

VOLTAGE REGULATION METHOD, APPARATUS, DEVICE, AND MEDIUM

[0001] The present application claims priority to Chinese Patent Application No. 202011418056.0, titled "VOLTAGE REGULATION METHOD, APPARATUS, DEVICE, AND MEDIUM", filed on December 7, 2020 with the National Intellectual Property Administration, PRC, which is incorporated herein by reference in its entirety.

FIELD

[0002] The present disclosure relates to the technical field of computer algorithms, and in particular to a voltage regulation method and apparatus, a device and a medium.

BACKGROUND

[0003] With the increase in the number of functional modules in integrated chips, power consumption of an integrated chip also increases. In the conventional art, in order to reduce the power consumption of the integrated chip, a power supply voltage of the integrated chip is usually regulated based on a mapping relationship between an operating frequency and the power supply voltage of the integrated chip. However, failing to considering the difference in the manufacturing process of the integrated chip, a voltage regulation error, and an effect of the change in the number of cores operating in the integrated chip on the power supply voltage of the integrated chip, such method may lead to inaccurate and unreliable power supply voltage for the integrated chip. Currently, there is no effective solution to solve this technical problem.

[0004] In view of this, a technical problem to be solved urgently by those skilled in the art is how to improve the accuracy and reliability in a process of regulating the power supply voltage of the integrated chip.

SUMMARY

[0005] In view of this, a voltage regulation method, apparatus and device, and a medium are provided according to the present disclosure, to improve the accuracy and reliability in the

process of regulating the power supply voltage of the integrated chip. The specific scheme is described as follows.

[0006] A voltage regulation method is provided, which is applied to a controller of an integrated chip, and includes:

5 regulating, based on a preset voltage regulation relationship, a power supply voltage of the integrated chip, where the preset voltage regulation relationship is established by:

 acquiring a target demand voltage of the integrated chip at a target operating frequency, and recording a mapping relationship between the target operating frequency and the target demand voltage;

10 acquiring a target power supply voltage demanded by the integrated chip in a case that the number of cores is N , where $N \geq 1$;

 setting a voltage regulation error of an external voltage regulation circuit of the integrated chip when supplying power to the integrated chip based on attribute characteristics of the external voltage regulation circuit;

15 determining, based on an external power supply voltage and an actual power supply voltage of the integrated chip, a target voltage difference between an internal voltage and an external voltage of the integrated chip; and

 regulating the mapping relationship based on the target power supply voltage, the voltage regulation error, and the target voltage difference to obtain the preset voltage regulation relationship.

[0007] Preferably, the integrated chip is an SOC chip.

[0008] Preferably, the regulating, based on a preset voltage regulation relationship, a power supply voltage of the integrated chip includes:

25 regulating the power supply voltage of the integrated chip evenly based on the preset voltage regulation relationship.

[0009] Preferably, the regulating the power supply voltage of the integrated chip evenly based on the preset voltage regulation relationship includes:

 regulating, according to a voltage regulation response duration of the integrated chip, the power supply voltage of the integrated chip evenly based on the preset voltage regulation

relationship.

[0010] Preferably, the setting a voltage regulation error of an external voltage regulation circuit of the integrated chip when supplying power to the integrated chip based on attribute characteristics of the external voltage regulation circuit includes:

5 acquiring a maximum power supply voltage for supplying power to the integrated chip in the mapping relationship;

 setting, based on the attribute characteristics of the external voltage regulation circuit, a voltage regulation error coefficient of the external voltage regulation circuit when supplying power to the integrated chip; and

10 determining the voltage regulation error based on the maximum power supply voltage and the voltage regulation error coefficient.

[0011] Preferably, the method further includes:

 storing the preset voltage regulation relationship in the controller.

