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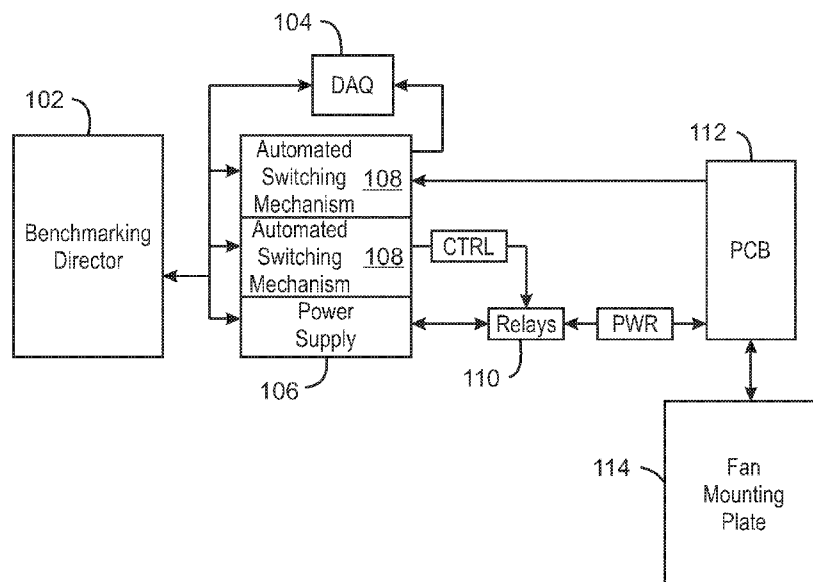
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[Continued on next page]

(54) Title: FAN BENCHMARK



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FIG. 1

(57) Abstract: In an example, a system to benchmark a fan can include a power supply to provide power and vary a voltage to a fan. The system can also include a memory resource to store instructions that, based at least on execution by a processing resource, determines a startup voltage, startup current, and nominal current for the fan. The system can also include a revolutions counter to report a number of revolutions per minute of the fan at a nominal voltage.



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FAN BENCHMARK

BACKGROUND

[0001] Computing systems can generate heat that can be dispersed and reduced through the use of moving air over a heated component. A fan can generate an air current in order to move air or another fluid in an intended direction. Reliability and proper functioning of a system's fan can assist in the reduction of the temperature of a heated component, and thereby improve the functioning of the component and system.

BRIEF DESCRIPTION OF THE DRAWINGS

[0002] Certain examples are described in the following detailed description and in reference to the drawings, in which:

[0003] FIG. 1 is a schematic diagram of an example of benchmarking a number of fans on a mounting plate;

[0004] FIG. 2 is a block diagram of an example printed circuit board and relays for benchmarking a number of fans;

[0005] FIG. 3 is a block diagram of an example of a simplified user interface for controlling aspects of benchmarking a fan;

[0006] FIG. 4 is a block diagram of an example system for benchmarking a fan;

[0007] FIG. 5 is a block diagram of an example of another system for benchmarking a fan;

[0008] FIG. 6 is a process flow diagram of an example method for benchmarking a fan; and

[0009] FIG. 7 is a block diagram of an example non-transitory, computer-readable medium comprising code that when executed by a processing resource benchmarks a fan.

DETAILED DESCRIPTION OF SPECIFIC EXAMPLES

[0010] Increased demand for fan reliability evaluations caused bottlenecking in the manual benchmarking step due to its labor intensity and limited capacity. This bottleneck from manual testing may lead to delays in test start time and add undue

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risk to product timelines and go-to-market deadlines. In practice, manual testing can be time consuming and more prone to reading inaccuracies and errors. Oscillations or drift of measurement equipment can lead to operator judgment being used to determine the recorded value in these examples, leading to interpretation errors, larger variations in measurements, and less repeatability in the results.

[0011] As described herein, the use of automated testing can reduce benchmark cycle time, increase accuracy and precision in testing, and allow technicians to do other work in parallel as testing proceeds. In one example, the present techniques include the automation of a fan benchmarking process which can be performed multiple times for every fan evaluated. For example, the benchmarking can be performed before and after environmental reliability testing. The present techniques can include instructions stored in a memory resource, such as LabVIEW program instructions, that when executed on a processing resource, interacts with different instruments, a custom designed printed circuit board (PCB), and a number of fans.

[0012] Using automation allows the automatic testing of a large number of fans by an automated system in a batch. As disclosed herein, the techniques discussed automatically measure and document the startup and operating properties of a number of connected fans at a time, avoiding operator intervention. As used herein, benchmarking and benchmark measurements includes measurements of RPM, current, voltage, and other characteristic parameters taken at a various conditions. The presently disclosed techniques can also provide digital documentation and formatting of testing results with outlier detection.

[0013] FIG. 1 is a schematic diagram 100 of an example of benchmarking a number of fans on a mounting plate. The schematic here includes boxes and arrows to show, in part, the linking of components, the flow of data, and the flow of power.

[0014] Equipment layout and general connection data paths through a benchmarking director 102 can control and perform processing of data. The benchmarking director can be a computer, implemented instructions stored in a memory, or other suitable process and hardware control. The benchmarking director 102 can communicate, command, and receive communications from a data acquisition unit (DAQ) 104, a power supply 106, and automated switching mechanisms 108. The automated switching mechanisms can include computer

controlled relays such as switch control units, or other suitable mechanisms. In an example, these communications and commands can take place through a General Purpose Interface Bus (GPIB). The benchmarking director 102 can also collect, analyze, and export received data. The data collected, analyzed, and exported may have come through the connected DAQ 104.

[0015] One of the automated switching mechanisms 108 can communicate commands to switch fans and data gathering from different fans through relays 110 which may also control which fan or fans receives power from the power supply 106. The relays can transmit data signals and power through a PCB 112 to the fan mounting plate 114. The fan mounting plate 114 can mount a fan and allow the supply of power and a variable voltage to that fan. In an example, the fan mounting plate can hold a large number of fans simultaneously in such a way that instructions from the benchmarking director 102 can be carried out through signals and power supply to the fans in order to gather requested benchmarking data.

[0016] When a fan on the fan mounting plate 114 undergoes testing, the PCB 112 can also detect raw benchmarking data that can be sent through an automated switching mechanism 108 to arrive at the DAQ 104. Raw benchmarking data can include measurements of revolutions per minute (RPM), current, voltage, and other characteristic parameters taken at various conditions. The current and voltage can include a starting voltage and a starting current as well as a nominal current and a nominal voltage. The starting voltage can be determined by finding the value of voltage at which a particular fan begins to spin. The nominal voltage and current relate to the voltage and current values when the power supplied allows satisfactory operation of the circuit within an operational range. As various circuits carry various nominal ranges, the nominal voltage and nominal current can vary with the circuit. In the presently disclosed techniques, the benchmarking director 102 accounts for these various nominal circuit voltages by measuring fan benchmarking data for nominal voltages of a particular circuit and analyses the benchmarking data received in light of the nominal voltages measured for the particular circuit.

