(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
21 February 2008 (21.02.2008)

PCT

(10) International Publication Number
WO 2008/021440 A2

(51) International Patent Classification:
H02H 7/10 (2006.01)

(21) International Application Number:
PCT/US2007/018149

(22) International Filing Date: 15 August 2007 (15.08.2007)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:

60/822,438	15 August 2006 (15.08.2006)	US
11/838,339	14 August 2007 (14.08.2007)	US

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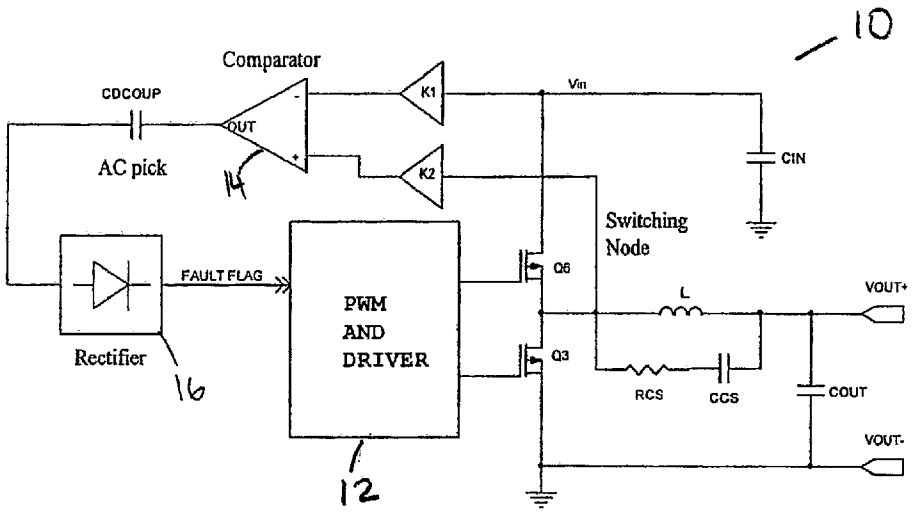
(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *without international search report and to be republished upon receipt of that report*

(54) Title: BUCK CONVERTER FAULT DETECTION METHOD



(57) Abstract: A circuit for detecting faults in at least one converter in a converter system, the at least one converter including a switching stage having high- and low-side switches connected at a switching node and fault circuitry for managing a plurality of fault conditions. The circuit including a gate driver circuit connected to gate terminals of the high- and low-side switches for providing PWM signals to control the switching stage; a comparator circuit for comparing a voltage at the switching node to the input voltage and providing an output signal, the comparator circuit having output, positive and negative terminals; a fourth capacitor connected to the output terminal of the comparator circuit to generate an AC component of the comparator circuit output signal; and a rectifier circuit connected to the fourth capacitor for rectifying the AC component of the comparator circuit and providing a fault-indicating signal to the gate driver. The fault-indicating signal is used to drive the fault circuitry to correct a fault condition selected from the plurality of fault conditions in the converter system.

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BUCK CONVERTER FAULT DETECTION METHOD

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application is based on and claims priority to U.S. Provisional Patent Application Serial No. 60/822,438, filed on 15 August 2006 and U.S. Patent Application Serial No. 11/838,339, filed 14 August 2007, the entire disclosures of which are hereby incorporated by reference.

BACKGROUND OF THE INVENTION

[0002] The present invention relates to converters, and more particularly to detecting fault in converters.

[0003] In a single or scalable buck converter system, each buck converter might experience faults such as input rail floating, high side switch gate floating, high side switch short or open, etc. Such faults might lead other converters to become electrically or thermally overstressed, and therefore normally in need of being reported to the converter or the system. Thus, what is needed is simple circuit that covers these fault scenarios in a converter.

SUMMARY OF THE INVENTION

[0004] It is an object of the present invention to provide a circuit for detecting input rail floating, high side switch gate floating, and high side switch short or open.