[0012] Correspondingly, a voltage regulation apparatus is further provided according to the
15 present disclosure, which is applied to a controller of an integrated chip, and includes:

 a voltage regulation module, configured to regulate, based on a preset voltage regulation relationship, a power supply voltage of the integrated chip, where the preset voltage regulation relationship is established by:

20 a relationship acquisition sub-module, configured to acquire a target demand voltage of the integrated chip at a target operating frequency, and recording a mapping relationship between the target operating frequency and the target demand voltage;

 a first acquisition sub-module, configured to acquire a target power supply voltage demanded by the integrated chip in a case that the number of cores is N , where $N \geq 1$;

25 a second acquisition sub-module, configured to set a voltage regulation error of an external voltage regulation circuit of the integrated chip when supplying power to the integrated chip based on attribute characteristics of the external voltage regulation circuit;

 a third acquisition sub-module, configured to determine, based on an external power supply voltage and an actual power supply voltage of the integrated chip, a target voltage difference between an internal voltage and an external voltage of the integrated chip; and

a relationship regulation sub-module, configured to regulate the mapping relationship based on the target power supply voltage, the voltage regulation error, and the target voltage difference to obtain the preset voltage regulation relationship.

[0013] Correspondingly, a voltage regulation device is further provided according to the present disclosure, which includes:

a memory, configured to store a computer program; and

a processor, configured to perform, when executing the computer program, steps of the voltage regulation method described above.

[0014] Correspondingly, a computer-readable storage medium is further provided according to the present disclosure, on which a computer program is stored, and the computer program, when executed by a processor, performs steps of the voltage regulation method described above.

[0015] It can be seen that in the voltage regulation method according to the present disclosure, first, the target demand voltage corresponding to the integrated chip at the target operating frequency is acquired, and the mapping relationship between the target operating frequency and the target demand voltage is recorded; the target power supply voltage demanded by the integrated chip in a case that the number of cores is N is acquired, and the voltage regulation error of the external voltage regulation circuit of the integrated chip when supplying power to the integrated chip is set based on the attribute characteristics of the external voltage regulation circuit, and the target voltage difference between the internal voltage and the external voltage of the integrated chip is determined based on the external power supply voltage and the actual power supply voltage of the integrated chip; then, the mapping relationship is regulated based on the target power supply voltage, the voltage regulation error, and the target voltage difference to obtain the preset voltage regulation relationship; finally, the power supply voltage of the integrated chip is regulated based on the preset voltage regulation relationship. Apparently, in the voltage regulation method according to the present disclosure, by considering the difference in the manufacturing process of the integrated chip, the voltage regulation error, and the effect of the change in the number of cores operating inside the integrated chip on the power supply voltage of the integrated chip, this method can significantly improve the accuracy and reliability in the process of regulating the power supply voltage of the integrated chip. Correspondingly, the voltage regulation

apparatus and device and the medium according to the present disclosure also have the above beneficial effects.

BRIEF DESCRIPTION OF THE DRAWINGS

5 **[0016]** In order to more clearly illustrate the technical solutions in the embodiments of the present disclosure or the conventional art, the drawings that used in the description of the embodiments or the conventional art will be briefly introduced in the following. Apparently, the drawings in the following description only show embodiments of the present disclosure, and those skilled in the art can also obtain other drawings according to the provided drawings
10 without any creative work.

[0017] Figure 1 is a flow chart of a voltage regulation method according to an embodiment of the present disclosure;

[0018] Figure 2 is a structural diagram of a voltage regulation apparatus according to an embodiment of the present disclosure; and

15 **[0019]** Figure 3 is a structural diagram of a voltage regulation device according to an embodiment of the present disclosure.

DETAILED DESCRIPTION OF EMBODIMENTS

[0020] Technical solutions in the embodiments of the present disclosure will be described
20 clearly and completely in the following with reference to the drawings in the embodiments of the present disclosure. Apparently, the described embodiments are only some, rather than all of the embodiments of the present disclosure. Based on the embodiments of the present disclosure, all other embodiments obtained by those skilled in the art without making creative efforts should belong to the protection scope of the present disclosure.

25 **[0021]** Referring to Figure 1, Figure 1 is a flow chart of a voltage regulation method according to an embodiment of the present disclosure, the voltage regulation method includes:

adjusting a power supply voltage of an integrated chip based on a preset voltage regulation relationship.

[0022] The preset voltage regulation relationship is established by the following steps S11

to S15.

