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SWITCHING POWER SUPPLY CIRCUIT AND SWITCHING POWER SUPPLY SYSTEM HAVING THE SAME

Abstract

Disclosed herein is a switching power supply circuit that includes a switching circuit having an input node connected to an input power supply terminal and an output node connected to an output power supply terminal through an output switch, a feedback circuit configured to feed back information based on a voltage appearing at a control node to the switching circuit, and an activation circuit configured to turn ON the output switch after an elapse of a predetermined time after a voltage appearing at the control node exceeds a predetermined value. The switching circuit is configured to adjust a level of a voltage appearing at each of the output node and the control node based on the information to a predetermined level. The feedback circuit includes an adjustment mechanism configured to adjust a relation between a voltage appearing at the control node and the information.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of Japanese Patent Application No. 2024-019439, filed on Feb. 13, 2024, the entire disclosure of which is incorporated by reference herein.

BACKGROUND OF THE ART

Field of the Art

[0002] The present disclosure relates to a switching power supply circuit and, more particularly, to a switching power supply circuit suitably constituting a switching power supply system by being parallel-connected to one or more other switching power supply circuits.

Description of Related Art

[0003] JP 2003-169471A discloses a switching power supply system constituted by a plurality of parallel-connected switching power supply circuits. The switching power supply system disclosed in JP 2003-169471A makes reactivation timing coincident among the plurality of switching power supply circuits by mutually short-circuiting on/off control terminals of PWM control ICs included in the respective switching power supply circuits.

[0004] However, when there is a difference in output voltage among a plurality of parallel-connected switching power supply circuits, a switching power supply circuit having a higher output voltage may be put into an overcurrent state or an overload state. Thus, in the switching power supply system described in JP 2003-169471A, even when the switching power supply circuits are reactivated simultaneously, the overcurrent or overload may occur in the switching power supply circuit having a higher output voltage to result in an immediate stop of switching operation.

SUMMARY

[0005] It is therefore an object of the present disclosure to provide a switching power supply circuit that can operate stably even when connected in parallel, and a switching power supply system using the same.

[0006] A switching power supply circuit according to the present disclosure includes a switching circuit whose input node is connected to an input power supply terminal and whose output node is connected to an output power supply terminal through an output switch, a feedback circuit that feeds back information based on a voltage appearing at a control node provided in parallel with the output node to the switching circuit, and an activation circuit that turns ON the output switch after the elapse of a predetermined time after a voltage appearing at the control node exceeds a predetermined value. The switching circuit adjusts the level of a voltage appearing at each of the output node and the control node based on the feedback information to a predetermined level, and the feedback circuit includes an adjustment mechanism that can adjust the relation between a voltage appearing at the control node and the feedback information.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] The above features and advantages of the present disclosure will be more apparent from the following description of certain preferred embodiments taken in conjunction with the accompanying drawings, in which:

[0008] FIG. **1** is a block diagram for explaining the configuration of a switching power supply system **10** according to an embodiment of the present disclosure; and

[0009] FIG. **2** is a circuit diagram of the switching power supply circuit **100**.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0010] Preferred embodiments of the present disclosure will be explained below in detail with reference to the accompanying drawings.

[0011] FIG. **1** is a block diagram for explaining the configuration of a switching power supply system **10** according to an embodiment of the present disclosure.

[0012] As illustrated in FIG. **1**, the switching power supply system **10** according to the present embodiment has a plurality of parallel-connected switching power supply circuits **100**. The switching power supply circuits **100** each have an input power supply terminal **101** which is supplied with an input voltage Vin, an output power supply terminal **102** which outputs an output voltage Vout, and an activation control terminal **103**. The output power supply terminals **102** included in the respective switching power supply circuits **100** are mutually short-circuited and connected in common to a load **12**. The input power supply terminals **101** included in the respective switching power supply circuits **100** are connected to different power supplies **11**. The power supply **11** may be a power pickup transformer that picks up power by utilizing a magnetic field generated around a high-voltage transmission line. The activation control terminals **103** included in the respective switching power supply circuits **100** are also mutually short-circuited.

[0013] FIG. **2** is a circuit diagram of the switching power supply circuit **100**.