[0005] A circuit for detecting faults in at least one converter in a converter system is provided. The at least one converter including a switching stage having high- and low-side switches connected at a switching node and fault circuitry for managing a plurality of fault conditions. The circuit including a gate driver circuit connected to gate terminals of the high- and low-side switches for providing PWM signals to control the switching stage; a comparator circuit for comparing a voltage

at the switching node to the input voltage and providing an output signal, the comparator circuit having output, positive and negative terminals; a fourth capacitor connected to the output terminal of the comparator circuit to generate an AC component of the comparator circuit output signal; and a rectifier circuit connected to the fourth capacitor for rectifying the AC component of the comparator circuit and providing a fault-indicating signal to the gate driver. The fault-indicating signal is used to drive the fault circuitry to correct a fault condition selected from the plurality of fault conditions in the converter system.

[0006] Other features and advantages of the present invention will become apparent from the following description of the invention that refers to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] Figure 1 is a block diagram of a circuit of converter and a fault detector of the present invention; and

[0008] Figure 2 is a graph illustrating a peak voltage at the switching node during input rail floating.

DETAILED DESCRIPTION OF EMBODIMENTS OF THE INVENTION

[0009] Figure 1 illustrates a converter having a PWM enabled gate driver for controlling a switching stage consisting of high- and low-side switches Q6 and Q3 connected at a switching node. A second terminal of the high-side switch is connected to an input voltage source V_{IN}, which is connected to a grounded capacitor CIN. A second terminal of the low-side switch is connected to the ground.

[0010] The present invention further includes a detection circuit comprised of a comparator 14 for comparing a voltage at the switching node, which may be scaled by a value provided by an amplifier circuit K2 connected to a positive terminal of the comparator 14, to the input voltage Vin, which may be scaled by a value provided by an amplifier circuit K1 connected to a negative terminal of the comparator 14. A capacitor CDCOUP, connected between an output terminal of the comparator 14 and an input of a rectifier 16, provides the AC component of an output signal of the capacitor CDCOUP to be rectified by the rectifier 16. A fault flag signal provided by the rectifier 16 may be used to drive fault-related circuitry of a downstream converter.

[0011] The circuit 10 uses the voltage at the switching node for comparison with the input voltage V_{IN} scaled by the amplifier K1, the output of the comparator 14 is decoupled through a first terminal of the capacitor CDCOUP, a second terminal of the capacitor CDCOUP is connected to the rectifier 16. This arrangement extracts the AC component of the output signal from the comparator 14. This AC component may be used to signal a fault condition in the converter 10.

[0012] Input rail floating, high-side switch short or open are the most common converter fault scenarios. When the high-side switch Q6 is short or open, the output of the comparator 14 will be constant high or low, respectively. Thereafter no AC component will be fed into the rectifier 16 through the decoupling capacitor CDCOUP.

[0013] For input rail floating, illustrated in Figure 2, in graph (a) a waveform of voltage at the switching node with floating input is displayed over a waveform of

[0014] Although the present invention has been described in relation to particular embodiments thereof, many other variations and modifications and other uses will become apparent to those skilled in the art. It is preferred, therefore, that the present invention not be limited by the specific disclosure herein.

WHAT IS CLAIMED IS:

1. A circuit for detecting faults in at least one converter in a converter system, the at least one converter including a switching stage having high- and low-side switches connected at a switching node and fault circuitry for managing a plurality of fault conditions, the circuit comprising:

a gate driver circuit connected to gate terminals of the high- and low-side switches for providing PWM signals to control the switching stage;

a comparator circuit for comparing a voltage at the switching node to the input voltage and providing an output signal, the comparator circuit having output, positive and negative terminals;

a fourth capacitor connected to the output terminal of the comparator circuit to generate an AC component of the comparator circuit output signal; and

a rectifier circuit connected to the fourth capacitor for rectifying the AC component of the comparator circuit and providing a fault-indicating signal to the gate driver,

wherein the fault-indicating signal is used to drive the fault circuitry to correct a fault condition selected from the plurality of fault conditions in the converter system.

2. The circuit of claim 1, further comprising an input voltage source connected to one terminal of the high-side switch and to a grounded first capacitor.

3. The circuit of claim 3, further comprising:

a series couples resistor and third capacitor stage, the stage being parallel connected to the inductor.

