A power supply system and method includes a switch state controller that is operational to control a switching power converter during certain power loss conditions that cause conventional switch state controllers to have diminished or no functionality. In at least one embodiment, during certain power loss conditions, such as when an auxiliary power supply is in standby mode or when the switching power converter is not operating, a power supply for the switch state controller does not provide sufficient operating power to the switch state controller during certain power loss conditions. In at least one embodiment, during such power loss conditions, power is generated for the switch state controller using sense input and/or sense output currents of the switching power converter to allow an integrated circuit (IC) switch state controller to generate a control signal to control a switch of the switching power converter.
SWITCH STATE CONTROLLER WITH A SENSE CURRENT GENERATED OPERATING VOLTAGE

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CROSS REFERENCE TO RELATED APPLICATIONS

(1) This application claims the benefit under 35 U.S.C. § 119(e) and 37 C.F.R. § 1.78 of U.S. Provisional Application No. 61/024,587, filed January 30, 2008 and entitled "Power Factor Correction with Boost Function Active in Standby Mode." U.S. Provisional Application No. 61/024,587 includes exemplary systems and methods and is incorporated by reference in its entirety.

BACKGROUND OF THE INVENTION

Field of the Invention

(2) The present invention relates in general to the field of signal processing, and, more specifically, to a power control system that includes a switch state controller for a switching power converter that operates in at least some circumstances from an operating voltage derived from one or more sense currents. Each sense current is resistively derived from a voltage of the switching power converter.

DESCRIPTION OF THE RELATED ART

(3) Power control systems often utilize a switching power converter to convert alternating current (AC) voltages to direct current (DC) voltages or DC-to-DC. Switching power converters often include a nonlinear energy transfer process to provide power factor corrected energy to a load. Power control systems provide power factor corrected and regulated output voltages to many devices that utilize a regulated output voltage.
(4) Figure 1 represents a power control system 100, which includes a switching power converter 102. Voltage source 101 supplies an alternating current (AC) input voltage $V_{in}(t)$ to a full bridge diode rectifier 103. The voltage source 101 is, for example, a public utility, and the AC voltage $V_{in}(t)$ is, for example, a 60 Hz/10 V line voltage in the United States of America or a 50 Hz/220 V line voltage in Europe. The rectifier 103 rectifies the input voltage $V_{in}(t)$ and supplies a rectified, time-varying, line input voltage $V_{C}(t)$ to the switching power converter.

(5) The switching power converter 102 includes power factor correction (PFC) stage 124 and driver stage 126. The switching power converter 102 includes at least two switching operations, i.e. switching switch 108 to provide power factor correction and switching switch 108 to provide regulation of output voltage $V_{o}(t)$. The PFC stage 124 is controlled by switch 108 and provides power factor correction. The driver stage 126 is also controlled by switch 108 and regulates the transfer of energy from the line input voltage $V_{C}(t)$ through inductor 110 to capacitor 106. The inductor current $i_{L}$ ramps 'up' when the switch 108 conducts, i.e. is "ON". The inductor current $i_{L}$ ramps down when switch 108 is nonconductive, i.e. is "OFF", and supplies current $i_{L}$ to recharge capacitor 106. The time period during which inductor current $i_{L}$ ramps down is commonly referred to as the "inductor flyback time". Diode 111 prevents reverse current flow into inductor 110. In at least one embodiment, the switching power converter 102 operates in discontinuous current mode, i.e. ramp up time of the inductor current $i_{L}$ plus the inductor flyback time is less than the period of the control signal $C_{So}$, which controls the conductivity of switch 108.

(6) Input current $i_{L}$ is proportionate to the 'on-time' of switch 108, and the energy transferred to inductor 110 is proportionate to the 'on-time' squared. Thus, the energy transfer process is one embodiment of a nonlinear process. In at least one embodiment, control signal $C_{So}$ is a pulse width modulated signal, and the switch 108 is a field effect transistor (FET), such as an n-channel FET. Control signal $C_{So}$ is a gate voltage of switch 108, and switch 108 conducts when the pulse width of $C_{So}$ is high. Thus, the 'on-time' of switch 108 is determined by the pulse width of control signal $C_{So}$. Accordingly, the energy transferred to inductor 110 is proportionate to a square of the pulse width of control signal $C_{So}$.

(7) Capacitor 106 supplies stored energy to load 112. The capacitor 106 is sufficiently large so as to maintain a substantially constant output voltage $V_{C}(t)$, as established by a switch state controller 114 (as discussed in more detail below). The output voltage $V_{C}(t)$ remains
substantially constant during constant load conditions. However, as load conditions change, the output voltage $V_c(t)$ changes. The switch state controller 114 responds to the changes in $V_c(t)$ and adjusts the control signal $C_S_0$ to restore a substantially constant output voltage as quickly as possible. The switch state controller 114 includes a small capacitor 115 to filter any high frequency signals from the line input voltage $V_{\chi}(t)$.

(8) The switch state controller 114 of power control system 100 controls switch 108 and, thus, controls power factor correction and regulates output power of the switching power converter 102. The goal of power factor correction technology is to make the switching power converter 102 appear resistive to the voltage source 101. Thus, the switch state controller 114 attempts to control the inductor current $i_L$ so that the average inductor current $i_L$ is linearly and directly related to the line input voltage $V_{\chi}(t)$. Prodic, *Compensator Design and Stability Assessment for Fast Voltage Loops of Power Factor Correction Rectifiers*, IEEE Transactions on Power Electronics, Vol. 22, No. 5, Sept. 2007, pp. 1719-1729 (referred to herein as "Prodic"), describes an example of switch state controller 114. The switch state controller 114 supplies the pulse width modulated (PWM) control signal $C_S_0$ to control the conductivity of switch 108. The values of the pulse width and duty cycle of control signal $C_S_0$ depend on sensing two signals, namely, the line input voltage $V_{\chi}(t)$ and the capacitor voltage/output voltage $V_c(t)$.

(9) Switch state controller 114 receives the two voltage signals, the line input voltage $V_{\chi}(t)$ and the output voltage $V_c(t)$, via a wide bandwidth current loop 116 and a slower voltage loop 118. The line input voltage $V_{\chi}(t)$ is sensed from node 120 between the diode rectifier 103 and inductor 110. The output voltage $V_c(t)$ is sensed from node 122 between diode 111 and load 112. The current loop 116 operates at a frequency $f_c$ that is sufficient to allow the switch state controller 114 to respond to changes in the line input voltage $V_{\chi}(t)$ and cause the inductor current $i_L$ to track the line input voltage to provide power factor correction. The current loop frequency is generally set to a value between 20 kHz and 130 kHz. The voltage loop 118 operates at a much slower frequency $f_v$, typically 10-20Hz. By operating at 10-20Hz, the voltage loop 118 functions as a low pass filter to filter an alternating current (AC) ripple component of the output voltage $V_c(t)$.

