An current-level decision device for a power supply device includes a reception end for receiving a current sense signal, a reference voltage generator for generating a first reference voltage, a reference voltage correction unit coupled to the reference voltage generator and the reception end for adjusting the reference voltage according to a variation of the current sense signal, so as to generate a second reference voltage; a comparator coupled to the reception end and the reference voltage correction unit for comparing the current sense signal and the second reference voltage to generate a comparison result, and a control unit coupled to the comparator for controlling a switch transistor of the power supply according to the comparison result.
CURRENT-LEVEL DECISION DEVICE FOR A POWER SUPPLY DEVICE AND RELATED POWER SUPPLY DEVICE

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of U.S. Provisional Application No. 61/044,908, filed on Apr. 15, 2008 and entitled "Over Current Protection Circuit with Adaptive Reference in a Power Supply Device", the contents of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention
2. Description of the Prior Art
3. Power supply is used to provide an electrical power for operating an electronic device. According to the circuit architecture, power supplies can be classified into two types, linear and switching. A switching power supply has benefits of small volume, light weight and high power efficiency, so it can be widely used in various kinds of electronic devices, such as mobile phones, PDAs, computers and peripherals, servers, and network appliances.
4. For sustaining the normal operation of the power supply, the protection mechanism of a control circuit for protecting the power supply is a very critical part (for example, protection functions of over-voltage, over-current, and over-power), and once the overload or the short condition happens, a power supply with complete protection functions can prevent the internal components or related appliances from being damaged.

Please refer to FIG. 1, which illustrates a schematic diagram of a switching power supply 

The switching power supply 

The operations of the circuit are stated as follows. First, the current sensing resistor generates the current sense signal VCS based on the primary winding current Id of the transformer. The secondary of the comparator compares the current sense signal VCS and a reference voltage VREF, and outputs an indication signal SOC to the control unit, such that the control unit can determine whether it has fallen into the range of current protection. For example, when the current sense signal VCS is higher than the reference voltage VREF, the comparator can indicate an over-current condition happens via the indication signal SOC; the control unit can then turn off the switch transistor Q1 to reduce current in the primary winding.

Simply speaking, the protection mechanism mentioned above is to compare the current sense signal VCS and the reference voltage VREF, such that the primary winding current can be controlled within a proper range for the purpose of protection. However, when the current sense signal VCS is higher than the reference voltage VREF, the switch transistor Q1 cannot be turned off immediately owing to some non-ideal factors, and it will take an interval of time for the control unit to turn off the switch transistor Q1. That is to say, there exists a time delay T_D, starting from the moment for the over-current condition being detected to the time for the switch transistor Q1 being turned off, and the current level right before being turned off will surpass the pre-defined level by a specific amount. In other words, the voltage level right before the over-current protection starts (abbreviated as "protection point voltage" hereafter) will be larger than the voltage level when the over-current condition is taking place. For different voltage level of the input voltage VIN, the voltage level of the protection point voltage varies accordingly.

For more details, please refer to FIG. 2, which illustrates the voltage difference of the protection point voltage for different input voltages within the same time delay. The input voltage VIN of the switching power supply is proportional to the slope of the current sense signal VCS. Therefore, with the same reference voltage VREF, a higher input voltage VIN will generate a current sense signal VCS of bigger slope, and a lower input voltage VIN will generate a current sense signal VCS of smaller slope. Note that, a power supply always has the same time delay T_D since the time delay T_D is independent of the level of the input voltage VIN. As illustrated in FIG. 2, when the current sense signal VCS rises to the power limiting level corresponding to the reference voltage VREF, or the current sense signal VCS is greater than or equal to the reference voltage VREF, the comparator transmits the indication signal SOC to the control unit, such that the switch transistor Q1 can be turned off. Since the circuit is composed of non-ideal factors, therefore, after the transmission delay T_D, the switch transistor Q1 starts being turned off, and the primary winding current Id can then be cut off. From the moment of the over-current condition being detected to the switch transistor Q1 being turned off, the input voltage VIN will continue to transfer power, such that the protection point voltage becomes VOPPH for the high input voltage VIN, or the protection point voltage becomes VOPPL for the low input voltage VIN. In other words, the protection point voltage will be higher than the reference voltage VREF, and as the input voltage VIN gets higher, the situation becomes even more obvious. Under this situation, when the input voltage VIN varies in a wide range, the protection point voltage will drift seriously, such that the output power levels corresponding to the high and the low input voltages differs a lot.