[0023] In step S11, a target demand voltage of the integrated chip at a target operating frequency is acquired, and a mapping relationship between the target operating frequency and the target demand voltage is recorded.

5 **[0024]** In step S12, a target power supply voltage demanded by the integrated chip in a case that the number of cores is N is acquired, where $N \geq 1$.

[0025] In step S13, a voltage regulation error of an external voltage regulation circuit of the integrated chip when supplying power to the integrated chip is set based on attribute characteristics of the external voltage regulation circuit.

10 **[0026]** In step S14, a target voltage difference between an internal voltage and an external voltage of the integrated chip is determined based on an external power supply voltage and an actual power supply voltage of the integrated chip.

[0027] In step S15, the mapping relationship is regulated based on the target power supply voltage, the voltage regulation error, and the target voltage difference to obtain the preset
15 voltage regulation relationship.

[0028] In this embodiment, in order to reduce the power consumption of the integrated chip during operation, a method for regulating the voltage of the integrated chip is provided, with which accuracy and reliability in the process of regulating the power supply voltage of the integrated chip can be significantly improved. Specifically, in the voltage regulation method, a
20 preset voltage regulation relationship is used to regulate the power supply voltage of the integrated chip.

[0029] In the process of establishing the preset voltage regulation relationship, firstly, the target demand voltage V of the integrated chip at the target operating frequency f is acquired, and the mapping relationship $f \rightarrow V$ between the target operating frequency f and the target
25 demand voltage V is recorded. It should be noted that in this embodiment, establishing the mapping relationship $f \rightarrow V$ is a common technical means for those skilled in the art, so the specific process of establishing the mapping relationship $f \rightarrow V$ will not be described in detail in this embodiment.

[0030] In practice, in addition to the operating frequency of the integrated chip affecting the
30 power supply voltage of the integrated chip, there are also many factors that will affect the

power supply voltage of the integrated chip, such as the number of cores operating in the integrated chip, the voltage regulation error of the external voltage regulation circuit in the integrated chip to the integrated chip and the target voltage difference between the internal and external voltages of the integrated chip due to the manufacturing process of the integrated chip. In this embodiment, in order to provide a more accurate power supply voltage for the integrated chip, the mapping relationship is regulated and corrected based on the number of cores operating in the integrated chip, the voltage regulation error of the external voltage regulation circuit, and the target voltage difference between the internal and external voltages of the integrated chip.

[0031] It is to be understood that with the increase in the number of cores operating in the controller, although the overall performance of the integrated chip can be improved, the power consumption of the integrated chip will also be increased. Therefore, the number of cores operating in the integrated chip will also affect the established mapping relationship. Therefore, in this embodiment, in order to make the mapping relationship more reliable and accurate, it is required to correct the mapping relationship based on the change of the number of cores in the integrated chip. In this process, the target power supply voltage demanded by the integrated chip in a case that the number of cores is N needs to be acquired. Assuming that each time the integrated chip adds an operating core, the integrated chip needs to increase the power supply voltage by ΔV_{α} , the target power supply voltage demanded by the integrated chip when the number of cores is N is expressed as $V_N = V + \Delta V_{\alpha} \cdot N$.

[0032] Secondly, in the process of regulating the power supply voltage of the integrated chip based on the external voltage regulation circuit in the integrated chip, the difference in the properties of the external voltage regulation circuit itself will also affect the power supply voltage of the integrated chip. In this embodiment, in order to provide a more accurate power supply voltage for the integrated chip, the voltage regulation error V_x of the external voltage regulation circuit when supplying power to the integrated chip is further acquired, where the voltage regulation error V_x is a regulation value set based on the attribute characteristics of the external voltage regulation circuit of the integrated chip.