(10) The switch state controller 114 controls the pulse width (PW) and period (TT) of control signal $C_S_0$. Thus, switch state controller 114 controls the nonlinear process of switching power converter 102 so that a desired amount of energy is transferred to capacitor 106. The desired
amount of energy depends upon the voltage and current requirements of load 112. To regulate the amount of energy transferred and maintain a power factor close to one, switch state controller 114 varies the period of control signal CSo so that the input current \( i_L \) tracks the changes in input voltage \( V\chi(t) \) and holds the output voltage \( Vc(t) \) constant. Thus, as the input voltage \( V\chi(t) \) increases, switch state controller 114 increases the period \( TT \) of control signal CSo, and as the input voltage \( V\chi(t) \) decreases, switch state controller 114 decreases the period of control signal CSo. At the same time, the pulse width \( PW \) of control signal CSo is adjusted to maintain a constant duty cycle \( (D) \) of control signal CSo, and, thus, hold the output voltage \( Vc(t) \) constant. In at least one embodiment, the switch state controller 114 updates the control signal CSo at a frequency much greater than the frequency of input voltage \( V\chi(t) \). The frequency of input voltage \( V\chi(t) \) is generally 50-60 Hz. The frequency \( 1/TT \) of control signal CSo is, for example, between 20 kHz and 130 kHz. Frequencies at or above 20 kHz avoid audio frequencies and frequencies at or below 130 kHz avoid significant switching inefficiencies while still maintaining good power factor, e.g. between 0.9 and 1, and an approximately constant output voltage \( Vc(t) \). Power control system also includes auxiliary power supply 128. Auxiliary power supply 128 is the primary power source for providing operating power to PFC and output voltage controller 114. However, as subsequently discussed in more detail with reference to Figure 3B, during certain power loss conditions, the auxiliary power supply 128 is unable to provide sufficient operating power to PFC and output voltage controller 114.

(11) Figure 2 depicts power control system 100 using voltage sensing. The power control system 100 includes series coupled resistors 202 to sense the input voltage \( V\chi(t) \) and generate an input sense voltage \( Vsx \). The series coupled resistors 202 form a voltage divider, and the input sense voltage \( Vsx \) is sensed across the last resistor 204. The voltage divider uses multiple resistors because input voltage \( V\chi(t) \) is generally higher than the voltage rating of individual resistors. Using a series of resistors allows the voltage across each resistor to remain within the voltage rating of the resistors. Using 300 kohm resistors as the first three resistors and a 9 kohm last resistor 204, the input sense voltage is 0.01-V\(\chi(t)\). The output voltage \( V_{out}(t) \) is sensed in the same manner using series coupled resistors 206 as a voltage divider to generate an output sense voltage \( Vso \).

(12) Figure 3A depicts the switch state controller 114 with two analog-to-digital converters (ADCs) 302 and 304. ADCs 302 and 304 convert respective sense voltages \( Vsx \) and \( Vso \) to
respective digital output voltages $V_x(n)$ and $V_o(n)$ using a reference voltage $V_{\text{REF}}$. The reference voltage can be a bandgap developed voltage reference.

(13) Figure 3B depicts a power supply system 350. The power supply system 350 includes switching power converter 102 to provide power factor correction and to provide output voltage $V_o(t)$. (Output voltage $V_o(t)$ is the same as output voltage $V_x(t)$ in Figure 1.) In at least one embodiment, the power supply system 350 provides power to a load 353 that can enter a very low power state (such as a standby-mode) or completely 'off' state. Examples of load 353 are computer systems or other data processing systems. During normal operation, switching power converter 102 is 'on' and performs a boost converter function to boost the input voltage $V_x(t)$ from, e.g. 130V, to generate output voltage $V_o(t)$, such as +400V. The output voltage $V_o(t)$ is provided to the main power supply 354 and to the standby power supply 352. "Normal" operation is when the power supply 350 is not in a low-power or 'off' state. The main power supply 354 provides a variety of voltages, such as +3V, +5V, and +12V, to power various components of load 353 during normal operation. The auxiliary power supply 128 provides primary power to switch state controller 114. The switch state controller 114 includes an input to receive the power from auxiliary power supply 128. However, during certain power loss conditions, auxiliary power supply 128 provides insufficient operating power to switch state controller 114. During such power loss conditions, switch state controller 114 becomes inoperative. The power loss conditions include a standby-mode when auxiliary power supply 128 is intentionally shut-down to save power. Power loss conditions also occur when switching power converter 102 is inoperative. In at least one embodiment, auxiliary power supply 128 receives power from switching power converter 102. Thus, when switching power converter 102 is inoperative, such as during a missed cycle of input voltage $V_x(t)$, auxiliary power supply 128 provides insufficient operating power to switch state controller 114.

(14) Voltage regulators and other components (not shown) can be connected between auxiliary power supply 128 and switch state controller 114. The standby power supply 352 supplies, for example, up to 5 W of power to load 353. The main power supply 354 supplies, for example, up to 500W of power. The particular amount of power supplied by the standby power supply 352 and the main power supply 354 are a matter of design choice.

(15) Each of the components 102, 114, 352, 354, and 128 include an underlined state, i.e. ON or OFF, that represents the state of the components 102, 114, 352, 354, and 128 in standby mode.
In standby-mode, only the standby power supply 352 is ON. In standby-mode, the standby power supply 352 provides an auxiliary output voltage $V_A$ that provides power to circuits (not shown) that operate during low power states, such as standby-mode monitoring circuits. The standby power supply 352 also provides power to components of load 353 that are used to initialize other components of load 353 as the components enter normal operation.

(16) Because switching power converter 102 is ‘off’ during standby-mode, the output voltage $V_o(t)$ drops to the input voltage $V_A(t)$. Thus, the standby power supply 352 must be designed to provide output power from voltages ranging from $V_A(t)$ to $V_o(t)$, such as $+130V$ to $+400V$. The resulting standby power supply 352 is, thus, generally less efficient than a power supply designed to operate with an approximately constant input voltage. Thus, there is a need for a switching power converter that can provide an approximately constant input voltage when operating.

**SUMMARY OF THE INVENTION**

(17) In one embodiment of the present invention, an apparatus includes a controller. The controller is configured to operate during at least one controller operational mode from an operating voltage generated from at least a first portion of the first sense current, wherein the first sense current is resistively derived from a first voltage sense of a switching power converter. The controller is also configured to receive at least a second portion of the first sense current and use the second portion of the first sense current to control a switching operation of the switching power converter.

(18) In another embodiment of the present invention, a method includes operating the controller during at least one controller operational mode from an operating voltage generated from at least a first portion of the first sense current, wherein the first sense current is resistively derived from a first voltage sense of a switching power converter. The method also includes receiving in a controller at least a second portion of the first sense current and using the second portion of the first sense current to control a switching operation of the switching power converter.

(19) In a further embodiment of the present invention, an apparatus includes means for operating the controller during at least one controller operational mode from an operating voltage generated from at least a first portion of the first sense current, wherein the first sense current is
resistively derived from a first voltage sense of a switching power converter. The apparatus also includes means for receiving in a controller at least a second portion of the first sense current and means for using the second portion of the first sense current to control a switching operation of the switching power converter.

BRIEF DESCRIPTION OF THE DRAWINGS

(20) The present invention may be better understood, and its numerous objects, features and advantages made apparent to those skilled in the art by referencing the accompanying drawings. The use of the same reference number throughout the several figures designates a like or similar element.