4. The circuit of claim 3, further comprising a circuit connected between the switching node and a positive terminal of the comparator circuit for scaling the voltage at the switching node by a first value.

5. The circuit of claim 4, further comprising a circuit connected to a negative terminal of the comparator circuit for scaling the input voltage by a second value

6. The circuit of claim 1, wherein the plurality of fault conditions is selected from at least one of input rail floating, high-side switch gate floating, high-side switch short and high-side switch open.

7. The circuit of claim 6, wherein the AC component of the output signal is absent in situations selected from at least one of

when the high-side switch is short the output signal of the comparator circuit is constantly high and

when the high-side switch is open the output signal of the comparator circuit is constantly low.

8. The circuit of claim 6, wherein a preset threshold is compared with the voltage at the switching node to determine input rail floating which exists when a peak voltage at the switching node is less than the input voltage, the threshold is preset to the peak switching node voltage.

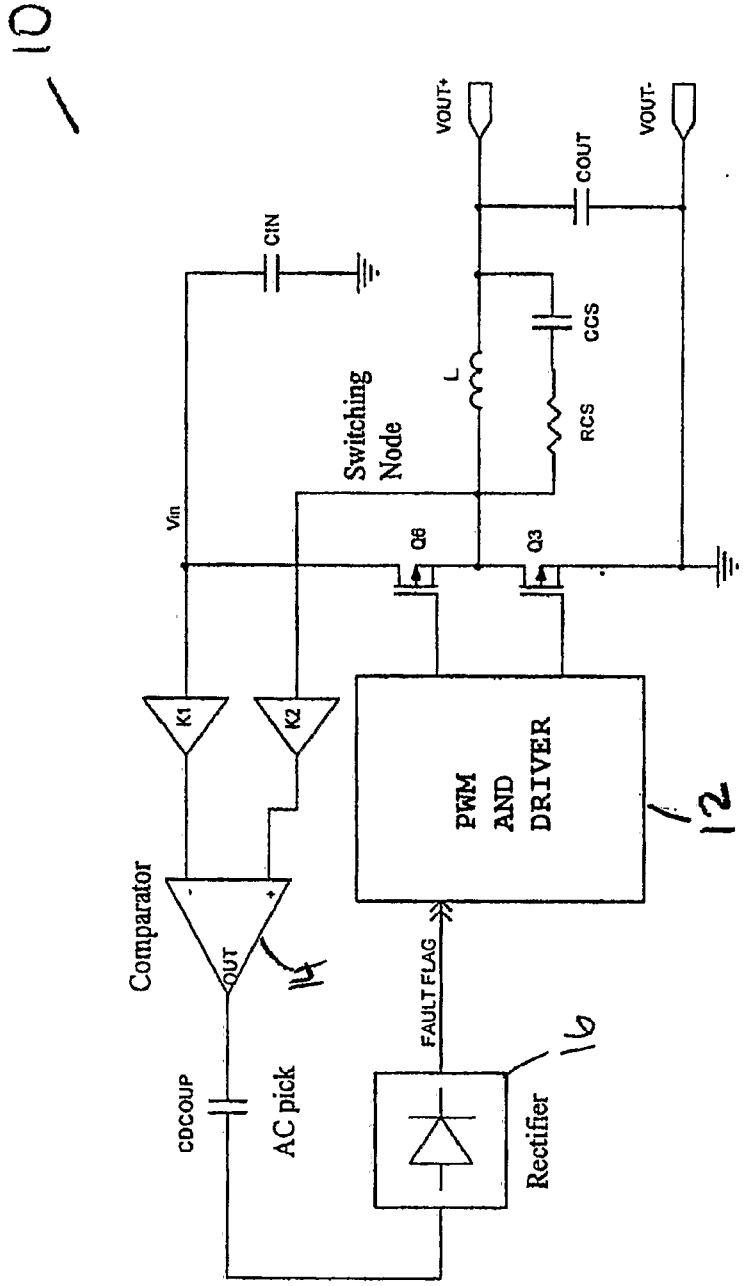
10
VOUT+
VOUT-
COUT
CIN
CCS
L
RCS
Switching Node
Vin
Q6
Q3
K1
K2
PWM AND DRIVER
12
Comparator
OUT
14
FAULT FLAG
16
CDCOUP
AC pick
Rectifier