[0017] The DAQ 104 can provide the raw benchmarking data to the benchmarking director 102 for further analysis, processing, and output. The output can include a user file such as a spreadsheet, a benchmarking report, or a pass fail result on specific fans by their position or number.

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[0018] The PCB 112 can be custom built component tailored to the specific fan mounting plate 114 or also the number of fans there mounted. In an example, the relays 110 can be used to interface with the fans on the fan mounting plate 114 and can control the power (PWR) separately and varied for fans connected. The relays can be directed through a control (CTRL) signal provided by the automated switching mechanism 108. In an example, the PWR provided can include a varied voltage, current or other control signals to the fans. The specific relays 110 arrangement can depend on the particular construction of the PCB 112 as a varied type of connectors can increase the number of interface configurations of the relays 110.

[0019] FIG. 2 is a block diagram of an example printed circuit board 112 and relays 110 for benchmarking a number of fans. Like numbered items are as described in FIG. 1. The schematic shows, in part, connections, communications, and more detail of the components on the PCB 112.

[0020] The PCB 112 can receive power and control data from the relays 110 to a number of connectors located on the PCB 112. In an example, the connection points can include connectors 202, screw terminals 204, or other suitable connectors to transmit power and data control signal to a fan mounting plate 114. While connectors 202 are shown, other two-piece pin and socket connections can be used such as cable connectors as well as other suitable connectors and interconnects for transmitting power, controlling fan movement, and receiving any data that may come back from a fan on the fan mounting plate 114. In an example, a connector to fan connection can include four lines such as a voltage line, a ground wire, a speed control (Pulse Width Modulation (PWM)), and a rotation detection/alarm (RD or RDA) or tachometer line. These lines or wires can be standalone wires or traces on the PCB 112. The RDA line can provide if the fan presently rotates or not.

[0021] The screw terminals 204 can be for fans not suited for the connectors 202 or other two-piece pin and socket connections, or work better with screw connectors. The screw terminals 204 can allow for legacy support since screw terminals 204 can work on fans or other equipment to be tested, for example up to 10 amps. In an example, the connectors 202 can be 4 amps rated and can be connected to a series of jumpers 206 to allow different pinouts to be set for the variety of fans that can be present in the fan mounting plate 114. In an example,

there can be a large number of connectors 202, and each connector can have a number of pins. In an example, each pin of a connector 202 can have an associated jumper 206 selection for configuring the pinout. This allows different fan pinouts to be configured for and different fans tested utilizing the same hardware infrastructure. In an example, having separate low and high current connection points like connectors 202 at 4 amps and screw terminals 204 at 10 amps can allow for lower current fans to use lower amp connectors 202 which in some examples may be low cost and allow for quicker connection and disconnection compared to the screw terminals 204. In an example of connector configurations, a lower current connector can allow smaller trace and via sizes for the PCB 112 in order to help make the PCB 112 suitably compact and maintain a form factor appropriate for the PCB 112.

[0022] The revolution counter 208 can include a stroboscope tachometer. The revolution counter 208 can include connector cables to connect to a fan or a number of fans on the fan mounting plate 114. The revolution counter can include digital counting of revolutions through a tachometer line and signal indicating if a particular fan can rotate and the fans rotation speed in terms of revolutions per a period of time such as revolutions per minute (RPM). In an example, the tachometer line can provide a pulse per motor winding, from which you can calculate the RPM. As the revolution counter 208 can be part of the PCB 112, the information received here about a fan's RPM can be transmitted through an automated switching mechanism 108 to the DAQ 104 and back to a benchmarking director 102 for storage and processing. Tachometer lines from fans can proceed through either the connectors 202 or the screw terminal 204 where these signals are then fed out through an automated switching mechanism 108 and the DAQ 104.

[0023] FIG. 3 is a block diagram of an example of a simplified user interface 300 for controlling aspects of benchmarking a fan. The user interface shown can be implemented as a user facing interface and display utilizing the hardware and process shown in FIG. 1 and FIG. 2 as well as other disclosed examples.

[0024] The displayed window 302 can be displayed to a user through a computer display, monitor built into a benchmarking device, or other suitable display and means for input and output with a user. In an example, the displayed window 302 can include a user input area 304 where a user can adjust settings for benchmarking. In the user input area 304 a number of inputs can be provided

including the indication of a save location 306 for data gathered and stored by a benchmarking director 102. The user input area 304 can also include a unique identifier 308 to identify a particular fan name or number that can be assigned to a fan being tested. In the user input area 304 can include a user adjustable output selection 310 where the output format of the data can be selected. For example an output selection 310 can be a spreadsheet, a text file, or another suitable output format. The user input area 304 can also include benchmark boundaries 312 that can indicate, for example, a start and end point of benchmark testing. The start and end points can be a specific number of fans, fans of a specific age, or fans with a certain time elapsed since last benchmark testing. The user input area 304 can also include signal options 314, pre/post benchmark options 316, and fan options 318. The signal options 314 can be manually set to indicate the type of revolution counter 208 may be active such as a digital signal indicating fan RPM through a tachometer line. In another example, the signal options 314 can be set to tachometer or manual tachometer to indicate the use of a stroboscope tachometer or other similar technology to determine through analog means the RPM. The pre/post benchmarking options 316 can include a user input to determine when benchmarking testing can occur. The pre/post benchmarking setting can indicate when benchmarking occurs. The use of the pre/post benchmarking setting can be used later in a spreadsheet macro or data manipulation program to format both preliminary testing data and post benchmarking testing data together into a single formatted file. The fan options 318 can indicate if a fan may be a single or double rotor which can affect how the data for a fans or fans rotation can be treated. The fan options 318 can indicate how a method processing data can follow different processes based on if the fans in a fan mounting plate 114 vary between single and double fans.

[0025] The displayed window 302 can also include raw data display 320, indicators 322, RPM display 324, voltage/current display 326, relay power 328, and tachometer select 330. The raw data display 320 can display the raw data as it can be received including benchmark data and continue to display that data for the fans tested. The indicators 322 can show or display which phase of testing may be underway at a particular moment displaying a filled in light if the power supply is active, if rotation can be detected, if a measurement can be taken as to voltage,

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current, or RPM, and if any other suitably indicated measurements are taken. The RPM display 324 can be an extension of the rotation indicator indicating the RPMs recorded over time, either for a specific fan being currently tested or a number of fans. The voltage/current display 326 can show measured current and voltage values over time for either a fan at a time or can show a progression from fan to fan. The relay power 328 can be a display to indicate which relay connected to the PCB 112 receives power at a particular time. The tachometer select 330 can show a particular tachometer currently receiving or providing data about an RPM.