[0033] In addition, due to the limitation of the manufacturing process of the integrated chip, the performance of transistors in different positions in the integrated chip will also have great differences, which will lead to different computing periods demanded by the same logic block

in the integrated chip; and the performance of transistors in the integrated chip will also vary in different environments. For example, a high temperature will lead to a large leakage current in the integrated chip, which will cause a large voltage drop when supplying power to the integrated chip. That is, under different ambient temperatures, the same external power supply voltage will be different when finally reaching the internal controller of the integrated chip. Therefore, when regulating the power supply voltage of the integrated chip, it is also required to consider the target voltage difference between the external power supply voltage and the actual power supply voltage of the integrated chip.

[0034] In this embodiment, in order to avoid the effect of the voltage drop in the integrated chip on the power supply voltage of the integrated chip, the target voltage difference between the internal and external voltages of the integrated chip is also determined based on the external supply voltage and the actual supply voltage of the integrated chip. That is, assuming that the actual demand power supply voltage of the integrated chip is V_1 , the external power supply voltage of the integrated chip is V_2 , and the actual power supply voltage of the integrated chip is V_3 , the target voltage difference of the integrated chip is $(V_2 - V_3)$, after obtaining the target voltage difference between the internal and external voltages of the integrated chip, the target voltage difference may be used to regulate and correct the mapping relationship. In this case, the actual power supply voltage for the integrated chip is $V_\beta = V_1 + (V_2 - V_3)$.

[0035] In summary, in a case of acquiring the target power supply voltage, the voltage regulation error of the external voltage regulation circuit when supplying power to the integrated chip, and the target voltage difference between the internal and external voltages of the integrated chip, the mapping relationship may be regulated and corrected based on the target power supply voltage, the voltage regulation error and the target voltage difference, to obtain the preset voltage regulation relationship. In the process of regulating the mapping relationship based on the target power supply voltage, the voltage regulation error and the target voltage difference, the target demand voltage in the mapping relationship is mainly regulated and corrected based on the target power supply voltage, the voltage regulation error and the target voltage difference, so that the demand voltage of the integrated chip at the target operating frequency can be more accurate and reliable.

[0036] It should be noted that in the process of regulating the mapping relationship based

on the target power supply voltage, the voltage regulation error and the target voltage difference, the order of regulating each factor is not specifically limited, as long as the mapping relationship can be regulated and corrected based on the target power supply voltage, the voltage regulation error and the target voltage difference.

5 **[0037]** For example, the target demand voltage V in the mapping relationship is corrected based on the target power supply voltage $V_N = V + \Delta V_\alpha \cdot N$, to obtain a first correction mapping relationship $f \rightarrow V + \Delta V_\alpha \cdot N$. Then, the demand voltage in the first correction mapping relationship is corrected based on the voltage regulation error V_x , to obtain a second correction mapping relationship $f \rightarrow V + \Delta V_\alpha \cdot N + V_x$. Finally, the demand voltage in the
10 second correction mapping relationship is corrected and regulated based on the target voltage difference, to obtain a third revised mapping relationship $f \rightarrow V + \Delta V_\alpha \cdot N + V_x + (V_2 - V_3)$.

[0038] It can be seen that in the voltage regulation method according to the present disclosure, first, the target demand voltage corresponding to the integrated chip at the target operating frequency is acquired, and the mapping relationship between the target operating
15 frequency and the target demand voltage is recorded; the target power supply voltage demanded by the integrated chip in a case that the number of cores is N is acquired, and the voltage regulation error of the external voltage regulation circuit of the integrated chip when supplying power to the integrated chip is set based on the attribute characteristics of the external voltage regulation circuit, and the target voltage difference between the internal
20 voltage and the external voltage of the integrated chip is determined based on the external power supply voltage and the actual power supply voltage of the integrated chip; then, the mapping relationship is regulated based on the target power supply voltage, the voltage regulation error, and the target voltage difference to obtain the preset voltage regulation relationship; finally, the power supply voltage of the integrated chip is regulated based on the
25 preset voltage regulation relationship. Apparently, in the voltage regulation method according to the present disclosure, by considering the difference in the manufacturing process of the integrated chip, the voltage regulation error, and the effect of the change in the number of cores operating inside the integrated chip on the power supply voltage of the integrated chip, this method can significantly improve the accuracy and reliability in the process of regulating
30 the power supply voltage of the integrated chip.