FIGURE 1

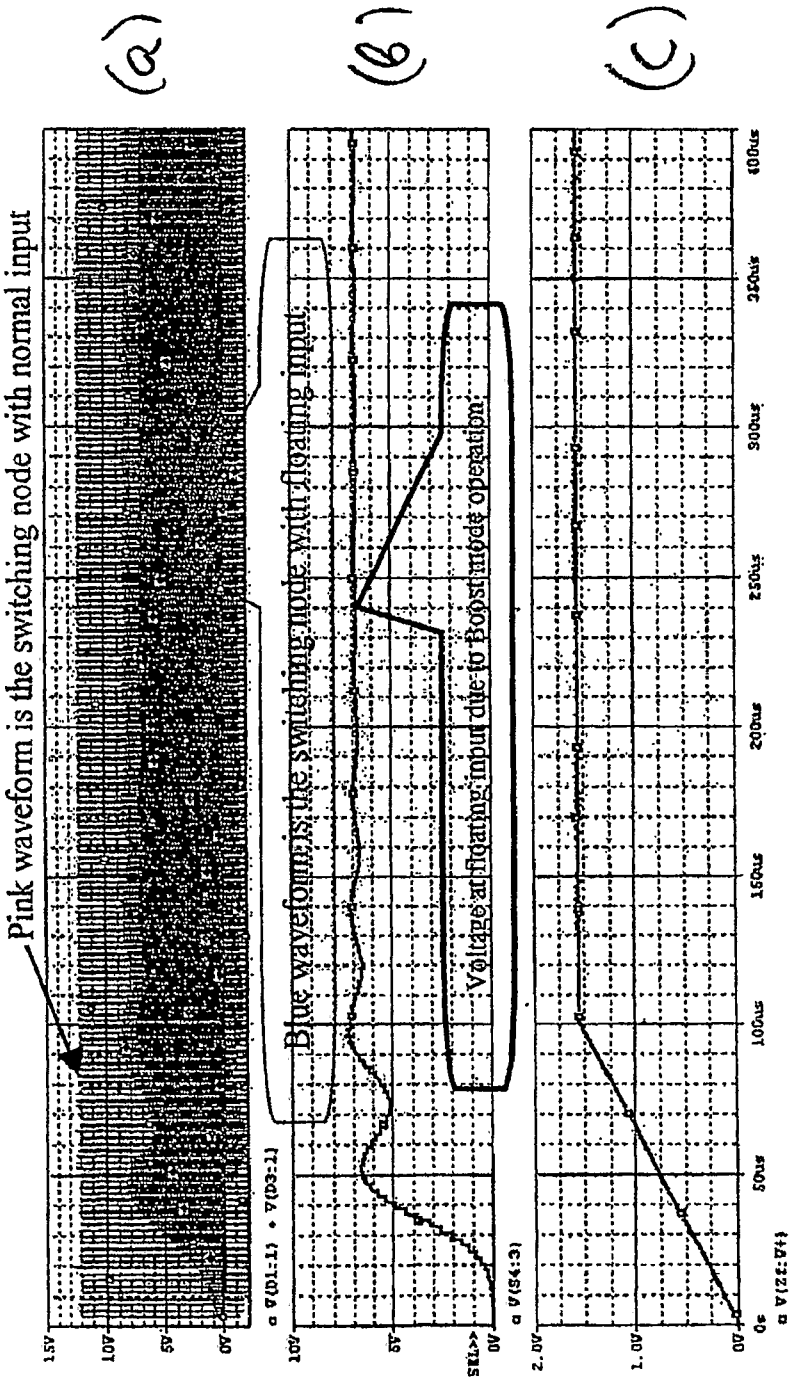
(a)
(b)
(c)
Pink waveform is the switching node with normal input
Blue waveform is the switching node with floating input
Voltage at floating input due to Boost mode operation

FIGURE 2