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Liu et al.

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(54) METHODS AND CIRCUITS FOR SENSING ISOLATED POWER CONVERTER OUTPUT VOLTAGE ACROSS THE ISOLATION BARRIER

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(52) U.S. Cl.
CPC ..... *H02M 3/33576* (2013.01); *H02M 1/0003* ... *H02M 3/33515* (2013.01); *H02M 3/3353* (2013.01); *H02M 3/33573* (2021.05); *H02M 3/33553* (2013.01)

(58) Field of Classification Search
CPC ... H02M 3/33576; H02M 1/0003; H02M 3/01; ...

(56) References Cited

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... 363/21.13
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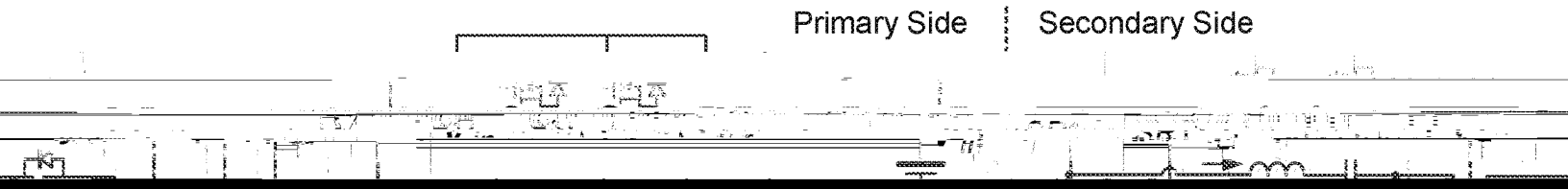
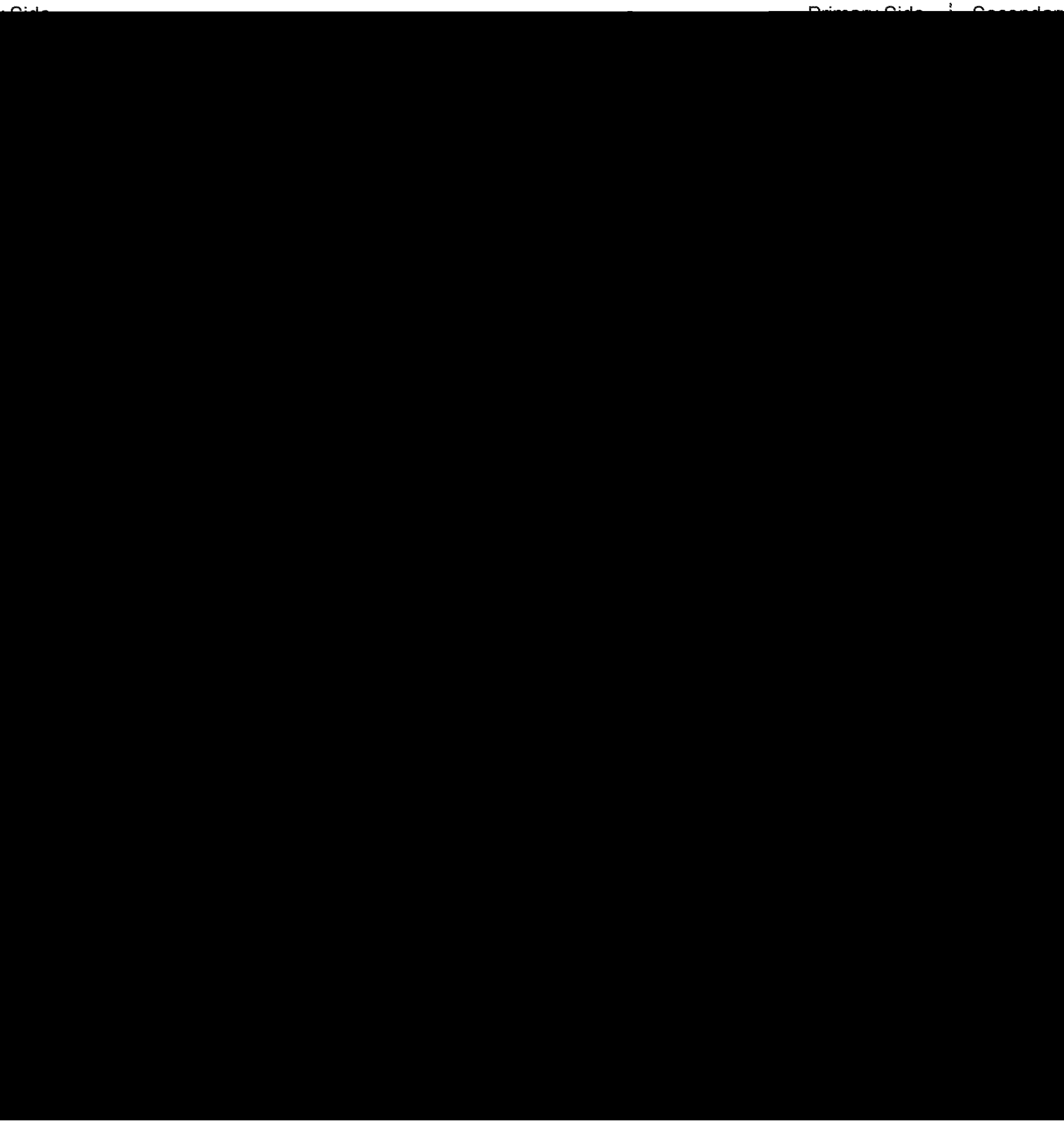
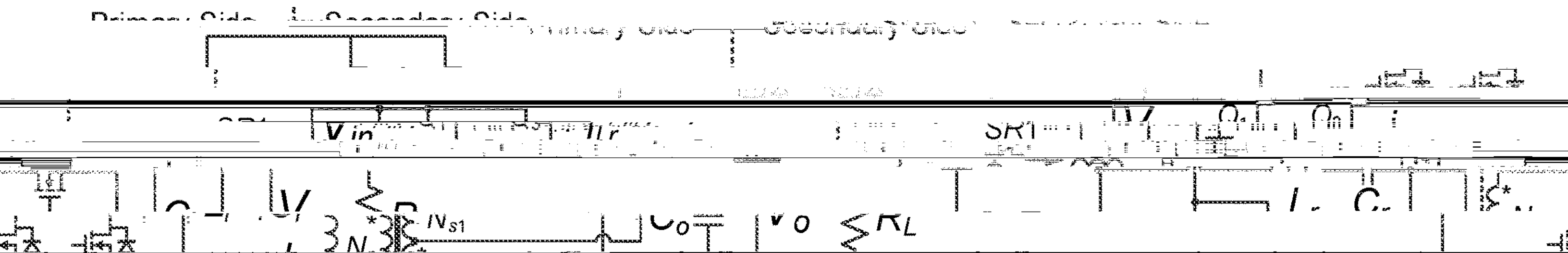
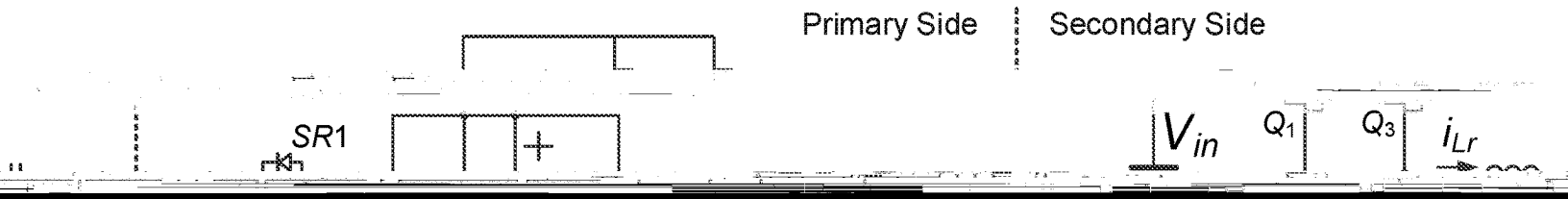