(21) Figure 1 (labeled prior art) depicts a power control system.

(22) Figure 2 (labeled prior art) depicts a power control system with voltage sensing.

(23) Figure 3A (labeled prior art) depicts a switch state controller of the power control system of Figure 2 that includes analog-to-digital converters to convert input and output sense voltages into a digital signal.

(24) Figure 3B (labeled prior art) depicts a power supply system.

(25) Figure 4 depicts a power control system with current sensing.

(26) Figure 5 depicts a boost converter.

(27) Figure 6 depicts a current sensing system.

(28) Figure 7 depicts a resistive impedance for current sensing.

(29) Figure 8 depicts an analog-to-digital converter.

(30) Figure 9 depicts a time division based secondary auxiliary power supply system.

(31) Figure 10 depicts a proportional division secondary auxiliary power supply system

(32) Figure 11 depicts a power supply system that uses one or more sense currents to supply power to an integrated circuit switch state controller at least when the power supply system is operating in standby-mode.
(33) Figure 12 depicts an exemplary graphical curve showing sense current power plotted versus output power of a switching power converter.

**DETAILED DESCRIPTION**

(34) A power supply system and method include a switch state controller that is operational to control a switching power converter during certain power loss conditions that cause conventional switch state controllers to have diminished or no functionality. In at least one embodiment, during certain power loss conditions, such as when an auxiliary power supply is in standby mode or when the switching power converter is not operating, the auxiliary power supply for the switch state controller does not provide sufficient operating power to the switch state controller during certain power loss conditions. In at least one embodiment, during such power loss conditions, power is generated for the switch state controller using sense input and/or sense output currents of the switching power converter to allow a switch state controller to generate a control signal to control a switch of the switching power converter. In at least one embodiment, the switch state controller is fabricated as an integrated circuit (IC).

(35) Thus, during converter power supply power loss conditions, the switch state controller remains operational to cause the switching power converter to supply an approximately constant output voltage to, for example, a standby power supply that provides power to a load. By supplying the standby power supply with an approximately constant output voltage during standby and normal operational modes, the standby power supply can be designed to operate more efficiently than a standby power supply designed to operate with a wide range of input voltages. In at least one embodiment, the power supplied to the switch state controller by the sense current(s) is proportional to the output voltage of the switching power converter. As the output power of the switching power converter increases, the increased power demand for the switch state controller is provided by the auxiliary power supply.

(36) Thus, in at least one embodiment, the sense current(s) can be used to provide power to the switch state controller. In at least one embodiment, the sense current(s) can provide power to the switch state controller during certain power loss conditions when auxiliary IC power is unavailable or diminished, such as during start-up of the switch state controller or during input voltage missed cycles. In at least one embodiment, the IC draws more sense current from an input of the power control system than the output of the power control system to, for example,
minimize any impact on the output voltage of the power supply. Also, by sensing sense currents, the power control system can eliminate at least one sense resistor used in a voltage sense system.

(37) Figure 4 depicts a power control system 400 with current sensing. A full diode bridge AC rectifier 402 rectifies line input voltage \( V_{\text{in}}(Y) \) to generate a rectified input voltage \( V_{\chi}(t) \). In at least one embodiment, the input voltage \( V_{\text{in}}(t) \) is the same as the input voltage \( V_{\text{in}}(t) \) in Figure 1. Switching power converter 404 represents one embodiment of a switching power converter that converts the rectified input voltage \( V_{\chi}(t) \) into a direct current (DC) output voltage \( V_o(t) \) for load 406. Switching power converter 404 can be any type of switching power converter, such as a boost converter or a buck converter. The switching power converter 404 includes at least two switching operations, i.e. switching a switch in switching power converter 404, such as switch 108 (Figure 1) to provide power factor correction and switching a switch in switching power converter 404, such as switch 108 (Figure 1) to provide regulation of output voltage \( V_o(t) \). In at least one embodiment, the output voltage \( V_o(t) \) is the same as the output voltage \( V_c(t) \) of Figure 1. The value of the output voltage \( V_o(t) \) depends on the input voltage requirements of load 406. In at least one embodiment, the output voltage \( V_o(t) \) is approximately 400 V. The switch state controller 408 uses data representing the line input voltage \( V_{\chi}(t) \) and the output voltage \( V_o(t) \) to generate control signal \( C_s \). Voltages \( V_{\chi}(t) \) and \( V_o(t) \) are dropped across respective resistances \( R_o \) and \( R_i \) to generate sense currents \( i_x \) and \( i_o \). Sense currents \( i_x \) and \( i_o \) respectively represent the line input voltage \( V_{\chi}(t) \) and the output voltage \( V_o(t) \). As subsequently explained in more detail, a secondary auxiliary power supply 405 generates an operating voltage \( V_{\text{DD}} \) using one or both of sense currents \( i_x \) and \( i_o \). Operating voltage \( V_{\text{DD}} \) can, for example, be supplied to the same external input, such as an IC pin, that receives the operating voltage \( V_{\text{AUX}} \), to a different external input of switch state controller 408, or to an internal input of switch state controller 408. Thus, when both auxiliary power supply 410 and secondary auxiliary power supply 405 are supplying power, auxiliary power supply 410 and secondary auxiliary power supply 405 can combine to generate the operating voltage for switch state controller 408. In at least one embodiment, the secondary auxiliary power supply 405 is physically separate from switch state controller 408. In at least one embodiment, the secondary auxiliary power supply 405 is included in the same integrated circuit as switch state controller 408. Exemplary resistances \( R_o \) and \( R_i \) are subsequently discussed in more detail. In at least one embodiment, switch state controller 408 is fabricated as an IC.
(38) The control signal Cs can be generated in any of a variety of ways, such as the exemplary
ways described in U.S. Patent Application Serial No. 11/967,271, entitled "Power Factor
Correction Controller With Feedback Reduction", inventor John L. Melanson, and assignee
Cirrus Logic, Inc. ("Melanson I") and U.S. Patent Application Serial No. 11/967,272, entitled
"Power Factor Correction Controller With Switch Node Feedback", inventor John L. Melanson,
and assignee Cirrus Logic, Inc. ("Melanson II"). Melanson I and Melanson II are incorporated
herein by reference in their entireties. In at least one embodiment, both the input voltage \( V\chi(t) \)
and the output voltage \( V_o(t) \) are sensed using both sense currents \( i_x \) and \( i_o \). In at least one
embodiment, only one or the other of input voltage \( V\chi(t) \) and output voltage \( V_o(t) \) are sensed as
currents.

(39) Figure 5 depicts a boost converter 500, which represents one embodiment of switching
power converter 404. Boost converter 500 includes inductor 110, diode 111, and switch 108 and
functions as described with reference to the same components in Figure 1.