[0014] As illustrated in FIG. **2**, the switching power supply circuit **100** includes a switching circuit **110**, a feedback circuit **120**, an activation circuit **130**, and an output switch **140**. The switching circuit **110** includes a transformer T including a primary winding **111** and a secondary winding **112**, a switching element **113** connected to one end of the primary winding **111**, and a switching control circuit **114** for controlling the switching element **113**. The other end of the primary winding **111** constitutes an input node N**1** of the switching circuit **110** and is connected to the input power supply terminal **101**. An output node N**3**, which is one end of the secondary winding **112**, is connected to an output node N**2** via a diode **116** (first diode) and is also connected to a control node N**4** via a diode **118** (second diode). The output node N**2** is connected to the output power supply terminal **102** through the output switch **140**. The other end of the secondary winding **112** is connected to ground via a ground node N**6**. The output node N**2** is connected to the ground node N**6** via a capacitor **117** (first capacitor). The activation circuit **130** is connected to the control node N**4** provided in parallel with the output node N**2**. The control node N**4** is connected to the ground node N**6** via a capacitor **119** (second capacitor).

[0015] The characteristics of the diode **118** may be the same as or different from those of the diode **116**. For example, the maximum rating of the diode **118** may be smaller than that of the diode **116**. The characteristics of the capacitor **119** may be the same as or different from those of the capacitor **117**. For example, the capacitance of the capacitor **119** may be smaller than that of the capacitor **117**. An electrolytic capacitor may be used for the capacitor **117** and a multilayer ceramic capacitor may be used for the capacitor **119**.

[0016] The switching control circuit **114** is constituted by, e.g., a controller IC and has a power supply node N**11**, a ground node N**12**, a control node N**13**, and feedback nodes N**14** and N**15**. The switching control circuit **114** operates with a voltage supplied between the power supply node N**11** and the ground node N**12** and controls, based on feedback information F supplied to the feedback node N**14**, the frequency and duty of a switching signal S output from the control node N**13** to adjust a voltage appearing at the output node N**2** to a predetermined level. The switching element **113** supplied with the switching signal S is constituted by, e.g., an N-channel MOS transistor.

[0017] A current flowing in the switching element **113** is supplied to the feedback node N**15** of the switching control circuit **114** through a resistor **115**. The switching control circuit **114** monitors the current supplied to the feedback node N**15**. When determining that the current flowing in the switching element **113** is an overcurrent, the switching control circuit **114** fixes the level of the switching signal S to an inactive level (e.g., a ground level) to stop the switching operation of the switching element **113**. This can prevent breakage of the switching element **113** due to an overcurrent. Similarly, also when determining that the feedback information F indicates an overload state, the switching control circuit **114** fixes the level of the switching signal S to an inactive level to stop the switching operation of the switching element **113**. The switching control circuit **114** is reactivated after the switching operation is stopped, and the switching operation is resumed after the elapse of a predetermined time.

[0018] The feedback circuit **120** generates feedback information F based on a voltage appearing at the control node N**4** provided in parallel with the output node N**2** and feeds back the feedback information to the switching circuit **110**. Voltages appearing at the output node N**2** and the control node N**4** substantially coincide with the output voltage Vout when the output switch **140** is ON. The feedback circuit **120** includes fixed resistors **121** and **124**, a variable resistor **122**, a shunt regulator **123**, a photodiode **125**, and a phototransistor **126**. The fixed resistor **121** and the variable resistor **122** are connected in series between the control node N**4** and the anode of the shunt regulator **123** to constitute a voltage divider circuit, and a voltage at a connection point therebetween is supplied to the reference node of the shunt regulator **123**. The fixed resistor **124** and the photodiode **125** are connected in series between the control node N**4** and the cathode of the shunt regulator **123**. The photodiode **125** and phototransistor **126** constitute a photocoupler and act to transmit the feedback information F from the secondary side to primary side while maintaining insulation between the primary and secondary sides.