[0026] While the items in FIG. 3, show some inputs and outputs a user can have access to, many other configurations and options could be added, adjusted, moved, or removed. The presently disclosed techniques could also have additional fan/runtime options and display of current test data and progress. In an example, a user input area 304 can also include manual RPM that could have been measured by a user through use of a stroboscope. Another adjustment is shown in raw data display 320 including an average correction factor for a voltage drop based on the connections from a memory resource 404. Another correction factor can be based on the voltage drop from current passing through the cabling, traces, or other parts used for connections between the PCB and the fan or fans. The use of an average correction factor may allow for a good calculation of the voltage at the fan based upon an effective resistance value and current measurements. In the RPM display 324 and the voltage/current display 326, multiple tests can be taken for measurements and averaged to form average benchmark values for reporting. While multiple tests can be formed and used to generate an average benchmark value, the number of tests performed can be determined by a user. The number of tests performed can also be a default value. As may be displayed or selected through the displayed window 302, startup voltage detection can be accomplished through a binary search algorithm that can be implemented to avoid the trial and error searching methods otherwise often chosen by a user undertaking manual testing. In examples where the binary search algorithm may be used, the user may also adjust to a level of accuracy of the startup voltage through the ability to control the maximum voltage change between 2 sequential tested voltages for starting ability.

[0027] Additionally, the user input area 304 can allow the manipulation of an Effective System Resistance (ESR) setting. The ESR setting can measure and account for the resistance of wiring and fan drop. In an example, the specific resistance can be an exact resistance entry or can be a number of fans a system will be managing input for in order to approximate resistance based on the number of fans. Other options include the adjusting of a current limit for a system where current limit can be limited from the power supply 106. In another example, the power supply 106 can trip and turn off if use exceeds a current limit. If exceeding the current limit, the method can stop with a popup message displaying. Another option can include RDA current threshold or an RPM Threshold for TACH lines. Both of which set the threshold for fans to be determined to be "on".

[0028] A setting of the user input area 304 can include multiple timing and delay adjustments to account for the various differences present between fan samples and to also allow overall program speed optimizations. In an example, these could include fan startup spin up, fan 12V spin up, fan spin down, and over 12V spin up delays. These represent the various delay times for the fans to both fully power up and fully stop under various conditions. In an example, an option in the user input area 304 can include a listing and adjustment of fan poles, including the number of poles on the motor. A setting for accuracy, measured in volts, can display and adjust a set startup voltage accuracy to be used through the benchmarking process. In an example, if sequential test voltages are within a certain tolerance, or variance in the test voltage determined is lower than the set accuracy, then the startup search can stop and use the voltage identified as the startup voltage. A setting adjustable in the user input area 304 can also include outlier detection settings. In an example, outliers can be determined via a simple standard deviation multiple or a more complex algorithm such as Chauvenet's criterion based upon the measured properties of the sample population.

[0029] Additional settings and options can include test equipment GPIB addresses and reset delays. In an example where delays are too short, subsequent GPIB commands can result in a timeout error. Additional settings and options can include various program limits such as startup voltage increment limit that limits the number of times a startup voltage will be re-tried after previously determined to work. Additional limits can also include high voltage and low voltage limits which define the

range of startup voltages that can be tried. Additional settings and options can include a Voltage Range to include an option that after the startup voltage for the 1st fan is determined, subsequent fans' tested startup voltage ranges are reduced to the Voltage Range surrounding the 1st fan's startup voltage, improving overall speed.

[0030] Additional settings and options can include measurement settings, such as sample rate and duration for both fan rotation detection and current/voltage measurement periods. Additional settings and options can include relay matrix size where the number of relays used to control power to the fans can be sized for the current implementation.

[0031] Indicators 322 in the display window 302 can include: fan to indicate the current fan being tested, countdown to indicate time until a next measurement period, and set voltage indicating the current power supply voltage. Indicators 322 in the display window 302 can include: a power supply indicator to show when a power supply is enabled, rotation to indicate a fan rotation, DAQ measure to show when measurements by a DAQ are taken, power supply measure indicator to include indication that a power supply is measuring, and a final startup to indicate the taking of a final property measurement.

[0032] The output of data can also be manipulated once stored, in some examples a user has developed a spreadsheet to convert a comma delimited output to a formatted spreadsheet based upon a previously used format. In the data handling performed, outlier detection in multiple trials can be automated based on upon a user settable criteria.

[0033] FIG. 4 is a block diagram of an example system for benchmarking a fan. Like numbered items are as described here and as in FIG. 2. The computing device 400 may be, for example, an access point controller, a server, a laptop computer, desktop computer, tablet computer, mobile device, among others. The computing device 400 may include a processing resource 402 such as a central processing unit (CPU) that may be configured to execute stored instructions, as well as a memory resource 404 that stores instructions that are executable by the processing resource 402. The processing resource 402 may be coupled to the memory resource 404 by a bus 406. The processing resource 402 can be a single core processor, a multi-core processor, a computing cluster, or any number of other configurations. Furthermore, the computing device 400 may include more than one

processing resource 402. The processing resource 402 can also connect through a storage array interface 408 to external storage arrays 410 by the bus 406. The storage array 410 can be an external system or array of systems that are hosting its own guest virtual machines or interacting with the virtual machines of the computing device 400.

[0034] The computing device 400 may also include a storage device 412. The storage device 412 can be a non-volatile storage device such as a hard drive, an optical drive, a thumbdrive, an array of drives, or any combinations thereof. The memory resource 404 can include random access memory (RAM), flash memory, or any other suitable memory systems. For example, the memory resource 404 may include dynamic random access memory (DRAM).

[0035] The computing device 400 and its components may be powered by a power supply 414. The processing resource 402 may be coupled to the power supply through the bus 406 which may communicate control signals or status signals between the processing resource 402 and the power supply 414. The power supply 414 may be further coupled to a power source 416. The power source 416 can be a supply external to the computing device 400 such as an external source with a battery backup, or an internal power supply such as a battery. In examples with a power source 416 that includes a power source backup, the processing resource 402 can control the functioning of the backup over a bus 406.

[0036] The processing resource 402 may also be connected through the bus 406 to an input/output (I/O) device interface 418 configured to connect the computing device 400 to one or more I/O devices 420. The I/O devices 420 may include, for example, a keyboard and a pointing device, wherein the pointing device may include a touchpad or a touchscreen, among others. The I/O devices 420 may be built-in components of the computing device 400 or may be devices that are externally connected to the computing device 400.