(40) Figure 6 depicts exemplary current sensing system 600. The input voltage \( V\chi(t) \) is
dropped across resistive impedance \( R_o \), and the sense current \( i_x \) is provided as an input to ADC
602. The output voltage \( V_o(t) \) is dropped across resistive impedance \( R_1 \), and the sense current \( i_o \)
is provided as an input to ADC 604. In at least one embodiment, \( R_o = R_1 \), and, in another
embodiment, \( R_o \) is less than \( R_1 \). The implementation and values of resistive impedances \( R_o \) and
\( R_1 \) are a matter of design choice and are discussed subsequently in more detail. ADC 602 and
ADC 604 convert respective sense currents \( i_x \) and \( i_o \) into respective digital values \( i\chi(n) \) and
\( i_o(n) \). Signals \( i\chi(n) \) and \( i_o(n) \) are used by switch state controller 408 to generate control signal Cs
as, for example, described in Melanson I and Melanson II.

(41) Figure 7 depicts an exemplary resistive impedance R, which represents an exemplary
embodiment of resistive impedances \( R_o \) and \( R_1 \). The voltages across resistive impedances \( R_o \) and
\( R_1 \) can be larger than the reliability voltage rating of individual resistors. Accordingly, in at least
one embodiment, resistive impedance \( R \) is implemented with series coupled resistors \( R_A, R_B, \) and
\( R_c \) to lower the voltage drop across any particular resistor. Resistive impedance \( R \) is depicted
with three (3) resistors. However, the exact number is a matter of design choice and depends, for
example, on the resistor components used to implement resistive impedance \( R \). Resistive
impedance \( R \) can be implemented using one or more active components (such as FETs), one or
more passive components (such as resistors), or both active and resistive components.
Figure 8 depicts ADC 800, which represents an exemplary embodiment of ADC 602 and ADC 604. The input current \(i_m\) represents sense current \(i_x\) for ADC 602 and sense current \(i_o\) for ADC 604. Current digital-to-analog converter (DAC) 802 provides a DAC reference current \(i_{ref}\) to node 804. The difference current \(i_D\) represents a difference between the input current \(i_m\) and the DAC reference current \(i_{ref}\). The difference current \(i_o\) generates a voltage \(V_P\) across resistor R3, and the voltage \(V_P\) is compared to a reference voltage \(V_{REF}\), such as +2V by comparator 806. The comparator 806 generates a comparison voltage \(V_c\) as an input to successive approximation register (SAR) 808. SAR 808 individually controls the conductivity of switches 810-818 of current DAC 802. In at least one embodiment, the current DAC includes current sources 820-828. In at least one embodiment, the value of the output currents of each successive current source doubles the previous output current value. SAR 808 uses, for example, any well-known logic algorithms to generate a digital output signal \(i(n)\) representing the analog input signal \(iM\).

Figure 9 depicts a secondary auxiliary power supply system 900 for switch state controller 408. Secondary auxiliary power supply system 900 represents one embodiment of secondary auxiliary power supply system 405. Referring also to Figure 4, a primary auxiliary power supply 410 provides an operating voltage, auxiliary voltage \(V_{aux}\), to switch state controller 408. Voltage \(V_{aux}\) is, for example, +15V. However, in at least one embodiment, during certain modes of operation of system power control system 400 and during certain events, such as one or more missed cycles of voltage \(V_X(t)\), the operating power used by the controller is greater than the power available from the primary auxiliary power supply 410. Thus, during times when auxiliary power supply 410 of power control system 400 is unable to meet the operating power needs of the switch state controller 408 and, thus, is unable to provide an operating voltage to switch state controller 408, such as at initial start-up switch state controller 408 or when exiting stand-by modes, the power available from auxiliary power supply 410 is insufficient to allow switch state controller 408 to operate. The secondary auxiliary power supply system 900 uses the sense currents \(i_x\) and \(i_o\) to generate a power supply voltage \(V_{DD}\) for switch state controller 408. The secondary auxiliary power supply system 900 uses the sense currents \(i_x\) and \(i_o\) to generate a power supply voltage \(V_{DD}\) for switch state controller 408.

In at least one embodiment, the switch state controller 408 uses sense signals \(iX(n)\) and \(iO(n)\) only a small fraction of the time during the operation of power control system 400. Switch state controller 408 closes switches (e.g. n-channel CMOS transistors) 902 and 904 using respective control signals \(CS_{AMO}\) and \(CS_{AMI}\) to sense the sense currents \(i_x\) and \(i_o\) from which
respective sense current signals $i\chi(n)$ and $i_o(n)$ are generated. Switches 902 and 904 are primarily open. While switches 902 and 904 are open, the sense currents $i_o$ and $i_x$ are available to charge capacitor 906 through respective diodes 908 and 910. The voltage developed across capacitor 906 is the power supply voltage $V_{DD}$ to provide power to switch state controller 408. The voltage $V_{DD}$ is regulated, e.g. +15V, by, for example, a Zener diode 912. In at least one embodiment, the voltage $V_{DD}$ is the primary voltage supply for switch state controller 408 during start-up of switch state controller 408 and supplements the power delivered by auxiliary power supply 410 when auxiliary power supply 410 is not capable of supplying sufficient operating power to switch state controller 408. In at least one embodiment, the power delivered by secondary auxiliary power supply system 900 is proportional to the output power delivered by power control system 400. The secondary auxiliary power supply system 900 can be entirely or partially included within switch state controller 408. For example, in at least one embodiment, all components of the secondary auxiliary power supply system 900 except capacitor 906 are included within switch state controller 408.

(45) In at least one embodiment, secondary auxiliary power supply system 900 draws more current from the input side of switching power converter 404 than the output side. Generally, drawing more power from the input side causes less fluctuation in the output voltage $V_o(t)$. To draw more current from the input side of switching power converter 404, the resistive impedance $R_o$ is set less than the resistive impedance $R_i$. In at least one embodiment, $R_o$ is 10% of $R_i$, i.e. $R_o = 0.1 \times R_i$. The values of resistors $R_o$ and $R_i$ are matters of design choice. Exemplary, respective values for $R_o$ and $R_i$ are 400 kohms and 4 Mohms. The ADC 602 and ADC 604 are still able to provide the sense data to switch state controller 408 to allow switch state controller 408 to properly generate control signal $C_s$.

(46) Figure 10 depicts secondary auxiliary power supply system 1000, which represents another embodiment of secondary auxiliary power supply 405. Secondary auxiliary power supply system 1000 supplies auxiliary power to switch state controller 408 during at least a portion of the operational time of switch state controller 408, such as when auxiliary power supply 410 cannot provide sufficient power to allow switch state controller 408 to operate. In at least one embodiment, switch state controller 408 uses only a fraction of the energy available from sense currents $i_x$ and $i_o$ to sense respective voltages $V_x(t)$ and $V_o(t)$. In at least one embodiment, at least a portion of the remainder of the energy available from sense currents $i_x$ and $i_o$ is used to power switch state controller 408 when, for example, auxiliary power supply
410 cannot provide sufficient operating power to operate switch state controller 408. Thus, secondary auxiliary power supply system 1000 can divide the energy available from sense currents ix and io to supply operating power to switch state controller 408 and provide feedback sensing of respective voltages \( V_i(x) \) and \( V_o(t) \).

