage level and that the power supply can supply the low output voltage, and instructions to enable a high output voltage from the power supply to the loads based on a determination that at least one load cannot operate at the low voltage level or that the power supply cannot supply the low output voltage. The low output voltage can be enabled without powering down the system 500.

[0035] Instructions 524 also include instructions to store a plurality of bits in a register, where each bit corresponds to each load and the power supply and where each bit indicates whether each load can operate at the low voltage level and whether the power supply can supply the low output voltage. Instructions 524 include instructions to enable the low output voltage if the bits indicate that each load can operate at the low voltage level and that the power supply can supply the low output

voltage, and enable the high output voltage if the bits indicate that at least one load cannot operate at the low voltage level or that the power supply cannot supply the low output voltage.

[0036] The techniques described above may be embodied in a computer-readable medium for configuring a computing system to execute the method. The computer-readable media may include, for example and without limitation, any number of the following non-transitive mediums: magnetic storage media including disk and tape storage media; optical storage media such as compact disk media (e.g., CD-ROM, CD-R, etc.) and digital video disk storage media; holographic memory; nonvolatile memory storage media including semiconductor-based memory units such as FLASH memory, EEPROM, EPROM, ROM; ferromagnetic digital memories; volatile storage media including registers, buffers or caches, main memory, RAM, etc.; and the Internet, just to name a few. Other new and obvious types of computer-readable media may be used to store the software modules discussed herein. Computing systems may be found in many forms including but not limited to mainframes, minicomputers, servers, workstations, personal computers, notepads, personal digital assistants, tablets, smartphones, various wireless devices and embedded systems, just to name a few.

CLAIMS

What is claimed is:

1. A system, comprising:
a power supply to supply power to a plurality of loads; and
a control module to:
determine an operating power capability of each load; and
enable a low output voltage from the power supply to the loads based
on a determination that each load can operate at a low voltage
level and that the power supply can supply the low output
voltage.
2. The system of claim 1, wherein the control module is to enable the low
output voltage to the loads without powering down the system.
3. The system of claim 1, wherein the loads are dependent upon the power
supply for output voltage.
4. The system of claim 1, wherein each load is to communicate a capability to
operate at the low voltage to the control module.
5. The system of claim 1, wherein the control module includes a register to
store a plurality of bits representing each load and the power supply.
6. The system of claim 5, wherein each bit indicates whether each load can
operate at the low voltage level and whether the power supply can supply the low
output voltage.
7. The system of claim 6, wherein the control module is to enable the low
output voltage if the bits indicate that each load can operate at the low voltage level
and the power supply can supply the low output voltage.
8. The system of claim 6, wherein the power supply can supply a high output

voltage.

9. The system of claim 8, wherein the control module is to enable the high output voltage if the bits indicate that at least one load cannot operate at the low voltage level or if the bits indicate that the power supply cannot supply the low output voltage.

10. A method, comprising:

determining, by a control module, an operating power capability of each of a plurality of loads of a system; and

enabling a low output voltage from a power supply to the loads based on a determination that each of the loads can operate at a low voltage level and that the power supply can supply the low output voltage; and
enabling a high output voltage from the power supply to the loads based on a determination that at least one load cannot operate at the low voltage level or that the power supply cannot supply the low output voltage.

11. The method of claim 10, comprising enabling the low output voltage to the loads without powering down the system.

12. The method of claim 10, comprising:

storing a plurality of bits in a register, each bit corresponding to each load and the power supply, respectively, and each bit indicating whether each load can operate at the low voltage level and whether the power supply can supply the low output voltage;

enabling the low output voltage if the bits indicate that each load can operate at the low voltage level and that the power supply can supply the low output voltage; and

enabling the high output voltage if the bits indicate that at least one load cannot operate at the low voltage level or that the power supply cannot supply the low output voltage.

13. A non-transitory computer-readable storage medium encoded with instructions executable by a processor of a system, the computer-readable storage medium comprising instructions to:

- determine an operating power capability of each of a plurality of loads and a power supply of the system;
- enable a low output voltage from the power supply to the loads based on a determination that each load can operate at the low voltage level and that the power supply can supply the low output voltage; and
- enable a high output voltage from the power supply to the loads based on a determination that at least one load cannot operate at the low voltage level or that the power supply cannot supply the low output voltage.