[0039] Based on the above embodiments, the technical solution is further explained and

optimized in this embodiment. In a preferred embodiment, the integrated chip is an SOC chip.

[0040] Specifically, in this embodiment, the integrated chip is an SOC chip. Because the SOC chip can effectively reduce the development cost and development cycle of electronic products, the SOC chip has been widely used in real life. Therefore, in this embodiment, the integrated chip is set as an SOC chip, thereby improving the universality of the voltage regulation method according to the present application in actual use.

[0041] Based on the above embodiments, the technical solution is further explained and optimized in this embodiment. In a preferred embodiment, the regulating the power supply voltage of the integrated chip based on the preset voltage regulation relationship includes:

regulating the power supply voltage of the integrated chip evenly based on the preset voltage regulation relationship.

[0042] In practice, if the regulation range of the power supply voltage of the integrated chip is large, a huge change in the ripple of the external voltage regulation circuit of the integrated chip may be caused. In this case, the power supply voltage of the controller may be out of the control range. Therefore, in this embodiment, in order to avoid the above situation, the power supply voltage of the integrated chip is evenly regulated based on the preset voltage regulation relationship, so as to ensure the reliability in a process of supplying power to the integrated chip.

[0043] That is, if the voltage for supplying power to the integrated chip is V_1 , and the current power supply voltage to the integrated chip is V_2 , in order to ensure the stability in the process of supplying power to the integrated chip, the power supply voltage of the integrated chip may be regulated in a step-up or step-down way.

[0044] In a preferred embodiment, the above step of regulating the power supply voltage of the integrated chip evenly based on the preset voltage regulation relationship includes:

regulating, according to a voltage regulation response duration of the integrated chip, the power supply voltage of the integrated chip evenly based on the preset voltage regulation relationship.

[0045] Specifically, in the process of regulating the power supply voltage of the integrated chip evenly based on the preset voltage regulation relationship, the power supply voltage of the integrated chip may also be regulated based on the voltage regulation response duration of

the integrated chip, this is because if the power supply voltage of the integrated chip is regulated based on the voltage regulation response duration of the integrated chip, the voltage jitter phenomenon can be avoided in the voltage regulation process of the integrated chip, thereby ensuring the integrity of the integrated chip during the voltage regulation process.

5 **[0046]** Based on the above embodiment, the technical solution is further explained and optimized in this embodiment. In a preferred embodiment, the step of the setting a voltage regulation error of an external voltage regulation circuit of the integrated chip when supplying power to the integrated chip based on attribute characteristics of the external voltage regulation circuit includes:

10 acquiring a maximum power supply voltage for supplying power to the integrated chip in the mapping relationship;

 setting, based on the attribute characteristics of the external voltage regulation circuit, a voltage regulation error coefficient of the external voltage regulation circuit when supplying power to the integrated chip; and

15 determining the voltage regulation error based on the maximum supply voltage and the voltage regulation error coefficient.

[0047] In this embodiment, in order to avoid the situation that the power supply voltage of the integrated chip is lower than the minimum demand power supply voltage of the integrated chip in the process of dynamic regulation of the power supply voltage, in order to set the voltage regulation error, first, a maximum power supply voltage $V_{\max}$ in the mapping relationship for supplying power to the integrated chip is acquired, and the voltage regulation error coefficient δ of the external voltage regulation circuit when supplying power to the integrated chip is set based on the attribute characteristics of the external voltage regulation circuit, and finally, the voltage regulation error $V_{\max} \cdot \delta$ is determined based on the maximum power supply voltage $V_{\max}$ and the voltage regulation error coefficient δ . It is conceivable that after the voltage regulation error $V_{\max} \cdot \delta$ is determined, the mapping relationship may be corrected by using the voltage regulation error $V_{\max} \cdot \delta$, that is, $f \rightarrow (V + V_{\max} \cdot \delta)$.

[0048] Apparently, with the technical solution according to this embodiment, the reliability in the process of supplying power to the integrated chip can be further ensured.