[0019] The level of the feedback information F varies depending not only on a voltage appearing at the control node N**4** equivalent to a voltage appearing at the output node N**2** but also on the dividing ratio of the voltage divider circuit constituted by the fixed resistor **121** and variable resistor **122**. At the design stage, the dividing ratio of the voltage divider circuit is set such that a voltage appearing at the output node N**2** has a predetermined level (e.g., 24 V); however, the level of a voltage actually appearing at the output node N**2** may deviate from the predetermined level due to individual difference ascribable to manufacturing variations. The variable resistor **122** serves as an adjustment mechanism to eliminate such a deviation. By adjusting the resistance value of the variable resistor **122**, the relation between a voltage appearing at the control node N**4** and the feedback information F is finely adjusted after manufacturing, whereby the level of a voltage appearing at the output node N**2** is adjusted to a predetermined level (e.g., 24 V).

[0020] The activation circuit **130** includes fixed resistors **131**, **132**, a timer IC **133**, a capacitor **134**, and an N-channel MOS transistor **135**. The fixed resistors **131** and **132** are connected in series between the control node N**4** and the ground to constitute a voltage divider circuit, and a voltage at a connection point therebetween is supplied to an input node N**21** of the timer IC **133**. The timer IC **133** outputs an activation signal A of a high level from an output node N**22** after the elapse of a predetermined time from when the voltage supplied to the input node N**21** exceeds a predetermined value. The activation signal A is supplied to the gate electrode of the transistor **135**. The transistor **135** is connected between the gate electrode of the output switch **140** constituted by a P-channel MOS transistor and the ground. Thus, when the activation signal A is activated to a high level, the gate electrode of the P-channel MOS transistor constituting the output switch **140** is grounded to turn ON the output switch **140**. That is, the output switch **140** is turned ON after the elapse of a predetermined time from when a voltage appearing at the control node N**4** exceeds a predetermined value. Meanwhile, the predetermined time counted by the timer IC **133** can be adjusted by the capacitance of the capacitor **134** connected to an adjustment node N**23**.

[0021] The activation signal A is supplied also to the activation control terminal **103**. As described above, the activation control terminals **103** are connected in common among the plurality of switching power supply circuits **100** and, accordingly, after activation of the switching circuits **110** included in the plurality of respective switching power supply circuits **100**, the activation signal A that has been activated earliest is supplied in common to the switching power supply circuits **100** through the corresponding activation control terminals **103**. As a result, the output switches **140** included in the respective switching power supply circuits **100** are turned ON substantially simultaneously. Although the activation signal A indirectly controls the output switch **140** through the transistor **135** in the example illustrated in FIG. **2**, it may directly control the output switch **140**.

[0022] By parallel-connecting the thus configured switching power supply circuits **100** as illustrated in FIG. **1**, the switching power supply system **10** according to the present disclosure can be constituted. In this configuration, the output voltage levels of the respective switching power supply circuits **100** can be made to substantially coincide with one another by adjusting the resistance values of the variable resistors **122**, thus preventing a specific switching power supply circuit **100** from being put into an overload state.

[0023] When an overcurrent or an overload occurs in a certain switching power supply circuit **100**, switching operation is stopped in this switching power supply circuit **100**, and the output voltage Vout therefrom becomes 0 V. As a result, an overcurrent or an overload occurs also in the remaining switching power supply circuits **100** and, eventually, switching operation is stopped in all the switching power supply circuits **100**. Thereafter, in each switching power supply circuit **100**, the switching control circuit **114** is reactivated to raise the voltage of the output node N**2**. Then, the activation signal A is activated in the switching power supply circuit **100** in which the voltage of the output node N**2** reaches a predetermined value earliest, and this activation signal A is supplied to the other switching power supply circuits **100**, whereby all the switching power supply circuits **100** start power output substantially simultaneously. This prevents a specific switching power supply circuit **100** from being put into an overcurrent or an overload state upon the activation.

[0024] In the example illustrated in FIG. **1**, the switching power supply circuits **100** are connected to different power supplies **11**, so that the levels of the input voltages Vin input to the respective switching power supply circuits **100** do not always coincide with one another. Even under such a condition, according to the switching power supply system **10** of the present embodiment, the levels of the output voltages Vout from the respective switching power supply circuits **100** substantially coincide with one another, thus preventing a specific switching power supply circuit **100** from being put into an overload state.