[0037] The processing resource 402 may be linked through the bus 406 to a display interface 422 configured to connect the computing device 400 to a display device 424. The display device 424 may include a display screen that may be a built-in component of the computing device 400. The display device 424 may also include a computer monitor, television, or projector, among others, that can be

externally connected to the computing device 400 or built into the computing device 400, for example, in a laptop or tablet.

[0038] The computing device 400 also includes a benchmarker 426 to manage, control, communicate, and direct power for the purpose of testing benchmark data. The benchmarker 426 can include instructions that when executed by a processing resource 402 gather voltage data, current data, and rotation data from benchmarked items. The computing device 400 can also include a fan interface 428 to connect the computing device 400 to a fan 430. The fan 430 can represent a fan or several fans, and may be shown connected through the system bus 406 to the other components for interaction, connection, and calculation to achieve benchmarking automatically avoiding manual interaction.

[0039] The block diagram of Fig. 4 may not be intended to indicate that the computing device can include the components shown in Fig. 4. Further, the computing device 400 may include any number of additional components not shown in Fig. 4, depending on the details of the specific implementation.

[0040] FIG. 5 is a block diagram of an example of another system for benchmarking a fan. Like numbered items are as shown in Fig. 4. The computing device 400 can include a power supply 414 to provide power and vary a voltage to a fan. The computing device can also include a memory resource 404 to store instructions that, based at least on execution by the processing resource 402, determines a startup voltage, startup current, and nominal current for the fan 430. The computing device can also include a revolutions counter 208 to report a number of revolutions per minute of the fan 430 at a nominal voltage.

[0041] In an example, the power supply 414 can provide and vary power to a second fan and the memory resource 404 can store instructions that, based at least on execution by the processing resource 402, determine a second startup voltage, a second startup current, and a second nominal current corresponding to the second fan. In an example, the revolutions counter 208 can report a second number of revolutions per minute corresponding to the second fan the nominal voltage. In an example, the fan and second fan are mounted on a mounting plate using a matrix method. The matrix method can include grouping fans in a grid so that common positive and negatives align and the fans can be powered with fewer relays and connection points back to the automated switching mechanism when compared to

having a relay for the fan to be benchmarked. In an example, the computing device 400 can include an automated switching mechanism that, based at least on execution of the instructions by the processing resource 402, the automated switching mechanism can direct a relay to switch the power supply 414 and revolutions counter 208 from the fan to the second fan.

[0042] In an example, the computing device 400 can include a printed circuit board to connect the power supply, memory resource 404, processing resource 402, automated switching mechanism, relay, and revolutions counter 208 to the fan. The printed circuit board can include a connector comprising at least one of a two-piece pin and socket connection a screw connection. In the computing device 400, the memory resource 404 may include instructions to perform at least one of setting timing and delays for the fan and a second fan, returning to a display current test data and progress, and process received user input of revolutions input. In the computing device 400, the memory resource 404 may include instructions to perform at least one of implementing an average correction factor for a voltage drop and forming average benchmark values based on a number of benchmark iterations finding the starting voltage, starting current, nominal current, and the number of revolutions per minute. In an example, multiple readings can be used to create an average for all automated measurements including current and voltage as well as RPM, or other automated measurements.

[0043] The computing device 400 can include a startup voltage that can be found by varying power supplied to the fan based on a binary search algorithm. In an example, the revolutions counter 208 can be connected to the fan tachometer output lines.

[0044] FIG. 6 is a process flow diagram of an example method 600 for benchmarking a fan. The method 600 shown here can be implemented on the systems shown in FIG. 4 and FIG. 5, as well through the schematics discussed in FIG. 1 and FIG. 2. Process flow begins at block 602.

[0045] At block 602, the method 600 includes providing power to a fan. The amount of power can be a nominal amount of voltage, a starting amount of voltage, or another suitable voltage. At block 604, the amount of power voltage to the fan can be varied. The variance achieved allows a specific determination of starting voltage. At block 606, the method 600 includes, based at least on execution of

stored instructions by a processing resource, a determination of a startup voltage, a startup current, a nominal current for the fan, and a number of revolutions per minute of the fan at a nominal voltage. In an example, the method 600 can also include providing power to a second fan, varying voltage to the second fan. The method 600 can also determine a second startup voltage, a second startup current, and a second nominal current corresponding to the second fan, and a second number of revolutions per minute corresponding to the second fan the nominal voltage.

[0046] The presently disclosed method 600, can also include setting timings and delays for the fan and a second fan, returning to a display current test data and progress, and processing received user input of RPM input. The disclosed method 600 also can include implementing an average correction factor for a voltage drop. In an example, the method may also include forming average benchmark values based on a number of benchmark iterations finding the starting voltage, starting current, nominal current, and the number of RPMs.

[0047] FIG. 7 is a block diagram of an example non-transitory, computer-readable medium 702 comprising code 700 that when executed by a processing resource 402 benchmarks a fan. Like numbered items are as described in FIG. 4.

[0048] The computer-readable medium 702 can be accessed by a processing resource 402 over a system bus 406. The computer-readable medium 702 can include the power provider 704 to provide a power supply. The computer-readable medium 702 can also include a voltage controller 706 to vary power and voltage to a fan. The computer-readable medium can also include a voltage, current, and revolution determiner 708 to direct the processing resource determine a second startup voltage, a second startup current, a second nominal current corresponding to the second fan, and a second number of revolutions per minute corresponding to the second fan the nominal voltage.

[0049] In an example, the computer-readable medium 702 can include an arrangement where the fan and second fan are mounted on a mounting plate using a matrix method. In an example, the computer-readable medium 700 can include an automated switching mechanism that, based at least on execution of the instructions by the processing resource 402, directs a relay to switch the power supply and revolutions counter from the fan to the second fan.

[0050] The block diagram of FIG. 7 may not be intended to indicate that the computer-readable medium 702 can include the components or modules shown in FIG. 7. Further, any number of additional components may be included within the computer-readable medium 702, depending on the details of the management of application properties disclosed herein.

[0051] While the present techniques may be susceptible to various modifications and alternative forms, the examples discussed above have been shown by way of example. It may be understood that the techniques are not intended to be limited to the particular examples disclosed herein. Indeed, the present techniques include alternatives, modifications, and equivalents falling within the scope of the appended claims.