30 **[0049]** Based on the above embodiment, the technical solution is further explained and

optimized in this embodiment. In a preferred embodiment, the above voltage regulation method further includes:

storing the preset voltage regulation relationship to the controller.

[0050] In practice, the preset voltage regulation relationship may be directly stored in the controller of the integrated chip, so that when the power supply voltage of the integrated chip needs to be regulated, the controller can directly call the preset voltage regulation relationship stored therein to regulate the power supply voltage of the integrated chip, thereby saving the time required to call the preset voltage regulation relationship from a remote terminal, thus further accelerating the voltage regulation in the voltage regulating process of the integrated chip.

[0051] Referring to Figure 2, Figure 2 is a structural diagram of a voltage regulation apparatus according to an embodiment of the present disclosure, the voltage regulation apparatus includes: a voltage regulation module. The voltage regulation module is configured to regulate a power supply voltage of an integrated chip based on a preset voltage regulation relationship. The preset voltage regulation relationship is established by: a relationship acquisition sub-module 21, a first acquisition sub-module 22, a second acquisition sub-module 23, a third acquisition sub-module 24, and a relationship regulation sub-module 25. The relationship acquisition sub-module 21 is configured to acquire a target demand voltage of the integrated chip at a target operating frequency, and record a mapping relationship between the target operating frequency and the target demand voltage. The first acquisition sub-module 22 is configured to acquire a target power supply voltage demanded by the integrated chip in a case that the number of cores is N , wherein $N \geq 1$. The second acquisition sub-module 23 is configured to set a voltage regulation error of an external voltage regulation circuit of the integrated chip when supplying power to the integrated chip based on attribute characteristics of the external voltage regulation circuit. The third acquisition sub-module 24 is configured to determine, based on an external power supply voltage and an actual power supply voltage of the integrated chip, a target voltage difference between an internal voltage and an external voltage of the integrated chip. The relationship regulation sub-module 25 is configured to regulate the mapping relationship based on the target power supply voltage, the voltage regulation error, and the target voltage difference to obtain the preset voltage regulation relationship.

[0052] The voltage regulation apparatus according to the embodiment of the present disclosure has the beneficial effects of the voltage regulation method disclosed above.

[0053] Referring to Figure 3, Figure 3 is a structural diagram of a voltage regulation device according to an embodiment of the present disclosure, the voltage regulation device includes a memory 31 and a processor 32. The memory 31 is configured to store a computer program, and the processor 32 is configured to perform, when executing the computer program, the steps of the voltage regulation method disclosed above.

[0054] The voltage regulation device according to the embodiment of the present disclosure has the beneficial effects of the voltage regulation method disclosed above.

[0055] Correspondingly, a computer-readable storage medium is further provided according to an embodiment of the present disclosure, on which a computer program is stored, and the computer program, when executed by a processor, the steps of the voltage regulation method disclosed above.

[0056] The readable storage medium according to the embodiment of the present disclosure has the beneficial effects of the voltage regulation method disclosed above.

[0057] The embodiments in this specification is described in a progressive manner, each embodiment focuses on the difference from other embodiments, and the same or similar parts between the embodiments may be referred to each other. As for the apparatus disclosed in the embodiment, since it corresponds to the method disclosed in the embodiment, the description thereof is simple, and for relevant details, reference may be made to the description of the method.

[0058] Finally, it should also be noted that in this text, relational terms such as "first" and "second" etc. are only used to distinguish one entity or operation from another, and do not necessarily require or imply that there is such actual relationship or order exists between these entities or operations. Furthermore, the terms "comprises", "includes" or any other variation thereof are intended to cover non-exclusive inclusions such that a process, method, article, or apparatus comprising a set of elements includes not only those elements, but also includes elements not expressly listed, or elements inherent in such a process, method, article, or apparatus. Without further limitations, an element defined by the phrase "comprising a ..." does not exclude the presence of additional identical elements in the process, method, article

or apparatus comprising the element.

