

## **Control Circuit Apparatus and Power Supply Circuit Control Method**

### **Cross Reference to Related Applications**

5 [0001]

The present document is based on Japanese Priority Document JP2004-008996, filed in the Japanese Patent Office on January 16, 2004, the entire contents of which being incorporated herein by reference.

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### **Background of the Invention**

#### **1. Field of the Invention**

[0002]

15 The present invention relates to a control circuit apparatus and, in particular, it relates to a control circuit apparatus which enables to reduce power consumption by improving a conversion efficiency in its voltage converter using a thin film choke coil.

#### **2. Description of Related Art**

20 [0003]

Low power consumption is advancing in electronic control apparatuses typically of a digital still camera, a digital video camera and the like.

[0004]

25 As to this low power consumption in the electronics apparatuses, for example, such an arrangement is proposed in which a circuit system for a constant voltage operable by controlling the operation of a secondary active clamp circuit is directly driven by an analog PWM (Pulse Width Modulation)  
30 control circuit in order to reduce an input power to its voltage control circuit system, to improve a power conversion

efficiency as well as to achieve a low power consumption (for example, Patent Document 1: Japanese Patent Application Publication No. 2002-027744.

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### Summary of the Invention

[0005]

According to this technology, however, because its circuitry becomes inevitable large-scaled, there is a problem that a compact and a light-weight design becomes difficult.

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[0006]

Generally, in an electronic control apparatus, an output voltage supplied from a power supply is once converted to a predetermined voltage, and it is supplied to a load side wherein to carry out various processing. However, in a digital video camera, HDD (hard disc drive), DVD (digital versatile disc) drive unit or the like, fluctuation in its output load current is extremely large, and power consumed in the load side is not constant. Therefore, in the stage of design, its voltage converter circuit is designed in consideration of a maximum load. For this reason, in the case of a maximum load applied, its voltage conversion efficiency becomes highest, however, in the case where its load is not maximum, its conversion efficiency will drop. It is generally not so often that an operation under the maximum load is performed. As a result, there is a problem that low power consumption cannot be achieved in such instances.

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[0007]

The present invention is contemplated in consideration of the aforementioned circumstances, and, in particular, to achieve low power consumption in the control circuit apparatus by providing a constant current circuit between its voltage

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converter and its load so as to be able to improve a voltage conversion efficiency therein.

[0008]

A control circuit apparatus of the present invention  
5 is characterized by including: a first voltage converter which  
uses a thin film choke coil for converting a voltage of power  
to be supplied to a load in a subsequent stage, from a first  
voltage to a second voltage; and a constant current circuit  
for maintaining a current value of power supplied at the second  
10 voltage from the voltage converter at a predetermined current  
value, irrespective of power consumption in the load.

[0009]

The above may be further including: a calculation circuit  
for calculating a current value of power consumed in the load;  
15 and a charging battery, which is chargeable with a portion  
of the power supplied from the first voltage converter or which  
supplies power to the load; wherein if the current value of  
power consumption calculated by the calculation circuit is  
smaller than a predetermined current value, the constant  
20 current circuit makes the charging battery to charge a portion  
of the current of power corresponding to a difference between  
the predetermined current value and the current value of power  
consumption; and if the current value of power consumption  
calculated by the calculation circuit is greater than the  
25 predetermined current value, the constant current circuit  
makes the charging battery to supply power corresponding to  
a difference between the predetermined current value and the  
current value of power consumption.

[0010]

30 The load described above may be provided as a second  
voltage converter for converting a voltage of power supplied

from the constant current circuit from the second voltage to a third voltage.

[0011]

A power supply circuit control method of the present invention including the steps of: converting a voltage of power to be supplied to a load in a subsequent stage, from a first voltage to a second voltage by a first voltage converter with the use of thin film choke coil; and maintaining a current value of power supplied at the second voltage from the voltage converter at a predetermined current value by using a constant current circuit, irrespective of power consumption in the load.

[0012]

The above may be further including the steps of: calculating a current value of power consumed in the load by a calculating circuit; charging a charging battery with a portion of power supplied from the first voltage converter or supplying power to the load from the charging battery; wherein if the current value of power consumption calculated by the calculation circuit is smaller than a predetermined current value, the constant current circuit makes the charging battery to charge power corresponding to a difference between the predetermined current value and the current value of power consumption; and if the current value of power consumption calculated by the calculation circuit is greater than the predetermined current value, the constant current circuit makes the charging battery to supply power corresponding to a difference between the predetermined current value and the current value of power consumption.