SUMMARY OF THE INVENTION

It is therefore a primary objective of the claimed invention to provide a current-level decision device for a power supply and the related power supply.

The present invention discloses a current-level decision device for a power supply, which comprises a reception end for receiving a current sense signal, a reference voltage generator for generating a first reference voltage, a reference voltage correction unit, coupled to the reference voltage generator and the reception end, for adjusting the first reference voltage according to variation of the current sense signal, so as to generate a second reference voltage, a first comparator, coupled to the reception end and the reference voltage correction unit, for comparing the current sense signal and the
second reference voltage, to generate a first comparison result, and a control unit, coupled to the first comparator, for controlling a power switch of the power supply according to the first comparison result.

[0012] The present invention also discloses a power supply capable of preventing an over-current damage, which comprises a transformer, comprising a primary winding circuit and a secondary winding circuit, a switch transistor, coupled to the secondary winding circuit, a current sensing unit, coupled to the switch transistor, for generating a current sense signal according to current flowing through the switch transistor in the primary winding circuit, and a current-level decision device, coupled to the current sensing unit and the switch transistor, which further comprises a reception end for receiving a current sense signal, a reference voltage generator for generating a first reference voltage, an reference voltage correction unit, coupled to the reference voltage generator and the reception end, for adjusting the first reference voltage according to variation of the current sense signal, so as to generate a second reference voltage, a first comparator, coupled to the reception end and the reference voltage correction unit, for comparing the current sense signal and the second reference voltage, to generate a first comparison result, and a control unit coupled to the first comparator for controlling a power switch of the power supply according to the first comparison result.

[0013] These and other objectives of the present invention will no doubt become obvious to those of ordinary skill in the art after reading the following detailed description of the preferred embodiment that is illustrated in the various figures and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] FIG. 1 illustrates a schematic diagram of a switching power supply of the prior art.
[0015] FIG. 2 illustrates the voltage difference of the protection point voltages for different input voltages within the same time delay.
[0016] FIG. 3 is a schematic diagram of a power supply in accordance with an embodiment of the present invention.
[0017] FIG. 4 is a schematic diagram of a current-level decision device as shown in FIG. 3.
[0018] FIG. 5 illustrates a schematic diagram of the reference voltage correction unit shown in FIG. 4 according to a preferred embodiment of the present invention.
[0019] FIG. 6 illustrates a schematic diagram of generating a second comparison result in FIG. 5.

DETAILED DESCRIPTION

[0020] Please refer to FIG. 3, which is a schematic diagram of a power supply 30 in accordance with an embodiment of the present invention. Preferably, the power supply 30 is a switching power supply, capable of preventing over-current damage. The power supply 30 comprises a transformer 300, a switch transistor Q1, a current sensing resistor Rs and a current-level decision device 302. The transformer 300, composed of a primary winding circuit and a secondary winding circuit, is used for transforming the input voltage signal VIN to an output voltage signal VOUT. The switch transistor Q1, coupled to the primary winding of the transformer 300, is used for switching the operations of the transformer 300. The current sensing resistor Rs, coupled to the switch transistor Q1, generates a current sense signal VCS based upon the primary winding current Id flowing through the switch transistor Q1. The current-level decision device 302, coupled to the switch transistor Q1 and the current sensing resistor Rs, is used for monitoring the primary winding current Id to be operated within a protected range. Once the current Id operates outside the protected range, the switch transistor Q1 will be turned off to reach the goal of over-current protection.

[0021] Please refer to FIG. 4, which is a schematic diagram of the current-level decision device 302 as shown in FIG. 3. The current-level decision device 302 comprises a reception end 400, a reference voltage generator 402, a reference voltage correction unit 404, a first comparator 406 and a control unit 408. The reception end 400, coupled to the current sensing resistor Rs, is used for receiving the current sense signal VCS, such that the current sense signal VCS is transferred to the reference voltage correction unit 404 and the first comparator 406. The reference voltage generator 402, coupled to the reference voltage correction unit 404, is used for generating a first reference voltage VREF1. The reference voltage correction unit 404 can receive the current sense signal VCS and the first reference voltage VREF1, and adjusts the first reference voltage VREF1 according to variation of the current sense signal VCS, so as to generate a second reference voltage VREF2. Furthermore, the first comparator 406 compares the current sense signal VCS and the second reference voltage VREF2 to generate a first comparison result CMP1 and output to the control unit 408, such that the control unit 408 controls the conduction status of the switch transistor Q1 according to the first comparison result CMP1. Simply speaking, the current-level decision device 302 can adjust the first reference voltage VREF1 according to variation of the current sense signal VCS, such that the second reference voltage VREF2 can meet the demands of different system requirements.