[0025] The output node N**3** is one end of the secondary winding **112** of the transformer T, i.e., the anode of the diode **116**. The level of the output node N**3** is higher than the voltage level of the output node N**2** by the forward direction voltage of the diode **116**, and higher than the voltage level of the control node N**4** by the forward direction voltage of the diode **118**. However, since the levels of the output node N**2** and the control node N**4** are almost linked to the level of the output node N**3**, the control node N**4** and the output node N**2** can be considered to be almost the same as each other with respect to the operation of the feedback circuit **120** and the activation circuit **130**. For this reason, the activation circuit **130** may be connected to the control node N**4**.

[0026] In this embodiment, the input node N**5** of the feedback circuit **120** is connected to the control node N**4** connected to the activation circuit **130**, rather than to the output node N**2** connected to the output power supply terminal **102** via the output switch **140**. By connecting the input node N**5** of the feedback circuit **120** to the control node N**4**, the output voltage Vout can be correctly read without being affected by the load **12** connected to the output power supply terminal **102**, and a specified voltage can be output even if there is no load.

[0027] In principle, it is desirable to read the feedback information F from the output node N**2**. If the feedback information F is read from the control node N**4**, the loss of the diode **116** is not taken into consideration, and the output voltage level of each switching power supply circuit **100** may vary due to the influence of individual differences in the diode **116**, which may result in unstable operation during parallel operation. However, the output voltage level of the switching power supply circuit **100** is adjusted by adjusting the variable resistor **122** while monitoring the output voltage Vout appearing at the output power supply terminal **102**, and the adjustment result is also reflected in the output node N**2**. Therefore, there is no problem in referring to the voltage of the control node N**4** as the feedback information F.

[0028] Malfunction of the feedback circuit **120** caused by reading a voltage flowing back from another switching power supply circuit **100** during parallel operation can be prevented by inserting a diode between the output switch **140** and the output power supply terminal **102**. However, in this embodiment, it is not necessary to use such a diode, which is advantageous in terms of component cost, output efficiency, board size, and the like.

[0029] While the preferred embodiment of the present disclosure has been described, the present disclosure is not limited to the above embodiment, and various modifications may be made within the scope of the present disclosure, and all such modifications are included in the present disclosure.

[0030] The technology according to the present disclosure includes the following configuration examples but not limited thereto.

[0031] A switching power supply circuit according to the present disclosure includes a switching circuit whose input node is connected to an input power supply terminal and whose output node is connected to an output power supply terminal through an output switch, a feedback circuit that feeds back information based on a voltage appearing at a control node provided in parallel with the output node to the switching circuit, and an activation circuit that turns ON the output switch after the elapse of a predetermined time after a voltage appearing at the control node exceeds a predetermined value. The switching circuit adjusts the level of a voltage appearing at each of the output node and the control node based on the feedback information to a predetermined level, and the feedback circuit includes an adjustment mechanism that can adjust the relation between a voltage appearing at the control node and the feedback information.

[0032] According to the present disclosure, using the adjustment mechanism that can adjust the relation between a voltage appearing at the control node provided in parallel with the output node and the feedback information allows adjustment of the level of an output voltage output from the output power supply terminal. Thus, in a case where a plurality of switching power supply circuits are parallel-connected to constitute a switching power supply system, it is possible to prevent a specific switching power supply circuit from being preferentially put into an overcurrent state or an overload state.

[0033] In the present disclosure, the feedback circuit may include a voltage divider circuit that divides a voltage appearing at the control node, and the adjustment mechanism may be constituted by a variable resistor included in the voltage divider circuit. With this configuration, it is possible to easily adjust the level of an output voltage.

[0034] In the present disclosure, the switching circuit may include a transformer including a primary winding connected to the input node and a secondary winding connected to the output node and the control node, a switching element connected to the primary winding, and a switching control circuit that controls the switching element. The switching control circuit may stop the switching operation of the switching element when determining that a current flowing in the switching element is an overcurrent. This can eliminate an overcurrent state.

[0035] In the present disclosure, the switching control circuit may stop the switching operation of the switching element when determining that the feedback information indicates an overload state. This can eliminate an overload state.