[0013]

The apparatus according to the present invention can be used in a state at a higher level of voltage conversion

efficiency, as a result, enabling to reduce power consumption therein.

### **Brief Description of the Drawings**

5 [0014]

FIG. 1 is a block diagram explaining an electronic control circuit according to an embodiment of the present invention;

FIG. 2 is a block diagram explaining a control IC and a DC/DC converter of FIG. 1;

10 FIG. 3 is a graph explaining conversion efficiencies of the DC/DC converter of FIG. 1;

FIG. 4 is a block diagram explaining a constant current circuit of FIG. 1; and

15 FIG. 5 is a flowchart showing steps of processing in a constant current control.

### **Description of the Embodiment(s)**

[0015]

An embodiment of the present invention will be described  
20 in the following. An exemplary correspondence between the invention as claimed in this specification and its embodiment of the present invention will be as follows. This description is to verify that the embodiment which supports the invention claimed in this specification is duly stated in this  
25 specification. Therefore, even if there arises any other embodiment although which corresponds to the invention claimed within the scope of the present invention but is not described explicitly in the embodiment of the present invention here, it should be understood that it does not mean that any such  
30 embodiment does not correspond to the present invention. Conversely, even if an exemplary embodiment is described here

as corresponding to the invention, this does not mean that the embodiment thereof does not correspond to any other invention other than this.

[0016]

5 Further, this description is not meant to include the whole aspects and the scope of the invention duly claimable in this specification. In other words, although this description concerns with the invention described in this specification, but it does not preclude the existence of any  
10 other inventions which are not claimed in this application, but may arise in the future as a divisional, amendment, or additional applications.

[0017]

A control circuit apparatus according to an aspect of  
15 the embodiment of the present invention is characterized by including: a first voltage converter (for example, a DC/DC converter 4 in FIG. 1) which uses a thin film choke coil for converting a voltage of a power to be supplied to a load in a subsequent stage, from a first voltage to a second voltage;  
20 and a constant current circuit (for example, a constant current circuit 5 in FIG. 1) for maintaining a current value of the power supplied at the second voltage supplied from the voltage converter at a predetermined current value, irrespective of power consumption in the load.

25 [0018]

The control circuit apparatus may further be including: a calculation circuit (for example, a power consumption monitoring unit 32 in FIG. 4) for calculating a current value of power consumed in the load; and a charging battery, which  
30 is chargeable with a portion of the power supplied from the first voltage converter or which supplies power to the load;

wherein if the current value of the power consumption calculated by the calculation circuit is smaller than a predetermined current value, the constant current circuit makes the charging battery to charge a portion of the power corresponding to a difference between the predetermined current value and the current value of the power consumption; and if the current value of the power consumption calculated by the calculation circuit is greater than the predetermined current value, the constant current circuit makes the charging battery to supply power corresponding to a difference between the predetermined current value and the current value of power consumption.

[0019]

A power supply circuit control method of the present invention including the steps of: converting a voltage of power to be supplied to a load in a subsequent stage, from a first voltage to a second voltage by a first voltage converter with the use of thin film choke coil; and maintaining a current value of power supplied at the second voltage from the voltage converter at a predetermined current value by using a constant current circuit, irrespective of power consumption in the load.

[0020]

The power supply circuit control method may further including the steps of: calculating a current value of power consumed in the load by a calculating circuit; charging a charging battery with a portion of power supplied from the first voltage converter or supplying power to the load from the charging battery; wherein if the current value of power consumption calculated by the calculation circuit is smaller than a predetermined current value, the constant current circuit makes the charging battery to charge power

corresponding to a difference between the predetermined current value and the current value of power consumption; and if the current value of power consumption calculated by the calculation circuit is greater than the predetermined current value, the constant current circuit makes the charging battery to supply power corresponding to a difference between the predetermined current value and the current value of power consumption.

[0021]

10       The load described above may be provided as a second voltage converter (for example, a DC/DC converter 7 in FIG. 1) for converting the voltage of power supplied from the constant current circuit from the second voltage to a third voltage.

15       [0022]

A control circuit apparatus according to an embodiment of the present invention will be described in the following by referring to the accompanying drawings.