[0022] Please refer to FIG. 5, which illustrates a schematic diagram of the reference voltage correction unit 404 shown in FIG. 4 according to a preferred embodiment of the present invention. The reference voltage correction unit 404 comprises a switch transistor Q2, a reset transistor Q3, a first current source 500, a second comparator 502, a filtering unit 504, a division unit 506 and a resistor 508. The second comparator 502 is used for comparing the first reference voltage VREF1 and the current sense signal VCS, to generate a second comparison result CMP2 to a gate of the switch transistor Q2, so as to control the conduction status of the switch transistor Q2. In this embodiment, the switch transistor Q2 is an n-type metal oxide semiconductor field effect transistor (MOSFET). Therefore, as shown in FIG. 6, when the current sense signal VCS is smaller than the first reference voltage VREF1, the second comparison result CMP2 is in low level, and the switch transistor Q2 is turned off. When the current sense signal VCS is greater than the first reference voltage VREF1, the second comparison result CMP2 is in high level, and the switch transistor Q2 is turned on, such that current generated by the first current source 500 flows through the filtering unit 504. The filtering unit 504 comprises capacitors C1, C2 and a resistor R1, and is utilized for filtering signals of the drain of the switch transistor Q2. The division unit 506 comprises a second current source 510 and a third current source 512, and the third current source 512 is controlled by a filtering result of the filtering unit 504, so as to adjust the current amount flowing through the resistor 508. The resistor 508 is acted as a current to voltage converter. In other words, when the current sense signal VCS is greater than the first
reference voltage VREF1, the reference voltage correction unit 404 can increase current generated by the third current source 512, to reduce current flowing through the resistor 508. As a result, the second reference voltage VREF2 becomes smaller than the first reference voltage VREF1, to meet requirements of different systems. Furthermore, in FIG. 5, the reset transistor Q3 is an n-type MOSFET, and utilized for resetting the reference voltage correction unit 404 according to a reset signal RST, so as to recover the second reference voltage VREF2 to an initial value (i.e. the first reference voltage VREF1).

[0023] Therefore, the power supply 30 can adjust the first reference voltage VREF1 via the reference voltage correction unit 404, to solve the problem of time delay, and prevent the voltage drifting problem associated with the protection points. Note that, FIG. 3 to FIG. 5 exhibit embodiments of the present invention, and those skilled in the art can make numerous modifications and alterations accordingly.

[0024] To sum up, the present invention regulates the reference voltage based upon variation of the current sense signal, such that the actual voltage for activating the over-current protection is identical to the expected voltage for activating the over-current protection, meanwhile, the problems of time delay and the drift of the protection point voltage can be greatly improved.

[0025] Those skilled in the art will readily observe that numerous modifications and alterations of the device and method may be made while retaining the teachings of the invention. Accordingly, the above disclosure should be construed as limited only by the metes and bounds of the appended claims.

What is claimed is:

1. A current-level decision device for a power supply comprising:
   a reception end for receiving a current sense signal;
   a reference voltage generator for generating a reference voltage;
   a reference voltage correction unit, coupled to the reference voltage generator and the reception end, for adjusting the first reference voltage according to variation of the current sense signal, so as to generate a second reference voltage;
   a first comparator, coupled to the reception end and the reference voltage correction unit, for comparing the current sense signal and the second reference voltage, to generate a first comparison result; and
   a control unit, coupled to the first comparator, for controlling a power switch of the power supply according to the first comparison result.

2. The current-level decision device of claim 1, wherein the reference voltage correction unit comprises:
   a switch unit, comprising a first end, a second end and a third end, for conducting a signal connection between the first end and the third end according to signals received by the second end;
   a first current source, coupled to the first end of the switch unit, for generating a first current;
   a second comparator, coupled to the reference voltage generator, the reception end and the second end of the switch unit, for comparing the first reference voltage and the current sense signal, to generate a second comparison result to the second end of the switch unit;
   a filtering unit, coupled to the third end of the switch unit, for performing filtering on signals of the third end of the switch unit;
   a division unit, coupled to the filtering unit, for generating a current signal according to a filtering result of the filtering unit; and
   a current to voltage conversion unit, coupled to the division unit and the first comparator, for generating the second reference voltage to the first comparator according to the current signal generated by the separation unit.