[0036] In the present disclosure, one end of the secondary winding may be connected to the output node via a first diode and to the control node via a second diode, another end of the secondary winding may be grounded, the output node may be grounded via a first capacitor, and the control node may be grounded via a second capacitor. In this case, the maximum rating of the second diode may be smaller than that of the first diode, and the capacitance of the second capacitor may be smaller than that of the first capacitor. With this configuration, a specified voltage can be stably output from the output power supply terminal regardless of the size of the load connected to the output power supply terminal.

[0037] A switching power supply system according to the present disclosure includes a plurality of the above-described switching power supply circuits, wherein the output power supply terminals included in the plurality of respective switching power supply circuits are mutually short-circuited, the activation circuits included in the plurality of respective switching power supply circuits each include an activation control terminal that directly or indirectly controls the output switch, and the activation control terminals included in the plurality of respective switching power supply circuits are mutually short-circuited. With this configuration, it is possible to reactivate the plurality of switching power supply circuits simultaneously.
[0038] The switching power supply system according to the present disclosure may further include a plurality of power supplies connected respectively to the input power supply terminals included in the plurality of respective switching power supply circuits. With this configuration, even when there is a difference among the levels of input voltages supplied from the plurality of respective power supplies, it is possible to prevent a specific switching power supply circuit from being preferentially put into an overcurrent state or an overload state.
[0039] As described above, according to the present disclosure, there can be provided a switching power supply circuit that can operate stably even when connected in parallel, and a switching power supply system using the same.

Claims

1. A switching power supply circuit comprising: a switching circuit having an input node connected to an input power supply terminal and an output node connected to an output power supply terminal through an output switch; a feedback circuit configured to feed back information based on a voltage appearing at a control node provided in parallel with the output node to the switching circuit; and an activation circuit configured to turn ON the output switch after an elapse of a predetermined time after a voltage appearing at the control node exceeds a predetermined value, wherein the switching circuit is configured to adjust a level of a voltage appearing at each of the output node and the control node based on the information to a predetermined level, and wherein the feedback circuit includes an adjustment mechanism configured to adjust a relation between a voltage appearing at the control node and the information.
2. The switching power supply circuit as claimed in claim 1, wherein the feedback circuit includes a voltage divider circuit configured to divide a voltage appearing at the control node, and wherein the adjustment mechanism has a variable resistor included in the voltage divider circuit.
3. The switching power supply circuit as claimed in claim 1, wherein the switching circuit includes: a transformer including a primary winding connected to the input node and a secondary winding connected to the output node and the control node; a switching element connected to the primary winding; and a switching control circuit configured to control the switching element, and wherein the switching control circuit is configured to stop a switching operation of the switching element when a current flowing in the switching element is an overcurrent.
4. The switching power supply circuit as claimed in claim 3, wherein the switching control circuit is configured to stop the switching operation of the switching element when the information indicates an overload state.
5. The switching power supply circuit as claimed in claim 3, wherein one end of the secondary winding is connected to the output node via a first diode and to the control node via a second diode, wherein another end of the secondary winding is grounded, wherein the output node is grounded via a first capacitor, and wherein the control node is grounded via a second capacitor.
6. A switching power supply system comprising a plurality of switching power supply circuits, wherein each of the plurality of switching power supply circuits includes: a switching g circuit having an input node connected to an input power supply terminal and an output node connected to an output power supply terminal through an output switch; a feedback circuit configured to feed

back information based on a voltage appearing at a control node provided in parallel with the output node to the switching circuit; and an activation circuit configured to turn ON the output switch after an elapse of a predetermined time after a voltage appearing at the control node exceeds a predetermined value, wherein the switching circuit is configured to adjust a level of a voltage appearing at each of the output node and the control node based on the information to a predetermined level, wherein the feedback circuit includes an adjustment mechanism configured to adjust a relation between a voltage appearing at the control node and the information, wherein the activation circuit includes an activation control terminal configured to control the output switch, wherein the output power supply terminals included in the plurality of switching power supply circuits are mutually short-circuited, and wherein the activation control terminals included in the plurality of switching power supply circuits are mutually short-circuited.

7. The switching power supply system as claimed in claim 6, further comprising a plurality of power supplies each connected to the input power supply terminal included in an associated one of the plurality of switching power supply circuits.