[0023]

20       A control circuit apparatus shown in FIG. 1 is an apparatus to be incorporated in various types of electronic control equipment, and functions to electrically control the operations of various drive units in the electronic control equipment. A microcomputer 1 in the control circuit apparatus is comprised of a CPU (Central Processing Unit), a RAM (Random Access Memory) and a ROM (Read Only Memory), in which the CPU reads out a program incorporated in ROM and executes it by deploying in RAM as required. Further the microcomputer 1 functions to control the whole control circuit apparatus, and  
25       issues a command to operate loads 6, 9, to be described later,  
30       by sending a predetermined command to a control IC 2.

[0024]

The control IC 2, in response to a command given from the microcomputer 1, controls on/off of DC/DC (Direct Current to Direct Current) converter 4 or 7 to allow actual operation of load 6 or 9 in a subsequent stage.

[0025]

The DC/DC converter 4, which is under control of the control IC 2, converts a voltage of power supplied from a power supply 3 from 8.4V to 1.5V and supplies it to a constant current circuit 5. In order to be able to receive a power supply in such a state which ensures an utmost efficiency of voltage conversion by the DC/DC converter 4, the constant current circuit 5 monitors a power (a current value) consumed in the load 6 and a power consumed in the load 9 via the DC/DC converter 7. When a surplus power exists, the constant current circuit 5 supplies the surplus power to a charging battery 8 for charging itself, or when power is deficient, the constant current circuit 5 causes a deficient power to be supplied from the charging battery 8 to the load 6 and to the DC/DC converter 7.

[0026]

The load 6 operable at 1.5V of power supplied from the DC/DC converter 4 via the constant current circuit 5 is, for example, an electric motor or the like. The DC/DC converter 7 converts a 1.5V power supplied from the DC/DC converter 4 via the constant current circuit 5 to a 1.2V power, and supplies it to the load 9 operable at 1.2V power.

[0027]

In the next, the operation of the control circuit apparatus shown in FIG. 1 will be described. The microcomputer 1 issues a command to the control IC 2 to allow operation of

the loads 6, 9. The control IC 2 allows the DC/DC converters 4, 7 to be set -a state applied with a voltage so as to supply power to the loads 6 and 9 (to be set on-state).

[0028]

5           The DC/DC converter 4 converts an 8.4V power supplied from the power supply 3 to a 1.5V power supply voltage, and supplies it to the constant current circuit 5. The constant current circuit 5 supplies a 1.5V power to the load 6 thereby enabling it to execute a predetermined operation and also  
10       supplies a 1.5V power to DC/DC converter 7. The DC/DC converter 7 converts 1.5V power supplied from the constant current circuit 5 to 1.2V power, and supplies it to the load 9 to execute its operation.

[0029]

15           By way of example, the constant current circuit 5 monitors a state of power consumptions in the load 6 and the load 9 to which its power is supplied via the DC/DC converter 7 while supplying a power to the load 6 and to the DC/DC converter 7, and controls such that its current value is maintained at  
20       which the highest conversion efficiency in the DC/DC converter 4 is achievable. More specifically, the constant current circuit 5, if there is a surplus in the power supplied from the DC/DC converter 4, supplies the surplus power to the charging battery 8 for charging itself, and if there is a  
25       deficiency in the power, the constant current circuit 5 receives a power supply from the charging battery 8.

[0030]

          In the next, by referring to FIG. 2, detailed configurations of the control IC 2 and the DC/DC converter  
30       4 will be described.

[0031]

A comparator 11 in the control IC 2 supplies a feedback signal supplied from the DC/DC converter 4 via a terminal A to a PWM (Pulse Width Modulation) comparator 13. A SCP (Short Circuit Protection function) comparator 12 supplies a short circuit protection signal of the control IC 2 to a main controller 17 using a voltage supplied from a power supply 16.

[0032]

By modulating the feedback signal supplied from the comparator 11 into a PWM signal and changing a duty ratio thereof, the PWM comparator 13 supplies it to an AND circuit 14. When supplied with an on-signal from the main controller 17, the AND circuit 14 supplies the feedback signal as a drive pulse to the DC/DC converter 4 via an amplifier 15, thereby controlling the DC/DC converter 4 accordingly and also supplying the feedback signal thereto.

[0033]

On the basis of a drive pulse supplied from the control IC 2 to a gate terminal 21a, an FET (Field Effect Transistor) 21 in DC/DC converter 4 supplies an 8.4V DC power supplied from the power supply 3 via a drain terminal 21b to a thin film choke coil 23 via a source terminal 21c. A diode 22, the thin film choke coil 23 and a capacitor 24 in combination convert the voltage of power supplied from the FET 21 from 8.4V to 1.5V, and rectify it to supply to the constant current circuit 5. At this instant, the terminal A supplies a feedback signal to the control IC 2.