14. The non-transitory computer-readable storage medium of claim 13, wherein the low output voltage is enabled without powering down the system.

15. The non-transitory computer-readable storage medium of claim 13, comprising instructions to:

- store a plurality of bits in a register, wherein each bit corresponds to each load and the power supply and wherein each bit indicates whether each load can operate at the low voltage level and whether the power supply can supply the low output voltage;
- enable the low output voltage if the bits indicate that each load can operate at the low voltage level and that the power supply can supply the low output voltage; and
- enable the high output voltage if the bits indicate that at least one load cannot operate at the low voltage level or that the power supply cannot supply the low output voltage.

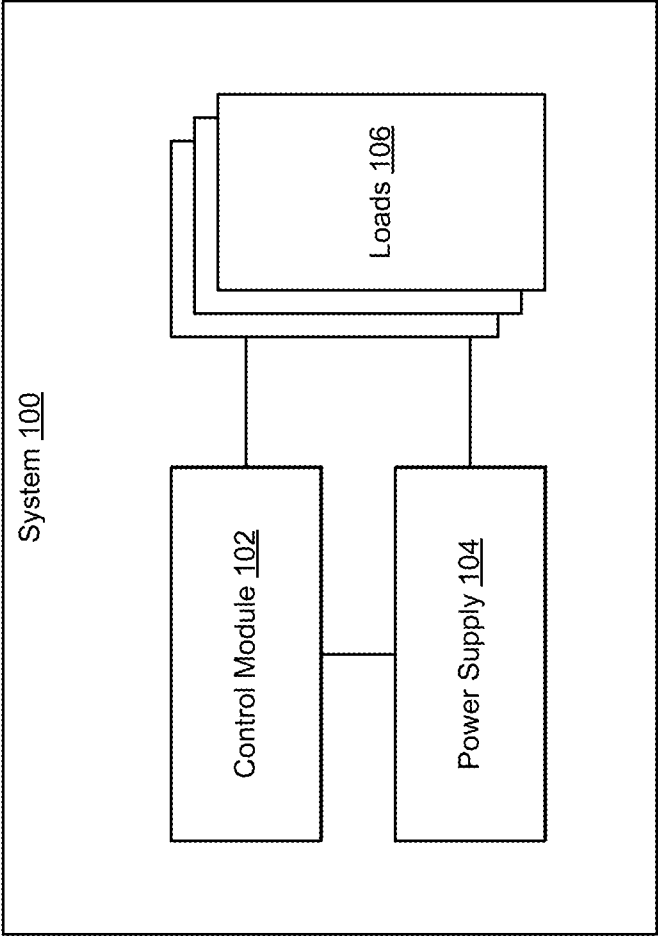


FIG. 1

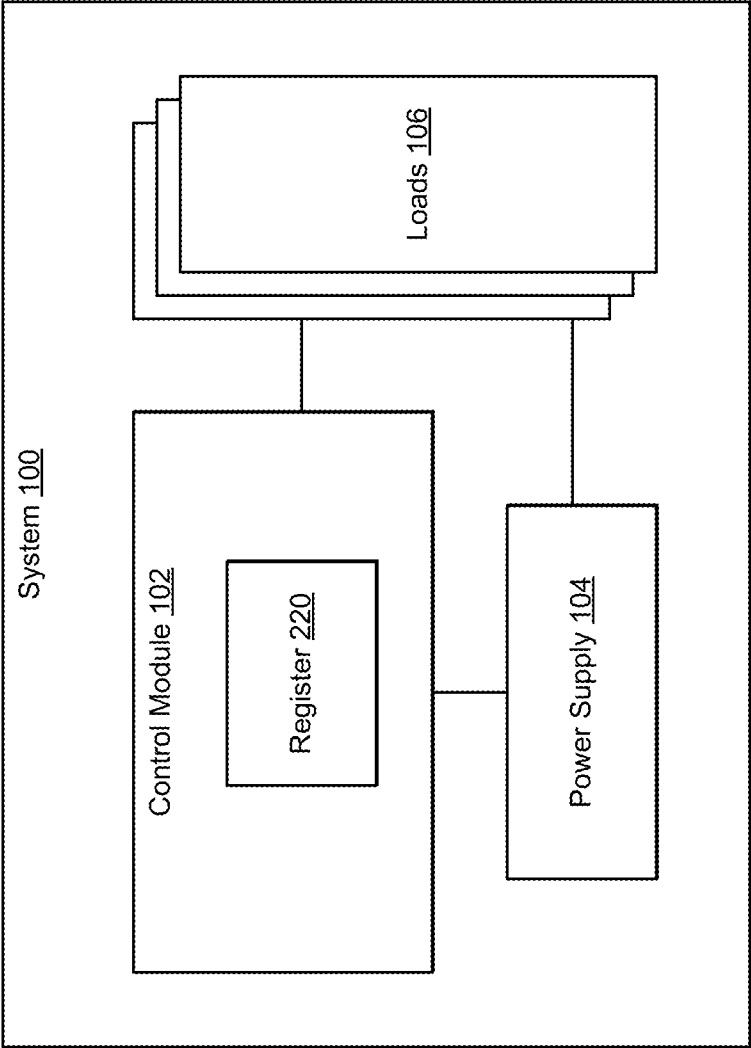


FIG. 2

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300

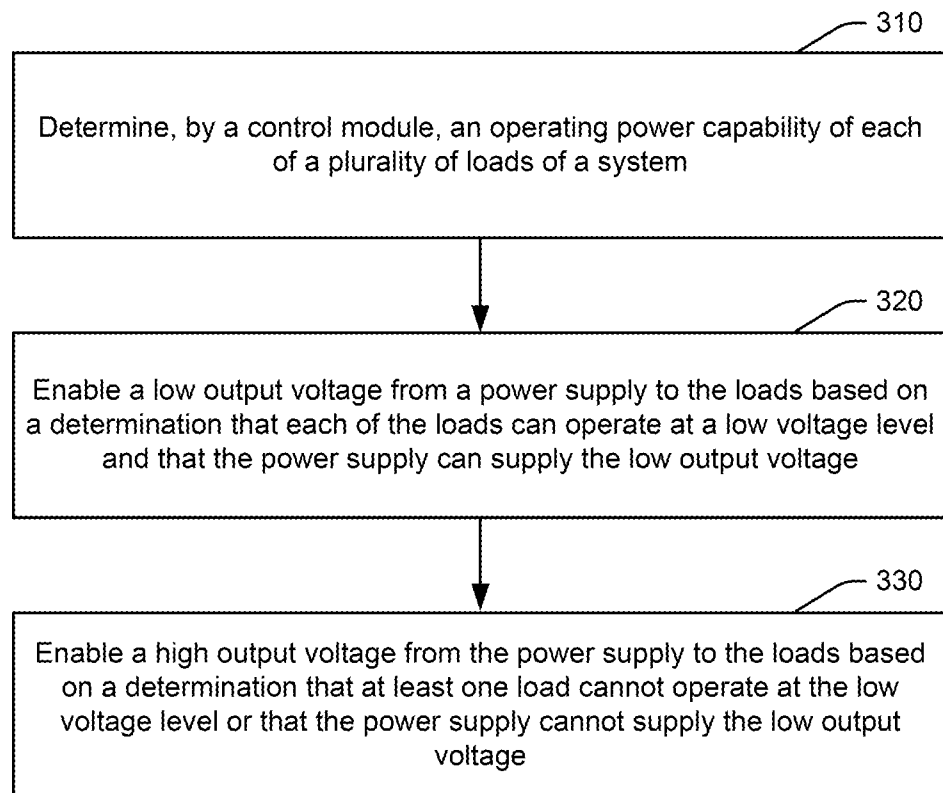


FIG. 3

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400

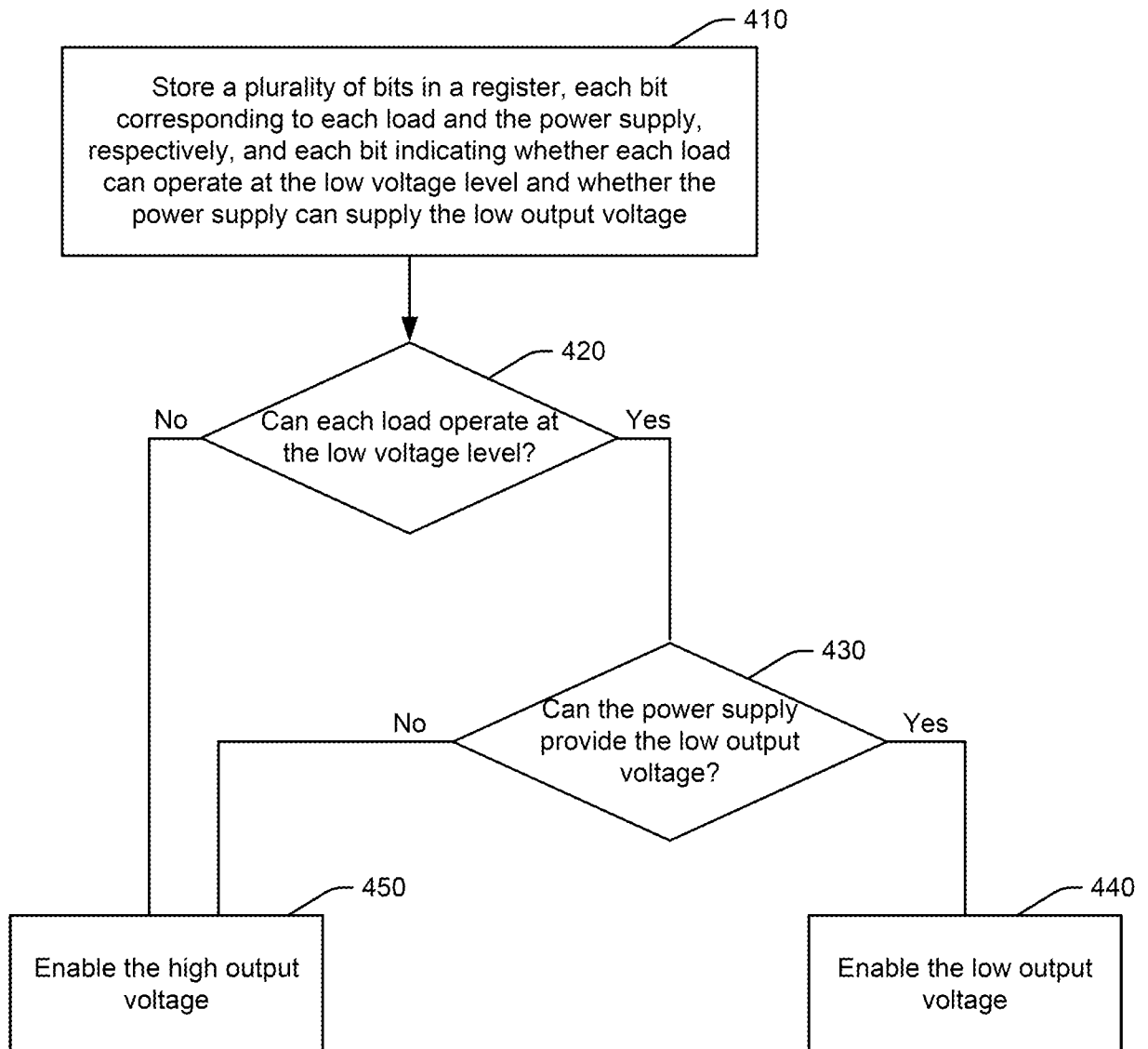


FIG. 4

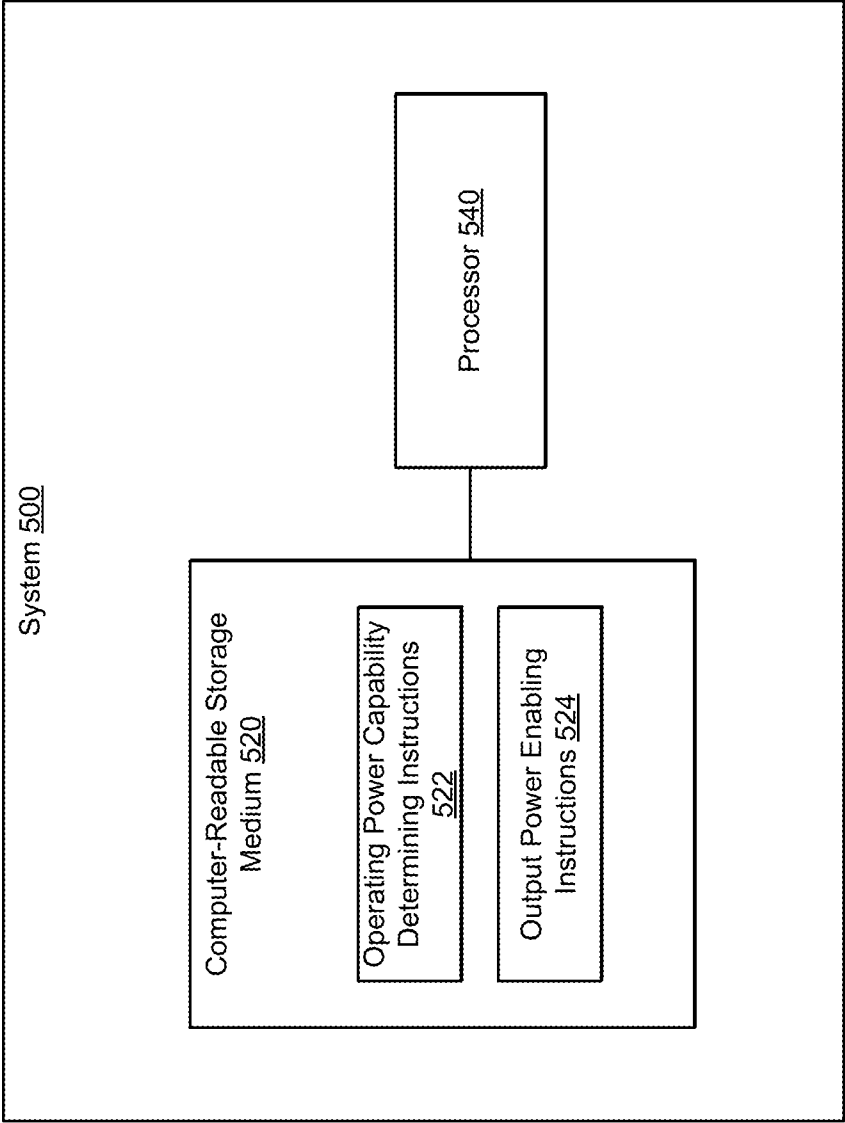


FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2015/031250**A. CLASSIFICATION OF SUBJECT MATTER****G06F 1/26(2006.01)i, G06F 1/32(2006.01)i**