CLAIMS

What is claimed is:

1. A system comprising:
a power supply to provide power and vary a voltage to a fan;
a memory resource to store instructions that, based on execution by a processing resource, to determine a startup voltage, startup current, and nominal current for the fan where determined voltages and currents to implement a correction factor based on connections from the memory resource to the fan; and
a revolutions counter to report a number of revolutions per minute of the fan at a nominal voltage, wherein the number of revolutions per minute to be measured and reported multiple times to form an average benchmark value for the number of revolutions.
2. The system of claim 1, wherein:
the power supply to provide and vary power to a second fan;
the memory resource to store instructions that, on execution by the processing resource, to determine a second startup voltage, a second startup current, and a second nominal current corresponding to the second fan; and
the revolutions counter to report a second number of revolutions per minute corresponding to the second fan the nominal voltage.
3. The system of claim 2, wherein the fan and second fan are mounted on a mounting plate using a matrix method.
4. The system of claim 2, comprising an automated switching mechanism that, based on execution of the instructions by the processing resource, to direct a relay to switch the power supply and revolutions counter from the fan to the second fan.
5. The system of claim 4, comprising:

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a printed circuit board to connect the power supply, memory resource, processing resource, automated switching mechanism, relay, and revolutions counter to the fan; and
the printed circuit board to comprise a connector comprising at least one of a two-piece pin and socket connection or a screw connection.

6. The system of claim 1, wherein, based on execution by the processing resource, the memory resource comprises the instructions to perform at least one of:
set timings and delays for the fan and a second fan;
return to a display current test data and progress; and
process received user input of revolutions input.

7. The system of claim 1, wherein the startup voltage is found by varying power supplied to the fan based on a binary search algorithm.

8. The system of claim 1, wherein the revolutions counter connect to fan tachometer output lines.

9. A method comprising:
providing power to a fan;
varying a voltage to the fan;
determining, based on execution of stored instructions by a processing resource, a startup voltage, a startup current, a nominal current for the fan, and a number of revolutions per minute of the fan at a nominal voltage;
implementing a correction factor for determined voltages and currents based on connections from a memory resource to the fan; and
measuring and reporting the number of revolutions per minute multiple times to form an average benchmark value for the number of revolutions per minute.

10. The method of claim 9, comprising:
providing power to a second fan;

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varying voltage to the second fan; and
determining a second startup voltage, a second startup current, and a second nominal current corresponding to the second fan, and a second number of revolutions per minute corresponding to the second fan the nominal voltage.

11. The method of claim 9, comprising at least one of:
setting timings and delays for the fan and a second fan;
returning to a display current test data and progress; and
processing received user input of revolutions input.

12. A tangible, non-transitory, computer-readable medium comprising instructions that, when executed by a processing resource, direct the processing resource to:

provide power to a fan with a power supply;
vary a voltage to the fan with the power supply;
determine, based at least on execution of stored instructions by a processing resource, a startup voltage, a startup current, a nominal current for the fan; and a number of revolutions per minute of the fan at a nominal voltage;
implement a correction factor for determined voltages and currents based on connections from a memory resource to the fan; and
measure and report the number of revolutions per minute multiple times to form an average benchmark value for the number of revolutions per minute.

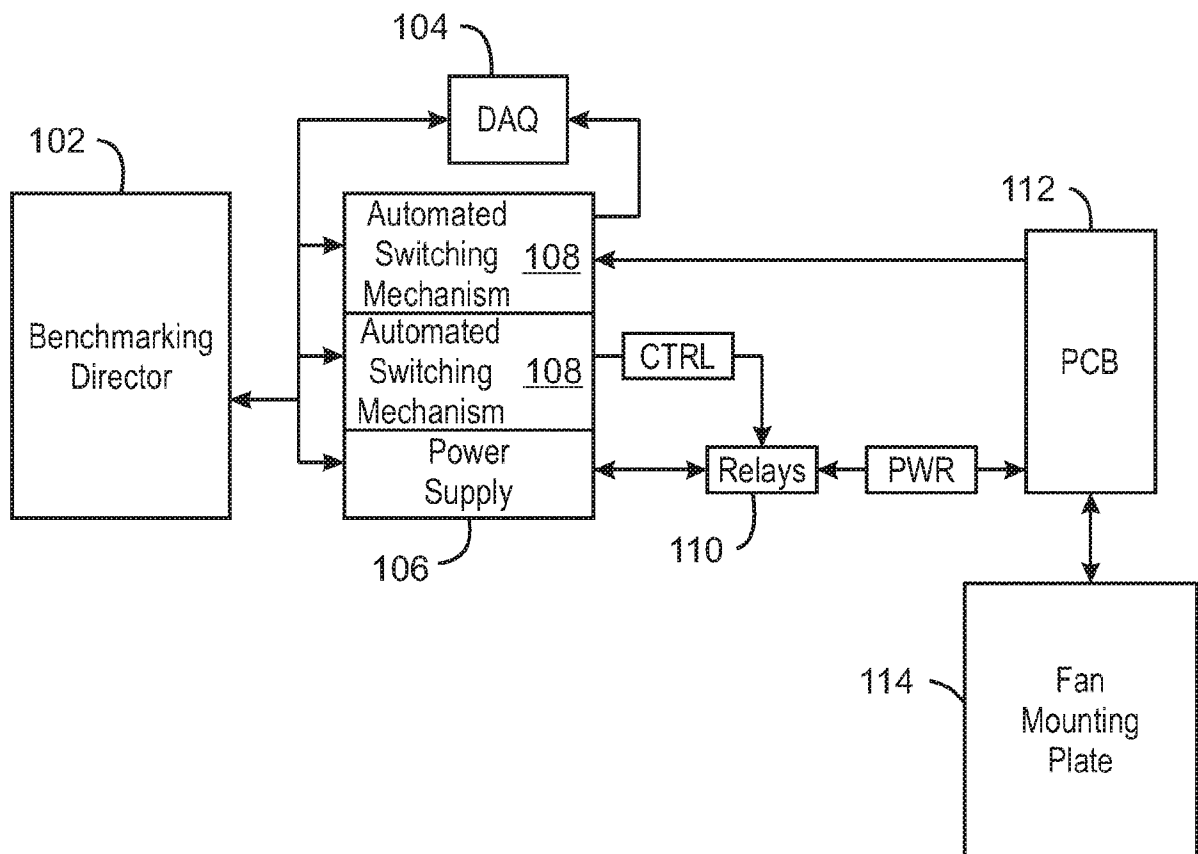
13. The computer-readable medium of claim 12, wherein:
the power supply is to provide and vary power to a second fan; and
the instructions to direct the processing resource determine a second startup voltage, a second startup current, a second nominal current corresponding to the second fan, and a second number of revolutions per minute corresponding to the second fan the nominal voltage.

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14. The computer-readable medium of claim 13, wherein the fan and second fan are mounted on a mounting plate using a matrix method.