[0034]

A voltage conversion ratio and a voltage conversion efficiency of the DC/DC converter 4 are determined depending on the characteristics of this thin film choke coil 23.

Although it is usually possible to change the characteristics thereof by changing the number of windings of the coil, because the thin film choke coil is manufactured using a thin film process, it is not possible to adjust the number of windings, as a result, it becomes very difficult to change the characteristics thereof.

[0035]

FIG. 3 shows conversion efficiencies of the DC/DC converter 4. The conversion efficiency of the DC/DC converter 4 becomes approximately 63% relative to a 50mA current consumed in the loads 6 and 9, approximately 79 relative to a 100mA current, approximately 93 relative to a 200mA current, 94 relative to a 300mA current, approximately 92 relative to a 400mA current, and approximately 88 relative to a 500mA current.

[0036]

That is, it is shown that when a load current which is a current of power consumed in the loads 6 and 9 is in a range from 200mA to 400mA, a high efficiency in excess of 90% is achievable. Further, when the load current is 300mA, the maximum efficiency is obtained, however, when its load current is outside the range from 200mA to 400mA, its efficiency drops drastically.

[0037]

In the next, by referring to FIG. 4, a detailed configuration of the constant current circuit 5 will be described.

[0038]

A current consumption monitoring unit 32 monitors a total value of a current value of power supplied to the load 6 and a current value supplied via the DC/DC converter 7 to be consumed

in the load 9. The current consumption monitoring unit 32 controls a distributor 31 such that if the total value is smaller than 300mA at which the maximum conversion efficiency is achievable, a surplus current of power is supplied to the  
5 charging battery 8 for charging itself, and if the total value is greater than 300mA, it receives a power supply from the charging battery 8.

[0039]

The distributor 31, in response to a command from the  
10 power consumption monitoring unit 32, distributes and supplies power to the load 6, the load 9 via the DC/DC converter 7 and the charging battery 8, as well as receives power supply from the charging battery 8 as required.

[0040]

15 In the next, a constant current control process by the constant current circuit 5 will be described with reference to FIG.5.

[0041]

In step S1 (FIG. 5), the power consumption monitoring  
20 unit 32 calculates a total value of a current value of power supplied to the load 6 and a current value of power supplied to the load 9 via the DC/DC converter 7.

[0042]

In step S2, the power consumption monitoring unit 32  
25 determines whether or not a total current value of power consumption calculated is less than 300mA. For example, if the total current value is determined to be less than 300mA, the distributor 31 is controlled in step S3 to supply to the charging battery 8 a surplus power corresponding to a  
30 difference between an actually consumed power and 300mA, and to distribute the rest of power to the load 6 and the DC/DC

converter 7, after then the process returning to step S1.  
[0043]

If it is determined in step S2 that the total value is not less than 300mA, the power consumption monitoring unit  
5 32 determines in step S4 whether or not the total value is larger than 300mA, and if it is determined, for example, to be larger than that, the process advances to step S5.  
[0044]

In step S5, the power consumption monitoring unit 32  
10 controls the distributor 31 to draw out a power corresponding to a load current exceeding 300mA from the charging battery 8 and supply it to be distributed to the load 6 and the DC/DC converter 7. After then, the process returns to step S1.  
[0045]

15 In step S4, if the total load current is determined not greater than 300mA, that is, the current consumption is 300mA, the process returns to step S1 to repeat the subsequent steps.  
[0046]

By the processes described above, the DC/DC converter  
20 4 is enabled to continue its voltage conversion in the state achievable of the utmost efficiency. That is, as shown in FIG. 3, if a load current is, for example, 50mA, although the power loss due to voltage conversion is 27.75 (mW) ( $=1.5 \text{ (V)} \times 50 \text{ (mA)} \times (1-0.63)$ ), the power loss becomes 27 (mW) ( $=1.5 \text{ (V)} \times 300 \text{ (mA)} \times (1-0.94)$ ), thereby enabling to reduce the power loss by  
25 enabling to operate at 300mA at which the conversion efficiency is highest by supplying a power supply to the charging battery 8.  
[0047]

30 According to the arrangement described above, the constant current circuit 5 controls the current value of the

power supplied from the DC/DC converter 4 so as to always be the utmost conversion efficiency in the DC/DC converter 4. Therefore even if a DC/DC converter is used, whose characteristic cannot be changed by changing the number of windings of its coil as the DC/DC converter 4 using the thin film coil, it becomes possible to continue to use under the utmost conversion efficiency condition, resulting in enabling to achieve reduced power consumption.