(47) In at least one embodiment, secondary auxiliary power supply system 1000 has two modes of operation: (1) Start Up Mode and (2) Normal Mode. Referring to Figures 4 and 10, in Start Up Mode, auxiliary power supply 410 provides insufficient operating power to switch state controller 408, and secondary auxiliary power supply system 1000 provides operating power to switch state controller 408 by using energy from sense current \( i_k \), sense current \( i_0 \), or both sense currents ix and io. Secondary auxiliary power supply system 1000 includes proportional divider circuits 1001 and 1002 to provide operating power to switch state controller 408 during Start Up Mode. During Start Up Mode, all available energy from sense currents ix and io is transferred by respective proportional divider circuits 1001 and 1002 via diodes 1010 and 1012 to charge capacitor 1014. The sense currents ix and io charge capacitor 1014 to voltage \( V_{DD} \), thus, raising the voltage of node 1008 to the operational voltage \( V_{DD} \) of switch state controller 408. The value of capacitor 1014 is a design choice and, in at least one embodiment, is chosen so that energy transfer from power currents \( i_{xp} \) and \( i_{op} \) is sufficient to charge capacitor 1014 to voltage \( V_{DD} \) and provide sufficient operating power for switch state controller 408 when auxiliary power supply 410 provides insufficient operating power to switch state controller 408.

(48) During Normal Mode, proportional divider circuits 1001 and 1002 proportionately divide respective sense currents ix and io into (i) respective power currents \( i_{xp} \) and \( i_{op} \) to provide power to switch state controller 408, (ii) respective support circuit biasing currents \( i_{xB} \) and \( i_{oB} \), and (iii) respective measurement currents \( i_{xM} \) and \( i_{oM} \) to sense respective voltages \( V_x(t) \) and \( V_o(t) \). Currents \( i_{xp} \) and \( i_{op} \) flow through respective p-channel FET transistors 1018 and 1020 to replace charge consumed by switch state controller 408 by charging capacitor 1014 to maintain voltage \( V_{DD} \) at node 1008. Biasing currents \( i_{xB} \) and \( i_{oB} \) flow through p-channel FET transistors 1022 and 1024 to provide biasing to respective proportional divider circuits 1001 and 1002. Measurement currents \( i_{xM} \) and \( i_{oM} \) flow through p-channel FET transistors 1026 and 1028 to measure respective voltages \( V_x(t) \) and \( V_o(t) \).

(49) The secondary auxiliary power supply system 1000 includes resistors \( R_o \) and \( Ri \), which, in at least one embodiment, are respective resistors \( R_o \) and \( Ri \) as described in conjunction with
Figures 6 and 7. Resistors R_o and R_i are connected to respective nodes 1004 and 1006. In at
least one embodiment, the secondary auxiliary power supply system 1000 is included in the
integrated circuit with switch state controller 408, and nodes 1004 and 1006 represent pins of the
switch state controller 408. In another embodiment, secondary auxiliary power supply system
1000 is physically separate from switch state controller 408, and node 1008 is connected to a pin
of switch state controller 408 to provide power to switch state controller 408.

(50) The gates of transistors 1018, 1022, and 1026 are interconnected, and the gates of
transistors 1020, 1024, and 1028 are interconnected. The voltage \( V_{GX} \) applied to gates of
transistors 1018, 1022, and 1026 controls the flow of current in proportional divider circuit 1001
during Start Up Mode and Normal Mode. The voltage \( V_{GO} \) applied to gates of transistors 1020,
1024, and 1028 controls the flow of current in proportional divider circuit 1002 during Start Up
Mode and Normal Mode. Voltages \( V_{GX} \) and \( V_{GO} \) are controlled by the state of respective analog
multiplexers 1030 and 1032.

(51) The analog multiplexers 1030 and 1032 are 2 input/1 output analog multiplexers with
respective select signals \( SEL_x \) and \( SEL_0 \). The two input signals of analog multiplexers 1030 and
1032 are voltages \( V_{DD} \) and \( V_{BIAS} \). The respective outputs of analog multiplexers 1030 and 1032
are voltages \( V_{GX} \) and \( V_{GO} \). When not operating in Normal Mode, the state of select signals \( SEL_x \)
and \( SEL_0 \) is set to select voltage \( V_{DD} \). Thus, during Start Up Mode, voltages \( V_{GX} \) and \( V_{GO} \) equal
voltage \( V_{DD} \). Driving the gates of transistors 1018, 1022, and 1026 and 1020, 1024, and 1028 to
voltage \( V_{DD} \) effectively turns transistors 1018, 1022, and 1026 and 1020, 1024, and 1028 "OFF",
i.e. nonconductive. Sense currents \( i_x \) and \( i_0 \) charge respective nodes 1004 and 1006. Once the
voltage at nodes 1004 and 1006 exceeds voltage \( V_{DP} \) by the forward bias voltage \( V_{BE} \) of diodes
1010 and 1012, diodes 1010 and 1012 conduct. With transistors 1018, 1022, and 1026 and 1020,
1024, and 1028 "off" and diodes 1010 and 1012 "ON", i.e. conducting, power current \( i_{XP} \) equals
sense current \( i_x \), and power current \( i_{OP} \) equals sense current \( i_0 \). The power currents \( i_{XP} \) and \( i_{OP} \)
provided to node 1008 charge capacitor 1014 to voltage \( V_{DD} \). Zener diode 1016 limits the
voltage across capacitor 1014 to voltage \( V_{DD} \).

(52) During Start Up Mode, transistors 1018, 1022, and 1026 and 1020, 1024, and 1028
remain OFF since the gate-to-source voltages \( V_{GS} \) of transistors 1018, 1022, and 1026 and 1020,
1024, and 1028 is below \( V_{TH} + V_{ON} \). "\( V_{TH} \)" represents the threshold voltage of transistors 1018,
1022, and 1026 and 1020, 1024, and 1028, and "\( V_{ON} \)" represents the voltage above the threshold.
voltage $V_{TH}$. In at least one embodiment, the threshold voltage $V_{TH}$ is at least 0.7 V, and voltage $V_{ON}$ is 100-200 mV. If $(V_{TH} + V_{ON}) < V_{BE}$, transistors 1018, 1022, and 1026 and 1020, 1024, and 1028 are conductive, and the sense currents $i_x$ and $i_o$ will be shared between respective transistors 1018, 1022, and 1026 and 1020, 1024, and 1028 and respective diodes 1010 and 1012. In at least one embodiment, the geometries of transistors 1018, 1022, and 1026, transistors 1020, 1024, and 1028, and diodes 1010 and 1012 cause respective power currents $i_{xp}$ and $i_{op}$ to exceed measurement currents $i_{xM}$ and $i_{oM}$ and bias currents $i_{xB}$ and $i_{oB}$. In at least one embodiment, respective power currents $i_{xp}$ and $i_{op}$ are approximately 90% of sense currents $i_x$ and $i_o$.

(53) During Normal Mode, the state of multiplexer select signals SELx and SELo selects voltage $V_{BA}$ as the voltage for gate voltages $V_G$ and $V_{GO}$. In at least one embodiment, the value of voltage $V_{BA}$ causes sense currents $i_x$ and $i_o$ to only flow through transistors 1018, 1022, and 1026 and 1020, 1024, and 1028. The current flowing through transistors 1018, 1022, and 1026 and 1020, 1024, and 1028 is proportionally split between respective power currents $i_{xp}$ and $i_{op}$, bias currents $i_{xB}$ and $i_{oB}$, and measurement currents $i_{xM}$ and $i_{oM}$.