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHEDMinimum documentation searched (classification system followed by classification symbols)
G06F 1/26; G06F 17/50; H02J 1/00; H02J 7/00; G06F 1/32; H03K 17/00Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility modelsElectronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & keywords: power supply, control module, operating power capability, a plurality of loads, low output voltage**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2013-0285614 A1 (LYALL KENNETH WINGER et al.) 31 October 2013 See paragraphs [0048]-[0052]; claim 5; and figure 4.	1-15
A	US 8712741 B2 (JEFFREY ROBERT PERRY et al.) 29 April 2014 See column 7, line 26 - column 8, line 58; and figure 2.	1-15
A	US 2012-0117402 A1 (ERIK P. MACHNICKI et al.) 10 May 2012 See paragraphs [0019]-[0031]; and figure 1.	1-15
A	US 2012-0054515 A1 (SAMUEL D. NAFFZIGER et al.) 01 March 2012 See paragraphs [0017]-[0025]; and figure 1.	1-15
A	US 2011-0057724 A1 (GUS CHARLES PABON) 10 March 2011 See paragraphs [0044]-[0058]; and figure 4.	1-15

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search
20 April 2016 (20.04.2016)Date of mailing of the international search report
22 April 2016 (22.04.2016)Name and mailing address of the ISA/KR
International Application Division
Korean Intellectual Property Office
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2015/031250

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