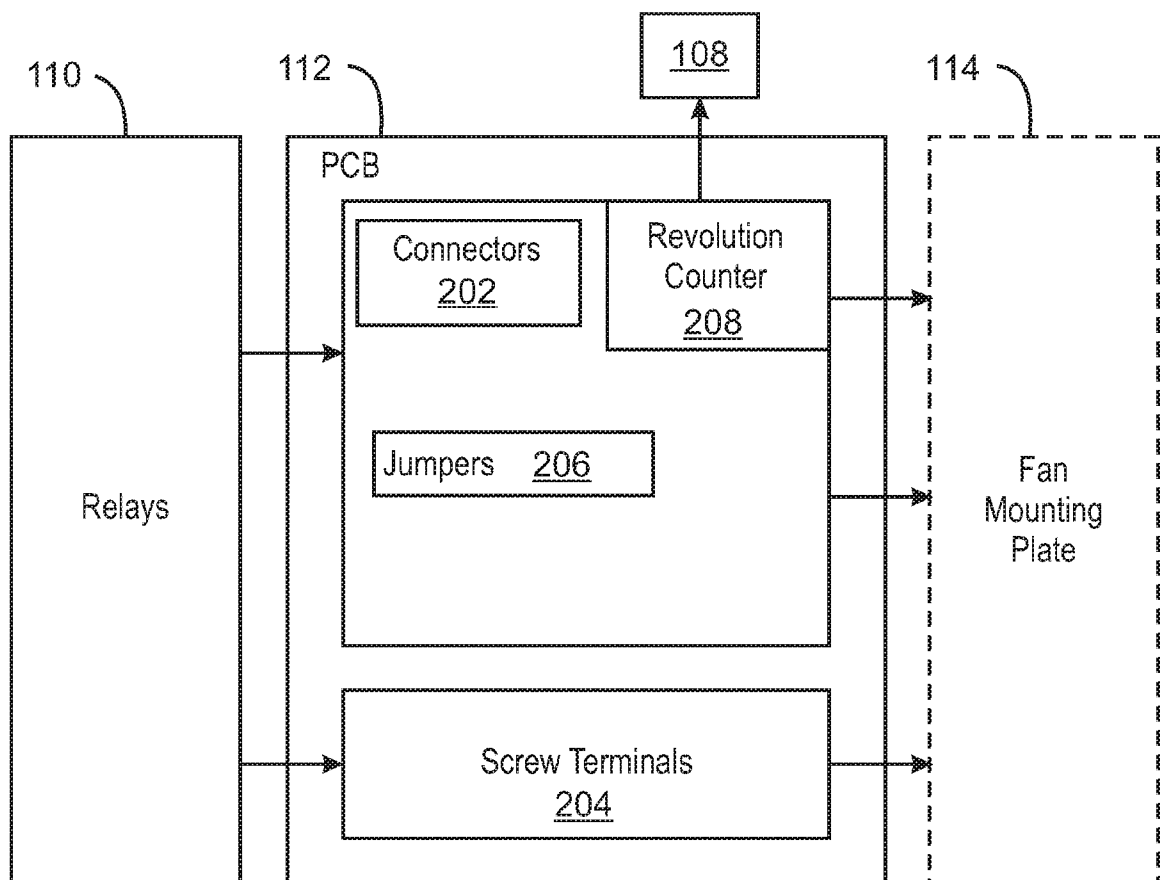
15. The computer-readable medium of claim 13, comprising an automated switching mechanism that, based at least on execution of the instructions by the processing resource, directs a relay to switch the power supply and revolutions counter from the fan to the second fan.

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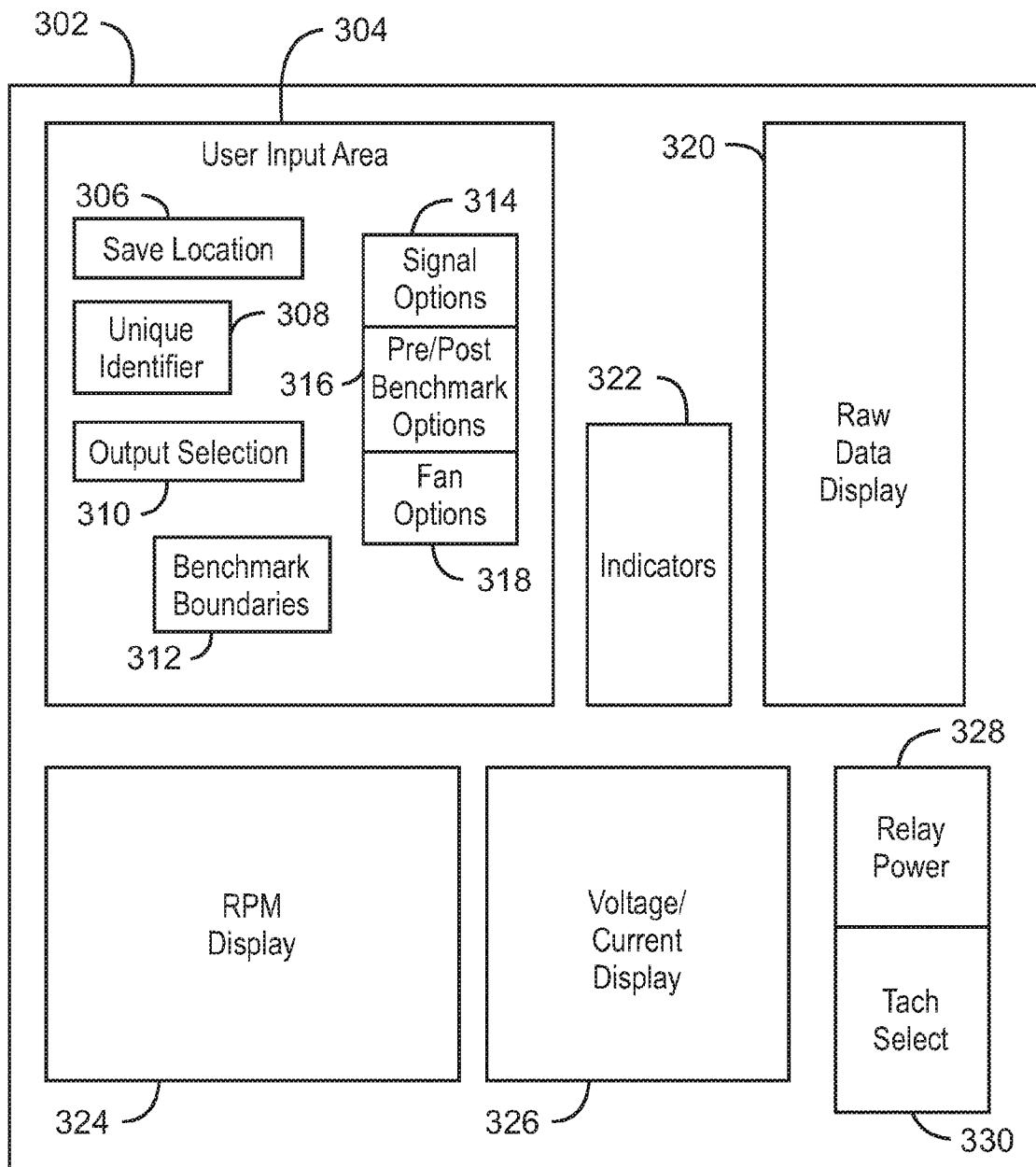
100
FIG. 1