[0059] The voltage regulation method, apparatus and device and the medium according to the present disclosure are described above in detail. In this description, specific examples are used to illustrate the principles and embodiments of the present disclosure. The above
5 embodiments are described only for understanding the method of the present disclosure and the core idea thereof. In addition, for those skilled in the art, according to the idea of the present disclosure, there will be changes in the specific embodiments and the scope of application. In summary, the content of this specification should not be construed as a limitation of the present disclosure.

CLAIMS

1. A voltage regulation method, applied to a controller of an integrated chip, comprising:
regulating, based on a preset voltage regulation relationship, a power supply voltage of
5 the integrated chip, wherein the preset voltage regulation relationship is established by:

acquiring a target demand voltage of the integrated chip at a target operating
frequency, and recording a mapping relationship between the target operating frequency and
the target demand voltage;

acquiring a target power supply voltage demanded by the integrated chip in a case
10 that the number of cores is N , wherein $N \geq 1$;

setting a voltage regulation error of an external voltage regulation circuit of the
integrated chip when supplying power to the integrated chip based on attribute characteristics
of the external voltage regulation circuit;

determining, based on an external power supply voltage and an actual power supply
15 voltage of the integrated chip, a target voltage difference between an internal voltage and an
external voltage of the integrated chip; and

regulating the mapping relationship based on the target power supply voltage, the
voltage regulation error, and the target voltage difference to obtain the preset voltage
regulation relationship.

20

2. The voltage regulation method according to claim 1, wherein the integrated chip is an
SOC chip.

3. The voltage regulation method according to claim 1, the regulating, based on a preset
25 voltage regulation relationship, a power supply voltage of the integrated chip comprises:

regulating the power supply voltage of the integrated chip evenly based on the preset
voltage regulation relationship.

4. The voltage regulation method according to claim 3, wherein the regulating the power

supply voltage of the integrated chip evenly based on the preset voltage regulation relationship comprises:

regulating, according to a voltage regulation response duration of the integrated chip, the power supply voltage of the integrated chip evenly based on the preset voltage regulation relationship.

5. The voltage regulation method according to claim 1, wherein the setting a voltage regulation error of an external voltage regulation circuit of the integrated chip when supplying power to the integrated chip based on attribute characteristics of the external voltage regulation circuit comprises:

acquiring a maximum power supply voltage for supplying power to the integrated chip in the mapping relationship;

setting, based on the attribute characteristics of the external voltage regulation circuit, a voltage regulation error coefficient of the external voltage regulation circuit when supplying power to the integrated chip; and

determining the voltage regulation error based on the maximum power supply voltage and the voltage regulation error coefficient.

6. The voltage regulation method according to any one of claims 1 to 5, further comprising:

storing the preset voltage regulation relationship in the controller.

7. A voltage regulation apparatus, applied to a controller of an integrated chip, comprising:

a voltage regulation module, configured to regulate, based on a preset voltage regulation relationship, a power supply voltage of the integrated chip, wherein the preset voltage regulation relationship is established by:

a relationship acquisition sub-module, configured to acquire a target demand voltage of the integrated chip at a target operating frequency, and record a mapping relationship between

the target operating frequency and the target demand voltage;

a first acquisition sub-module, configured to acquire a target power supply voltage demanded by the integrated chip in a case that the number of cores is N, wherein $N \geq 1$;

5 a second acquisition sub-module, configured to set a voltage regulation error of an external voltage regulation circuit of the integrated chip when supplying power to the integrated chip based on attribute characteristics of the external voltage regulation circuit;

a third acquisition sub-module, configured to determine, based on an external power supply voltage and an actual power supply voltage of the integrated chip, a target voltage difference between an internal voltage and an external voltage of the integrated chip; and

10 a relationship regulation sub-module, configured to regulate the mapping relationship based on the target power supply voltage, the voltage regulation error, and the target voltage difference to obtain the preset voltage regulation relationship.

8. A voltage regulation device, comprising:

15 a memory, configured to store a computer program; and

a processor, configured to perform, when executing the computer program, steps of the voltage regulation method according to any one of claims 1 to 6.

9. A computer-readable storage medium, comprising a computer program stored thereon,
20 wherein the computer program, when executed by a processor, performs steps of the voltage regulation method according to any one of claims 1 to 6.