Primary Side
Secondary Side

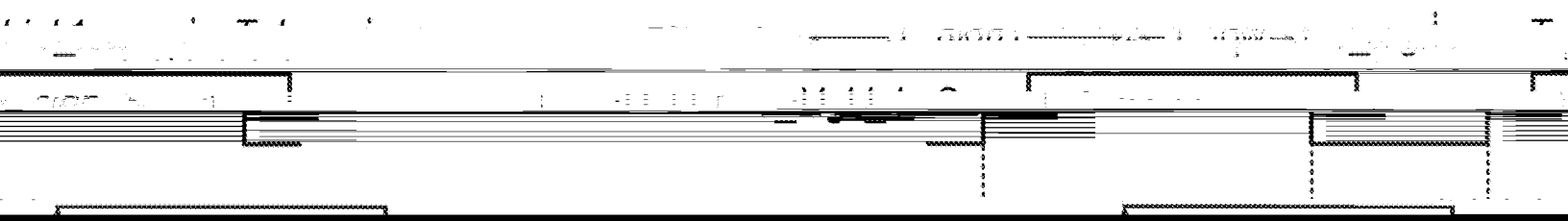

V_o
Primary Side
Secondary Side

[redacted]






Primary Side
Secondary Side
SR1
V_{in}
Q_1
Q_3
i_{Lr}



isolator at the primary side to produce a control signal; and

using a first microcontroller to determine the value of the

using the value of the secondary side output voltage to

primary side power switching devices of the isolated power

converter to regulate the secondary side

Another aspect of the invention relates to an isolated

FIG. **11** is a schematic diagram of a Vo sensing circuit according to one embodiment.

ferring a signal that is directly proportional to the value of the output voltage from one side of the isolation barrier (secondary side) to the other side of isolation barrier (pri-

or a digital isolator OP2. The optocoupler or digital isolator

e optocoupler or digital isolator, ... implemented together with an analog optocoupler (OP1), as

pe as V_{PWM}, as shown in FIG. 3. ... shown in FIG. 5. A suitable device is a three-terminal

ernal error amplifier, such as TL431 available from Texas ... It is noted that the peak value of V_{PWM} is Vccp, which is

coupler or digital isolator OP2.

In this description, the terms "optocoupler" and "digital ... As shown in FIG. 5, the error amplifier and feedback

value. The error voltage ... ing (that is, they perform effectively equivalent function), ... output voltage Vo to its steady state

r2 using the analog optocoupler ... an optocoupler is used for both an optocoupler implemen- ... side of the converter as Verro

voltage, Vo, can be predicted accurately by MCU2 at the primary side as 25V (=2.5V/0.1). Similarly, if measured Von

This means that if Vo changes quickly from 30V to 33V, it will take Von about 200 us to change from 3V to 3.3V. This

the primary side MCU2 can achieve accurate output over

Such delay may be substantially avoided by the embodi-

accurate PWM Vo sensing circuit that achieves accuracy of primary side by the optocoupler or digital isolator as

use of the inherent delay time of the digital PWM Vo sensing.

Similarly, the T_high time detection method as described with respect to the embodiment of FIG. 8 may also be used

claim 4, wherein the second de circuit comprises an error amplifier that error voltage.

trol circuit of claim 1, wherein the first primary uses a duration of the T_high interval of the e having a magnitude that he secondary side output

senses a secondary side ation (PWM) signal logic high time (T_high) interval that is al to a value of the secondary side output

power r that olator; rises a sam

e across the capacitor is used circuit to determine a gain of

converter to ge at a selected

The duty cycle of the second PWM signal (Vo PWM) is

to calibrate the Vo PWM signal to remove the ripple error

output voltage, and uses the steady state gain to cal-

apparent to one skilled in the art based on the embodiments described above.

The contents of all cited documents are incorporated herein by reference in their entirety.

EQUIVALENTS

Illustrative embodiments thereof, it will be understood that various changes may be made to the embodiments without departing from the scope of the invention. Accordingly, the described embodiments are to be considered exemplary and the invention is not to be limited thereby.

power converter:

introduced beca

determine an actual secondary side output voltage;

wherein the first primary side circuit controls the primary side power switching dev

5. The control circuit of secondary si produces the

6. The con side circuit PWM signal to generate a voltag is proportional to the value of t

and uses the measured magnitude of the generated voltage to determine the value of the secondary side output voltage.

7. A method for controlling a n isolated power converter, comprising:

sensing a secondary side output voltage of the isolated power converter using a first secondary side circuit that produces a pulse width modulation (PWM) signal proportional to a value of the secondary side output voltage;

isolation barrier to a primary side of the isolated converter; and

using a first primary side circuit to receive the PWM

The invention claimed is:

comprising:

a first secondary side circuit that produces a pulse width modul having a proportion

pling circuit including a capacitor that is charged and discharged according to the Thigh interval of the PWM signal, and a switch that shapes the PWM signal received from the first isolator by reducing a falling time and rising time of the PWM signal;

isolation barrier to a primary side of the isolated converter; and

a first primary side circuit including a processo receives the PWM signal from the first is

wherein the first primary side circuit samples a voltage across the capacitor at a sampling time set by a period of the PWM signal; and

wherein the sampled voltag by the first primary side switching devices of the isolated power regulate the secondary side output voltag

8. The method of claim 7, wherein the first secondary side circuit comprises a comparator that produces the PWM

wherein the first primary side circuit determines a steady-

proportional to a value of the secondary side output voltage.

converter to regulate the secondary side output voltage at the selected value.

having a logic high time (T_high) interval that is

state output voltage using the reference voltage

a first primary side circuit includ

receives the PWM signal from the firs

wherein the first primary side circuit co

pling circuit including a capacitor tha