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200
FIG. 2

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300
FIG. 3

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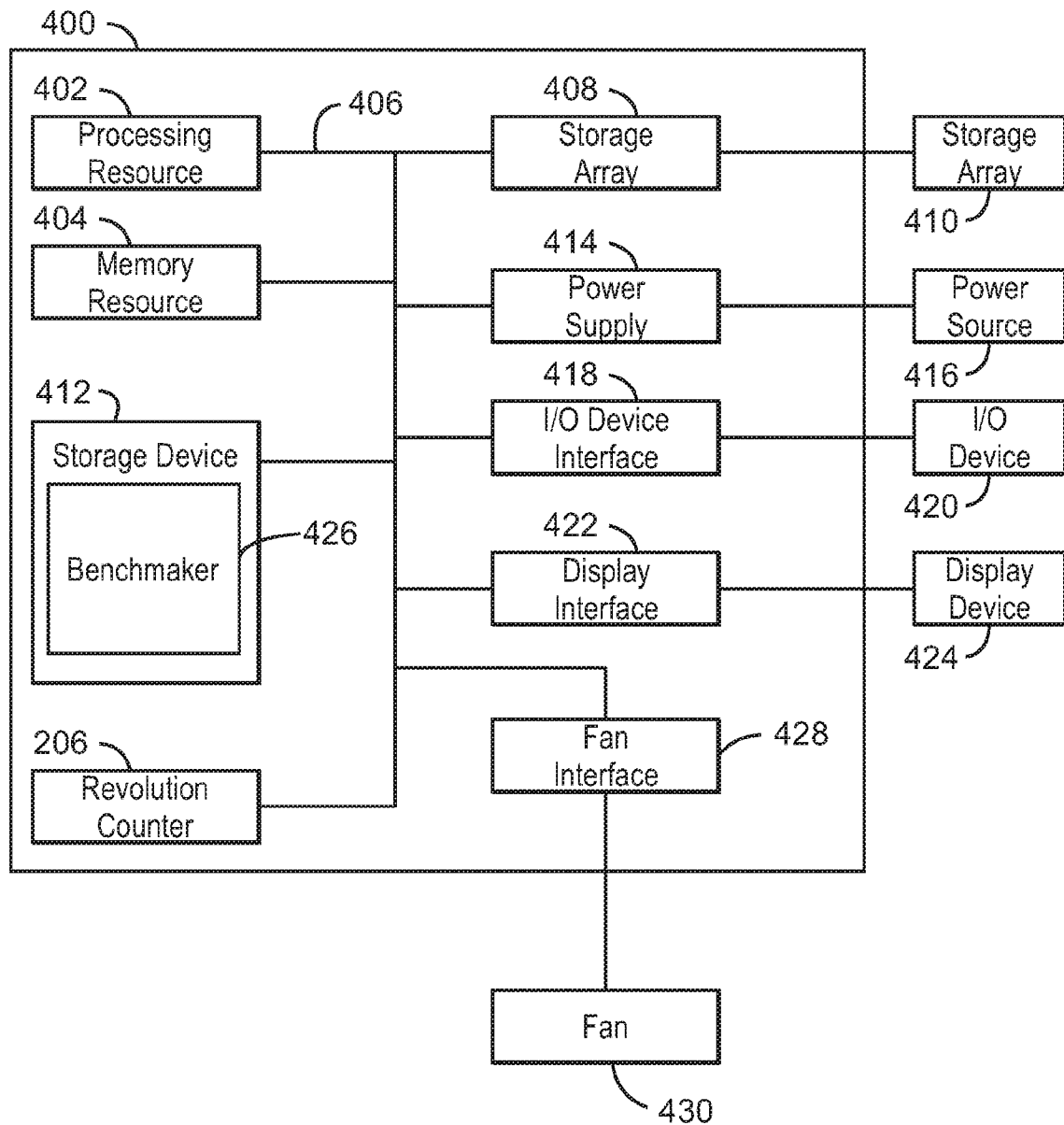