[0048]

10 In the case where the DC/DC converter 4 is designed such that its conversion efficiency becomes the highest at the maximum output (at a maximum current), it is, however, very rare for it to be operated at the maximum output. Therefore, in a normal operating condition, the charging battery 8 will be constantly charged fully with power, thereby allowing it to may be used also as a power supply, for example, of a stroboscope as required. Further, by disposing an additional DC/DC converter for converting from 1.5V to a relatively closer voltage of 1.2V in a subsequent stage as the DC/DC converter 15 7, it can convert at a higher efficiency, for example, than converting from 8.4V to 1.2V (generally, the smaller a difference between a voltage prior to its conversion and a voltage post its conversion is, the higher an efficiency is obtainable). As a result, still more reduction in power consumption becomes achievable.

25 [0049]

Still further, in the above description, as an example of DC/DC converter 4, it has been described the converter for converting from 8.4V to 1.5V. However, it is not limited thereto, and any DC/DC converter for converting from any other 30 voltage to another voltage may be used. In this case, a

constant current circuit capable of maintaining a current value, at which the highest conversion efficiency is achievable corresponding to the characteristics of a DC/DC converter to be used, may be used. Therefore, although it has been described by way of the exemplary case in which the constant current circuit coordinates between charging of the charging battery or receiving a power supply therefrom after comparing the load current with 300mA, it should be noted that it is not limited thereto, and it may be compared with any other current value.

10 [0050]

As described hereinabove, by disposing the constant current circuit in the subsequent stage of the DC/DC converter which uses the thin film choke coil so as to supply a current value corresponding to the characteristics of the DC/DC converter to the loads in the subsequent stages, it becomes possible always to utilize the power in the nearly utmost efficiency condition in the DC/DC converter. As a result, it becomes possible to achieve reduced power consumption over the whole of the system.

20 [0051]

In this specification, the steps describing the sequences of the process set forth should be understood to include not only those processes to be executed in time series in the order described above but also processes to be executed in parallel or separately even if they are not executed in time series.

**What is claimed is:**

1. A control circuit apparatus comprising:

a first voltage converter which uses a thin film choke coil for converting a voltage of power to be supplied to a load in a subsequent stage, from a first voltage to a second voltage; and

a constant current circuit for maintaining a current value of power supplied at said second voltage from said voltage converter at a predetermined current value, irrespective of power consumption in said load.

2. The control circuit apparatus according to claim 1, further comprising:

a calculation circuit for calculating a current value of power consumed in said load; and

a charging battery, which is chargeable with a portion of power supplied from said first voltage converter or which supplies power to said load; wherein

if said current value of power consumption calculated by said calculation circuit is smaller than a predetermined current value, said constant current circuit makes said charging battery to charge power corresponding to a difference between said predetermined current value and said current value of power consumption; and if said current value of power consumption calculated by said calculation circuit is greater than said predetermined current value, said constant current circuit makes said charging battery to supply power corresponding to a difference between said predetermined current value and said current value of power consumption.

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3. The control circuit apparatus according to claim 1,

wherein said load is a second voltage converter for converting a voltage of power supplied from said constant current circuit, from said second voltage to a third voltage.

- 5 4. A power supply circuit control method comprising the steps of:

converting a voltage of power to be supplied to a load in a subsequent stage, from a first voltage to a second voltage by a first voltage converter with the use of thin film choke

10 coil; and

maintaining a current value of power supplied at said second voltage from said voltage converter at a predetermined current value by using a constant current circuit, irrespective of power consumption in said load.

15

5. The power supply circuit control method according to claim 4 further comprising the steps of:

calculating a current value of power consumed in said load by a calculating circuit;

20 charging a charging battery with a portion of power supplied from said first voltage converter or supplying power to said load from said charging battery; wherein

if said current value of power consumption calculated by said calculation circuit is smaller than a predetermined current value, said constant current circuit makes said  
25 charging battery to charge power corresponding to a difference between said predetermined current value and said current value of power consumption; and if said current value of power consumption calculated by said calculation circuit is greater  
30 than said predetermined current value, said constant current circuit makes said charging battery to supply power

corresponding to a difference between said predetermined current value and said current value of power consumption.