3. The current-level decision device of claim 2, wherein the switch unit is a p-type metal oxide semiconductor field effect transistor, the first end is a source, the second end is a gate, and the third end is a drain.

4. The current-level decision device of claim 2, wherein the filtering unit comprises:
   a first capacitor, having one end coupled to the third end of the switch unit, and the other end coupled to a ground;
   a resistor, coupled to the third end of the switch unit; and
   a second capacitor, having one end coupled to the resistor, and the other end coupled to a ground.

5. The current-level decision device of claim 2, wherein the division unit comprises:
   a current output end, coupled to the current to voltage conversion unit, for outputting the current signal;
   a second current source, coupled to the current output end, for generating a second current to the current output end; and
   a third current source, coupled to the current output end, the filtering unit and a ground, for generating a third current from the current output end to the ground, and adjusting the third current according to the filtering result of the filtering unit.

6. The current-level decision device of claim 2, wherein the current to voltage conversion unit is a resistor.

7. The current-level decision device of claim 2, further comprising a reset unit, having a first end coupled to the third end of the switch unit, a second end coupled to a reset signal generator, and a third end coupled to a ground, for conducting a signal connection between the first end and the third end according to signals received by the second end.

8. The current-level decision device of claim 7, wherein the reset unit is an n-type metal oxide semiconductor field effect transistor, the first end is a drain, the second end is a gate, and the third end is a source.

9. A power supply capable of preventing an over-current damage comprising:
   a transformer, comprising a primary winding circuit and a secondary winding circuit;
   a switch transistor, coupled to the primary winding circuit;
   a current sensing unit, coupled to the switch transistor, for generating a current sense signal according to current flowing through the switch transistor in the primary winding circuit; and
   a current-level decision device, coupled to the current sensing unit and the switch transistor, comprising:
   a reception end for receiving a current sense signal;
   a reference voltage generator for generating a first reference voltage;
   a reference voltage correction unit, coupled to the reference voltage generator and the reception end, for adjusting the first reference voltage according to variation of the current sense signal, so as to generate a second reference voltage;
a first comparator, coupled to the reception end and the reference voltage correction unit, for comparing the current sense signal and the second reference voltage, to generate a first comparison result; and

a control unit, coupled to the first comparator, for controlling a power switch of the power supply according to the first comparison result.

10. The power supply of claim 9, wherein the reference voltage correction unit comprises:

a switch unit, comprising a first end, a second end and a third end, for conducting a signal connection between the first end and the third according to signals received by the second end;

a first current source, coupled to the first end of the switch unit, for generating a first current;

a second comparator, coupled to the reference voltage generator, the reception end and the second end of the switch unit, for comparing the first reference voltage and the current sense signal, to generate a second comparison result to the second end of the switch unit;

a filtering unit, coupled to the third end of the switch unit, for performing filtering on signals of the third end of the switch unit;

a division unit, coupled to the filtering unit, for generating a current signal according to a filtering result of the filtering unit; and

a current to voltage conversion unit, coupled to the division unit and the first comparator, for generating the second reference voltage to the first comparator according to the current signal generated by the separation unit.

11. The power supply of claim 10, wherein the switch unit is a p-type metal oxide semiconductor field effect transistor, the first end is a source; the second end is a gate, and the third end is a drain.

12. The power supply of claim 10, wherein the filtering unit comprises:
a first capacitor, having one end coupled to the third end of the switch unit, and the other end coupled to a ground; a resistor, coupled to the third end of the switch unit; and

a second capacitor, having one end coupled to the resistor, and the other end coupled to a ground.

13. The power supply of claim 10, wherein the division unit comprises:
a current output end, coupled to the current to voltage conversion unit, for outputting the current signal;
a second current source, coupled to the current output end, for generating a second current to the current output end; and

a third current source, coupled to the current output end, the filtering unit and a ground, for generating a third current from the current output end to the ground, and adjusting the third current according to the filtering result of the filtering unit.

14. The power supply of claim 10, wherein the current to voltage conversion unit is a resistor.

15. The power supply of claim 10 further comprising a reset unit, having a first end coupled to the third end of the switch unit, a second end coupled to a reset signal generator, and a third end coupled to a ground, for conducting a signal connection between the first end and the third end according to signals received by the second end.

16. The power supply of claim 15, wherein the reset unit is an n-type metal oxide semiconductor field effect transistor, the first end is a drain, the second end is a gate, and the third end is a source.

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