(54) The current division proportions are a function of the physical dimensions of respective transistors 1018, 1022, and 1026 and 1020, 1024, and 1028. In at least one embodiment, the ratio of physical geometries and, thus, the current division proportions allows a majority of the sense currents $i_x$ and $i_o$ to flow through respective transistors 1018 and 1020 to continue supplying energy to charge capacitor 1014 at node 1008. The remaining current, i.e. $i_x - i_{xP}$, in proportional divider circuit 1001 is divided between transistors 1022 and 1026. The remaining current, i.e. $i_o - i_{oP}$, in proportional divider circuit 1002 is divided between transistors 1024 and 1028. In at least one embodiment, the physical dimensions of transistor 1018 is greater than the physical dimensions of transistor 1026, and the physical dimensions of transistor 1026 is greater than the physical dimensions of transistor 1022. Thus, the measurement current $i_{xM}$ is greater than the bias current $i_{xP}$. In at least one embodiment, the physical dimensions of transistor 1020 is greater than the physical dimensions of transistor 1028, and the physical dimensions of transistor 1028 is greater than the physical dimensions of transistor 1024. Thus, the measurement current $i_{oM}$ is greater than the bias current $i_{oP}$.

(55) The accuracy of current division by proportional divider circuits 1001 and 1002 is determined by the ability of the respective drain bias regulators 1034 and 1036 to maintain the drains of respective transistors 1022 and 1026 at voltage $V_{DD}$. Bias current $i_{xB}$ flows through $p$-
channel FET 1038 to the diode connected n-channel FET 1040. Transistor 1040 along with n-channel FET 1042 form a current mirror whose output current $i_{XP}$ at the drain of transistor 1042 equals a scaled version of bias current $i_\beta$. The drain current of transistor 1042 is presented to the diode connected p-channel FET 1044 to generate a cascade bias for driving transistor 1038 and p-channel FET 1046. The bias forces the drain voltages of transistors 1022 and 1026 to voltage $V_{dd}$, which matches the drain voltage of transistor 1018. Bias current $i_\beta$ flows through p-channel FET 1048 to the diode connected n-channel FET 1050. Transistor 1050 along with n-channel FET 1052 form a current mirror whose output current $i_o$ at the drain of transistor 1052 equals a scaled version of bias current $i_\beta$. The drain current of transistor 1052 is presented to the diode connected p-channel FET 1054 to generate a cascade bias for driving transistor 1048 and p-channel FET 1056. The bias forces the drain voltages of transistors 1024 and 1028 to voltage $V_{dd}$, which matches the drain voltage of transistor 1020. Thus, drain bias regulators 1034 and 1036 provide the voltages used to cause respective proportional divider circuits 1001 and 1002 to proportionately divide respective sense currents $i_X$ and $i_O$ into power, measurement, and support bias currents.

(56) Voltage bias regulator 1058 generates voltage $V_{bias}$ during the Normal Mode so that all of sense currents $i_X$ and $i_O$ flow through respective transistors 1018, 1022, and 1026 and 1020, 1024, and 1028, i.e. $i_X = i_{xp} + i_{xh} + ixM$ and $i_O = ilp + iOB + ioM$. To reverse bias diodes 1010 and 1012 during Normal Mode, the respective voltages at nodes 1004 and 1006 is less than voltage $V_{BE}$ of diodes 1010 and 1012 with reference to voltage $V_{dd}$. To achieve current flow through transistors 1018, 1022, and 1026 and 1020, 1024, and 1028, the source to drain voltage of transistors 1018, 1022, and 1026 and 1020, 1024, and 1028 is larger than voltage $V_{ON}$, and voltage $V_{ON}$ is the voltage above the threshold voltage $V_m$ of transistors 1018, 1022, and 1026 and 1020, 1024, and 1028.

(57) Typically, voltage $V_{ON}$ is 100-200 mV. Thus, ideally, voltage $V_{bias}$ is set equal to the threshold voltage $V_{TH}$ of transistors 1018, 1022, and 1026 and 1020, 1024, and 1028. However, in reality, the difference between the threshold voltage $V_{TH}$ and the diode forward bias voltage $V_{BE}$ is generally $\leq +/\sim 200$ mV. If the voltage $V_{ON}$ is greater than or equal to 100 mV and less than or equal to 200 mV, then a bipolar device of junction diode referenced to voltage $V_{dd}$ can be used to generate voltage $V_{bias}$. The bias voltage $V_{bias}$ is, thus, $V_{dd} - V_{BE}$. When the voltage $V_{bias}$ is applied to the gates of transistors 1018, 1022, and 1026 and 1020, 1024, and 1028, the
source of transistors 1018, 1022, and 1026 and 1020, 1024, and 1028 is forced to \( V_{DD} - V_{BE} + V_{TH} \) + \( V_{ON} \).

(58) Thus, in at least one embodiment, the voltage bias regulator 1058 includes a diode connected bipolar junction transistor 1060 with an emitter connected to a current source 1062. The voltage \( V_{BIAS} \) is the emitter voltage of transistor 1060.

(59) Input converter 1064 receives measurement current \( i_{XM} \) and converts the measurement current \( i_{XM} \) into a signal representing voltage \( V_X(t) \). Output converter 1064 can be any conversion circuit such as ADC 800, a current to voltage converter, or an analog conversion circuit. Output converter 1066 receives measurement current \( i_{OM} \) and converts the measurement current \( i_{OM} \) into a signal representing voltage \( V_O(t) \). Output converter 1066 can be any conversion circuit such as ADC 800, a current to voltage converter, or an analog conversion circuit.

(60) Figure 11 depicts one embodiment of a power supply system 1100 that uses one or more sense currents \( i_x \) and \( i_o \), to supply power to switch state controller 1102 at least when power supply system 1100 is operating in standby-mode or in other situations when auxiliary power supply 410 does not provide sufficient operating power switch state controller 1102. For example, the input voltage \( V_X(t) \) may miss one or more cycles causing auxiliary power supply 410 to provide insufficient operating power to switch state controller 1102. Switch state controller 1102 receives power from auxiliary power supply 410 via an input 1108. Input 1108 can be any type of connection capable of allowing auxiliary power supply 410 to provide power to switch state controller 1102. The power supply system 1100 includes a switching power converter 1104, such as switching power converter 404, that, in at least one embodiment, provides power factor correction and boosts the input voltage \( V_X(t) \) to output voltage \( V_O(t) \). In at least one embodiment, input and output capacitors, such as respective capacitors 115 and 106 (Figure 4), are included in power supply system 1100 but not shown in Figure 11 for clarity. Standby secondary auxiliary power supply 1105 supplies, for example, up to 5 W of power to load 353 while load 353 is in standby. Secondary auxiliary power supply 1105 generates power supply voltage \( V_{DD} \) for operating switch state controller 1102 during situations when primary auxiliary power supply 410 provides insufficient operating power to switch state controller 1102.