FIG. 4

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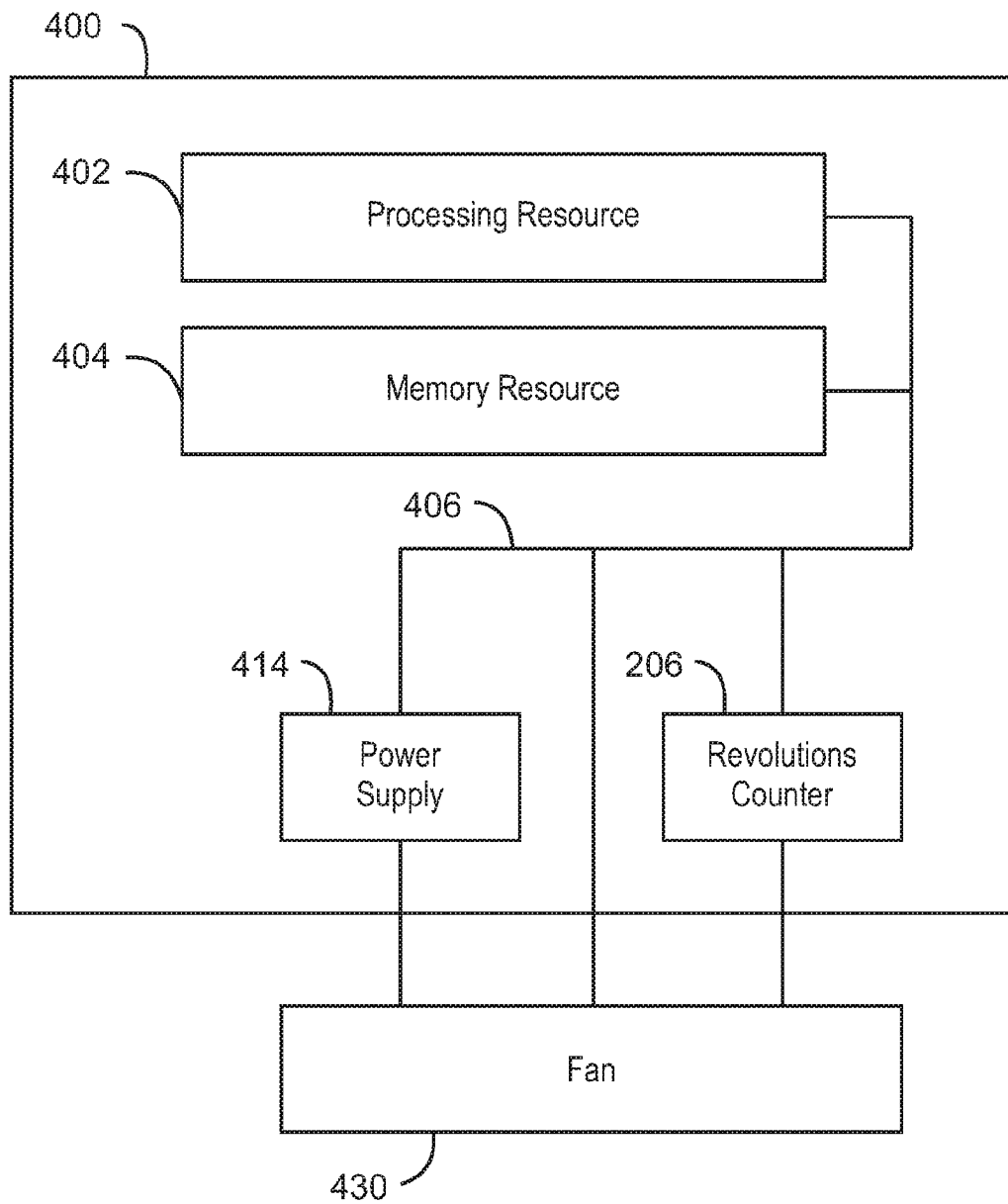
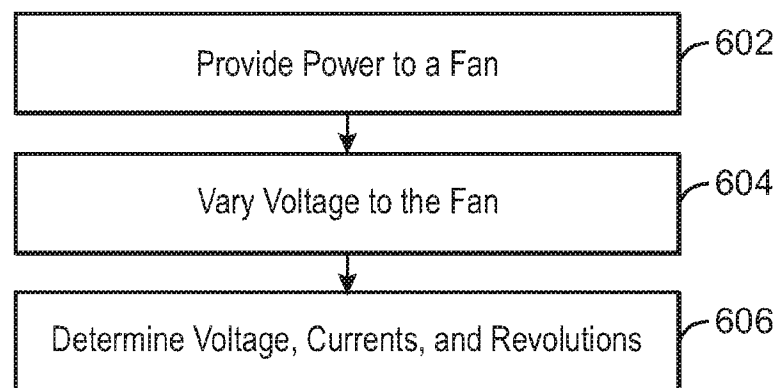


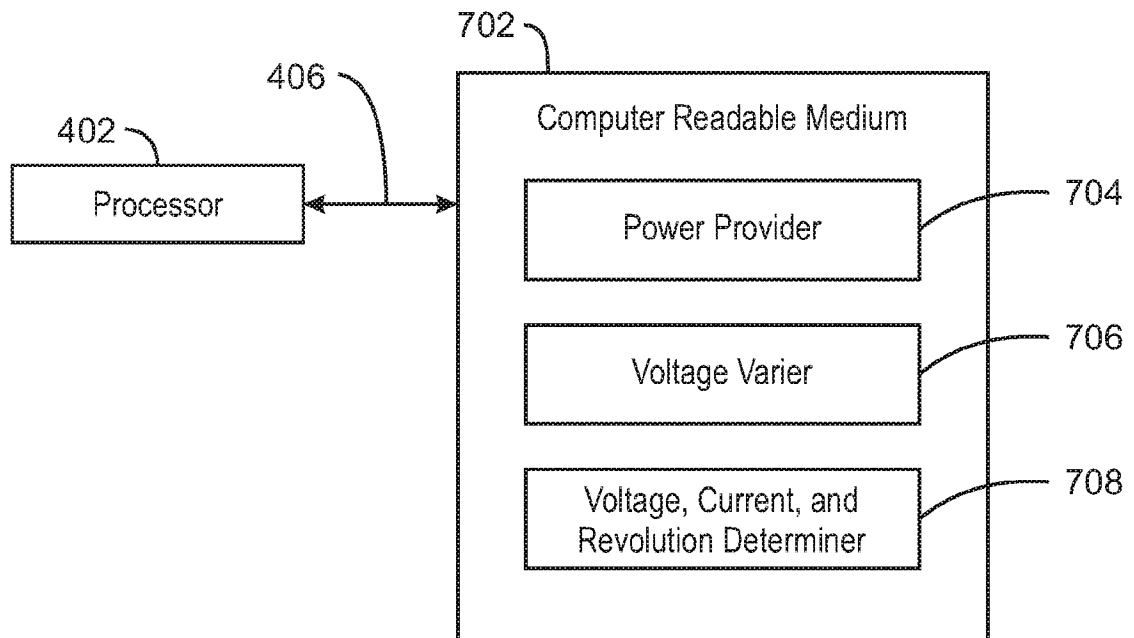
FIG. 5

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600
FIG. 6

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700
FIG. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2016/017301**A. CLASSIFICATION OF SUBJECT MATTER****G06F 1/20(2006.01)i, G06F 11/34(2006.01)i**

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

G06F 1/20; G21C 17/00; G01P 3/00; H01R 39/46; G06F 19/00; H02P 5/46; G05B 11/28; H02P 3/00; G06F 11/34

Documentation 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 models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) & Keywords: fan, benchmark, value, revolution, nominal, voltage, current, power

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2007-0050173 A1 (WEI-I CHEN et al.) 01 March 2007 See paragraphs [0005], [0011], [0018]-[0020], [0022], [0025], [0029]; claims 1, 5; and figure 1.	1-15
A	US 2010-0268506 A1 (SHU-HSIEN CHOU et al.) 21 October 2010 See paragraph [0011]; and figure 1.	1-15
A	US 2007-0285042 A1 (SCOTT FRANKEL et al.) 13 December 2007 See paragraph [0032]; and figure 1.	1-15
A	US 7132809 B1 (CHAO-HUANG CHANG) 07 November 2006 See column 3, lines 32-64; and figure 4.	1-15
A	US 2003-0193307 A1 (STEVEN BURSTEIN) 16 October 2003 See paragraph [0019]; and figure 1B.	1-15

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

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Name and mailing address of the ISA/KR

International Application Division

Korean Intellectual Property Office

189 Cheongsa-ro, Seo-gu, Daejeon, 35208, Republic of Korea

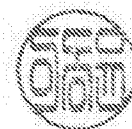


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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2016/017301

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