(61) The secondary auxiliary power supply 1105 enables switch state controller 1102 to operate during standby mode. Switch state controller 1102 is able to operate during standby
mode (and in other situations when auxiliary power supply 410 provides insufficient operating power to switch state controller 1102), and switching power converter 1104 maintains an approximately constant output voltage Vo(t). With switch state controller 1102 operating in standby mode and switching power converter 1104 maintaining an approximately constant voltage Vo(t), standby power supply 1106 can be designed to operate from an approximately constant input voltage and, thus, can be designed more cost effectively than standby power supplies designed to operate from a wider range of input voltages.

(62) The particular secondary auxiliary power supply 1105 for developing the auxiliary input voltage VDD to power the switch state controller 1102, at least during standby-mode, is a matter of design choice. In at least one embodiment, secondary auxiliary power supply 1105 is secondary auxiliary power supply system 900. In another embodiment, secondary auxiliary power supply 1105 is secondary auxiliary power supply system 1000. Secondary auxiliary power supply 1105 can be included as part of the IC containing switch state controller 1102 or can be physically separate from switch state controller 1102 and connected to switch state controller 1102 to provide voltage VDD (Figures 9 and 10). Thus, secondary auxiliary power supply 1105 can be implemented internally, externally, or a combination of internally and externally to the switch state controller 1102.

(63) Each of the components 354, 410, 1102, 1104, and 1106 includes an underlined state, i.e. ON or OFF, that represents the state of the components 354, 410, 1102, 1104, and 1106 in standby mode. Because the sense currents i_s and i_o are available in standby-mode, the switch state controller 1102 can remain ON. In standby-mode, the power factor correction control switch (such as switch 108 in Figure 1) of switching power converter 1104 has a very small pulse width, and, thus, does not need to conduct very often. For example, the duty cycle of control signal C_s is very small during standby-mode and low power operation. The duty cycle is, for example, nearly 0 % in standby-mode. Because of the low duty cycle of control signal C_s in standby-mode, the switch state controller 1102 requires less power to operate in standby-mode. Because of the low power requirement of switch state controller 1102 during standby-mode, the power derived from the sense current i_s, i_o, or i_r (i.e. sense currents i_s and/or i_o) provides sufficient power to allow switch state controller 1102 to operate during standby-mode. During a missed cycle of input voltage V_s(t), an output capacitor on an output of the switching power converter 1104 (such as capacitor 106 of Figure 4) is able to hold the output voltage Vo(t) at an approximately constant value for at least several consecutive missed cycles. Missed cycles are
generally sporadically dispersed among the cycles of input voltage $V\chi(t)$. Because the sense current $i_o$ is derived from the output voltage $V_o(t)$, sense current $i_o$ is available during missed cycles of input voltage $V\chi(t)$.

(64) Because switch state controller 1102 and switching power converter 1104 operate during standby-mode, the standby power supply 1106 can be designed to operate efficiently with a constant input voltage $V_o(t)$ supply.

(65) The secondary auxiliary power supply 1105 for developing the auxiliary input voltage $V_{DD}$ to power the switch state controller 1102, at least during standby-mode, is a matter of design choice. In at least one embodiment, secondary auxiliary power supply 1105 is secondary auxiliary power supply system 900. In another embodiment, secondary auxiliary power supply 1105 is secondary auxiliary power supply system 1000. The secondary auxiliary power supply 1105 can be implemented internally, externally, or a combination of internally and externally to the switch state controller 1102.

(66) Figure 12 depicts an exemplary graphical curve 1202 showing switch state controller power plotted versus output power of switching power converter 1104. The exemplary switch state controller power curve 1202 represents power provided by secondary auxiliary power supply 1105 from sense currents $i_x$ and/or $i_o$ and the auxiliary power supply 410 as the output power supplied by the switching power converter 1104 changes. As the output power supplied by the switching power converter 1104 increases, more power is supplied to the switch state controller 1102 from the auxiliary power supply 410 to allow the switch state controller 1102 to increase the pulse width of the control signal $C_s$, and, thus, increase the power supplied by switching power converter 1104. Thus, the power supplied to the switch state controller 1102 by the auxiliary power supply 410 is proportional to the output power supplied by switching power converter 1104. The exemplary switch state controller power curve 1202 indicates that the sense currents $i_x$ and/or $i_o$ can provide sufficient energy to switch state controller 1102 to allow switch state controller 1102 to operate during times of low power demand on switching power converter 1104. The power demand curve 1204 of switch state controller 1102 indicates the power demand of the switch state controller 1102 from standby mode to normal operation mode.

(67) Thus, feedback input and/or output currents are available during standby-mode of the power supply, and, thus, the switch state controller enables the switching power converter to supply an approximately constant output voltage to a standby power supply.
(68) Although the present invention has been described in detail, it should be understood that various changes, substitutions and alterations can be made hereto without departing from the spirit and scope of the invention.
WHAT IS CLAIMED IS:

1. An apparatus comprising:
   a controller, wherein the controller is configured to:
   operate during at least one controller operational mode from an operating voltage
   generated from at least a first portion of the first sense current, wherein the
   first sense current is resistively derived from a first voltage sense of a
   switching power converter;
   receive at least a second portion of the first sense current; and
   use the second portion of the first sense current to control a switching operation of
   the switching power converter.

2. The apparatus of claim 1 wherein the switching operation of the switching power
   converter is a member of a group consisting of: (i) operating a switch of the switching power
   converter to provide power factor correction and (ii) operating the switch of the switching power
   converter to regulate an output voltage of the switching power converter.

3. The apparatus of claim 1 wherein the controller is configured to operate from the
   operating voltage generated from at least the first portion of the first sense current when a
   primary auxiliary power supply provides insufficient power to allow the controller to at least
   control an output voltage of the switching power converter.

4. The apparatus of claim 1 wherein the first sense current is resistively derived from
   at least one of one of: (i) an input voltage to the switching power converter and (ii) an output
   voltage of the switching power converter.

5. The apparatus of claim 1 wherein the controller is further configured to cause the
   switching power converter to generate an approximately constant output voltage when the
   controller operates from the operating voltage generated from at least the first portion of the first
   sense current.
6. The apparatus of claim 1 wherein the controller is further configured to use at least the second portion of the first sense current to control at least one of (i) power factor correction of the switching power converter and (ii) regulation of an output voltage of the switching power converter.

7. The apparatus of claim 1 wherein the at least one controller operational mode comprises a start-up-mode of the controller.

8. The apparatus of claim 1 further comprising:
a secondary auxiliary power supply having a first input to receive at least the second portion of the first sense current, wherein the secondary auxiliary power supply system is configured to generate the operating voltage from at least the second portion of the first sense current.

9. The apparatus of claim 8 wherein the secondary auxiliary power supply and the controller comprise components included in an integrated circuit.

10. The apparatus of claim 1 wherein the controller is configured to operate from an operating voltage derived from at least the first sense current and a second sense current, wherein the second sense current is resistively derived from a second voltage sense of the switching power converter.

11. The apparatus of claim 10 wherein the first sense current senses an input voltage to the switching power converter and the second sense current senses an output voltage of the switching power converter.

12. The apparatus of claim 10 wherein the controller includes a first converter to convert the first portion of the first sense current into data representing the input voltage to the switching power converter and a second converter to convert a second portion of the second sense current into data representing the output voltage of the switching power converter, wherein the apparatus further comprises:
a secondary auxiliary power supply, and the secondary auxiliary power supply comprises:
a first sense current proportional divider circuit coupled to the controller to
provide the first portion of the first sense current to the first converter for
sensing the input voltage of the switching power converter; and
a second sense current proportional divider circuit coupled to the controller to
provide the second portion of the second sense current to the second
converter for sensing the output voltage of the switching power converter;
wherein the first and second proportional divider circuits are configured to
generate the operating voltage from the first portion of the first sense
current and the second portion of the second sense current.

13. The apparatus of claim 10 the controller comprises:
a first converter to convert the second portion of the first sense current into data
representing the input voltage of the switching power converter; and
a second converter to convert a second portion of the second sense current into data
representing the output voltage of the switching power converter; and
the apparatus further comprises a secondary auxiliary power supply, and the second
auxiliary apparatus comprises:
first circuitry coupled to the controller to provide the first sense current to the first
converter for sensing the input voltage of the switching power converter
and to at least contribute to generation of the operating voltage for the
controller during non-overlapping periods of time; and
second circuitry coupled to the controller to provide the second sense current to
the second converter for sensing the output voltage of the switching power
converter and to at least contribute to generation of the operating voltage
for the controller during non-overlapping periods of time.

14. The apparatus of claim 1 further comprising:
a secondary auxiliary power supply having a first input to receive at least the second
portion of the first sense current and a second portion of a second sense current,
wherein the second sense current is resistively derived from a second voltage
sense of the switching power converter and the secondary auxiliary power supply
system is configured to generate the operating voltage from at least the second
portions of the first and second sense currents.
15. The apparatus of claim 14 further comprising:
a first resistive circuit, coupled between the input of the switching power converter and
the second auxiliary power supply, to provide resistance to the first sense current; and
a second resistive circuit, coupled between an output of the switching power converter
and the second auxiliary power supply, to provide resistance to the second sense
current.

16. The apparatus of claim 15 wherein the second resistive circuit has a greater
resistance than the first resistive circuit.

17. The apparatus of claim 1 wherein the first sense current is a member of a group
consisting of: a sense current derived from an input voltage to the switching power converter
and a sense current derived from the output voltage of the switching power converter.

18. The apparatus of claim 1 further comprising the switching power converter,
wherein the switching power converter is coupled to the controller.

19. The apparatus of claim 18 wherein the switching power converter is a member of
a group consisting of: a boost converter and a buck converter.

20. A method comprising:
operating the controller during at least one controller operational mode from an operating
voltage generated from at least a first portion of the first sense current, wherein
the first sense current is resistively derived from a first voltage sense of a
switching power converter;
receiving in a controller at least a second portion of the first sense current; and
using the second portion of the first sense current to control a switching operation of the
switching power converter.
21. The method of claim 20 wherein the switching operation of the switching power converter is a member of a group consisting of: operating a switch of the switching power converter to provide power factor correction and operating the switch of the switching power converter to regulate an output voltage of the switching power converter.

22. The method of claim 20 further comprising:
operating the controller to cause the switching power converter to generate an approximately constant output voltage when the controller operates from the operating voltage generated from at least the first portion of the first sense current.

23. The method of claim 20 wherein the first sense current is resistively derived from at least one of one of: (i) an input voltage to the switching power converter and (ii) an output voltage of the switching power converter.

24. The method of claim 20 operating the controller further comprises:
operating the controller from the operating voltage generated from at least the first portion of the first sense current when a primary auxiliary power supply provides insufficient power to allow the controller to at least control an output voltage of the switching power converter.

25. The method of claim 24 wherein the primary auxiliary power supply provides insufficient power to allow the controller to at least control an output voltage of the switching power converter during standby-mode of the power supply system.

26. The method of claim 20 wherein operating the controller further comprises:
operating the controller during at least one controller operational mode from an operating voltage generated from at least a first portion of the first sense current and a first portion of a second sense current, wherein the second sense current is resistively derived from a second voltage sense of a switching power converter.
27. The method of claim 26 wherein operating the controller from the operating voltage generated from the first and second sense currents comprises operating the controller from the operating voltage generated from the first sense current and from a second sense current at least when a primary auxiliary power supply provides insufficient power to allow the controller to at least control an output voltage of the switching power converter.

28. The method of claim 26 further comprising:
providing the first sense current to the first converter for sensing the input voltage of the switching power converter and to at least contribute to generation of the operating voltage for the controller during non-overlapping periods of time; and
providing the second sense current to the second converter for sensing the output voltage of the switching power converter and to at least contribute to generation of the operating voltage for the controller during non-overlapping periods of time.

29. The method of claim 26 wherein the first sense current has a greater magnitude than the second sense current.

30. The method of claim 26 further comprising:
providing a second portion of the first sense current to a first converter for sensing the input voltage of the switching power converter while providing a first portion of the first sense current to a secondary auxiliary power supply system for generating the operating voltage.

31. The method of claim 26 wherein the first sense current is a member of a group consisting of: a sense current derived from an input voltage to the switching power converter and a sense current derived from the output voltage of the switching power converter.

32. The method of claim 20 further comprising:
determining a switch control signal to control a switch of the switching power converter, wherein the switch controls input current to the switching power converter.
33. An apparatus comprising:

means for operating the controller during at least one controller operational mode from an operating voltage generated from at least a first portion of the first sense current, wherein the first sense current is resistively derived from a first voltage sense of a switching power converter;

means for receiving in a controller at least a second portion of the first sense current; and

means for using the second portion of the first sense current to control a switching operation of the switching power converter.
Figure 12

Switch State Controller
114 Power Demand 1204

IC Switch State Controller
1102 Power Demand 1202

Normal mode

Switch State Controller
POWER

Standby mode

Switching Power
Converter Output Power
# INTERNATIONAL SEARCH REPORT

**International application No**  
PCT/US2009/032358

## A. CLASSIFICATION OF SUBJECT MATTER

**INV. H02M1/42**

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

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)  
H02M GOIR

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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

EPO-Internal, WPI Data

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category*</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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<tr>
<td>X</td>
<td>&quot;TOP200-4/14 TOPSwitch Family Three-terminal Off-line PWM Switch&quot;</td>
<td>1,2,4-6, 8-12,</td>
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<td>PRODUCT DATASHEET, POWER INTEGRATIONS INC., [Online] July 1996 (1996-07),</td>
<td>14-23, 26,27,</td>
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<td>XP002524650 San Jose, CA, USA Retrieved from the Internet: URL: <a href="http://www">http://www</a> .datasheet4u .com/download.ph p?id=311769&gt; [retrieved on 2009-04-20] figures 4,10 page 5, paragraph 1 page 9, paragraph 1 -----</td>
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<td>4 January 2005 (2005-01-04)</td>
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<td>paragraphs [0052] - [0054]; figure 8</td>
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**Date of the actual completion of the international search**  
27 April 2009

**Date of mailing of the international search report**  
05/06/2009

**Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016**  
Kail, Maximilian

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