PATENT ASSIGNMENT

Electronic Version v1.1
Stylesheet Version v1.1

SUBMISSION TYPE:	NEW ASSIGNMENT
NATURE OF CONVEYANCE:	Invention Disclosure Form showing Funding/Ownership

CONVEYING PARTY DATA

Name	Execution Date
Martin Liu	06/19/2007

RECEIVING PARTY DATA

Name:	Flextronics
Street Address:	2090 Fortune Drive
City:	San Jose
State/Country:	CALIFORNIA
Postal Code:	95131

PROPERTY NUMBERS Total: 1

Property Type	Number
Application Number:	12765412

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OP $40.00 12765412

ATTORNEY DOCKET NUMBER:	FLEX-04200
NAME OF SUBMITTER:	Thomas B. Haverstock

Total Attachments: 8
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INVENTION DISCLOSURE FORM
Rev. 03.12.05

Send Completed Form To: Flextronics Legal Dept.
2090 Fortune Drive
San Jose, CA 95131
Attention: Tim Stewart

LEGAL ONLY
Docket No. _____
Date Received:____

Or email To: tim.stewart@flextronics.com

If help is needed in completing this form, email tim.stewart@flextronics.com for assistance

1. TITLE OF INVENTION: Two stage resonant converter
2. INVENTOR(S): Martin Liu

A. Name _Martin Liu Ext. No

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Please circle one: (Flextronics employee)/Outside Consultant/Other

If Consultant or Other, provide particulars

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B. Name

_____ Ext. No. _____

Home Address _____ Home No. _____

_____

Email Address _____

Citizenship _____

Please circle one: Flextronics employee/Outside Consultant/Other

If Consultant or Other, provide particulars

Work Site: _____

C. (If more than two inventors, attach the same information on additional sheets)

3. FUNDING/OWNERSHIP OF THE INVENTION:

Please circle one: By Flextronics / By Other Company / By Government

If By Other Company or Government, provide particulars

4. CONCEPTION OF INVENTION: (i.e., the idea in your mind of the invention)

A. Date of first drawing or description?

Jun. 1st, 2007

Where can first drawing or description be found?

Haven't published yet

B. Date of first oral disclosure to others able to understand? Jun. 18th, 2007

To whom? Bahman Sharifipour (vice presendent of Flex power system)

5. REDUCTION TO PRACTICE: (only if accomplished; e.g., experiments, prototypes)

Prototype hasn't been made at this stage

Date Completed _____ Witnessed by? _____ Was prototype made? _____

By whom made? _____ Where is it? _____

6. TEST OF DEVICE

Date Tested _____ Witness(es) _____

Results _____

7. PUBLIC DISCLOSURE (outside of a confidential disclosure agreement). Has invention been:
Disclosed: Yes __ No √
If Yes, Circumstances: _____
If No, Is any public disclosure planned? Describe when and circumstances
Yes, will presented to Patent Committee and fill Preliminary Patent in July 2007
Offered for sale: Yes __ No√
If Yes, Circumstances: _____
If No, Is any offer for sale planned? Describe when and circumstances
No such plan
Used In Public: Yes __ No √
If Yes, Circumstances: _____
If No, Is any use in public planned? No plan yet Describe when and circumstances
Actually Sold: Yes__ No√
If Yes, Date and customer of first sale: _____
If No, Is any actual sale planned? No plan yet Describe when and circumstances

8. USE (internally or under a confidential disclosure agreement): Is invention presently being so used or are there plans to make such a use? Yes __ No √ If Yes, Describe the specific plans and dates for such current or planned use?

9. COMMERCIALIZING THE INVENTION - - To your knowledge, are there current plans to use this invention in any product? If so, describe products in which your invention is planned to be used.

Some high power switching mode power supply application in the future

10. If a joint invention, indicate what contribution was made by each inventor.

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INVENTION DISCLOSURE FORM

11. DESCRIPTION OF THE INVENTION

This description of invention should be written in the inventor's own words. Laboratory notebook entries, sketches, prints, photos, and other illustrations, as well as reports of any nature in which the invention is referred to, if available, should form a part of this disclosure and reference can be made thereto in the description of construction and operation. After the disclosure is prepared, it should be submitted to the Flextronics legal department as described on the top of the first page of this disclosure so that the invention can be corroborated and docketed.

(Attach additional sheets, if necessary.)

a. State in general terms the problem addressed by your invention.

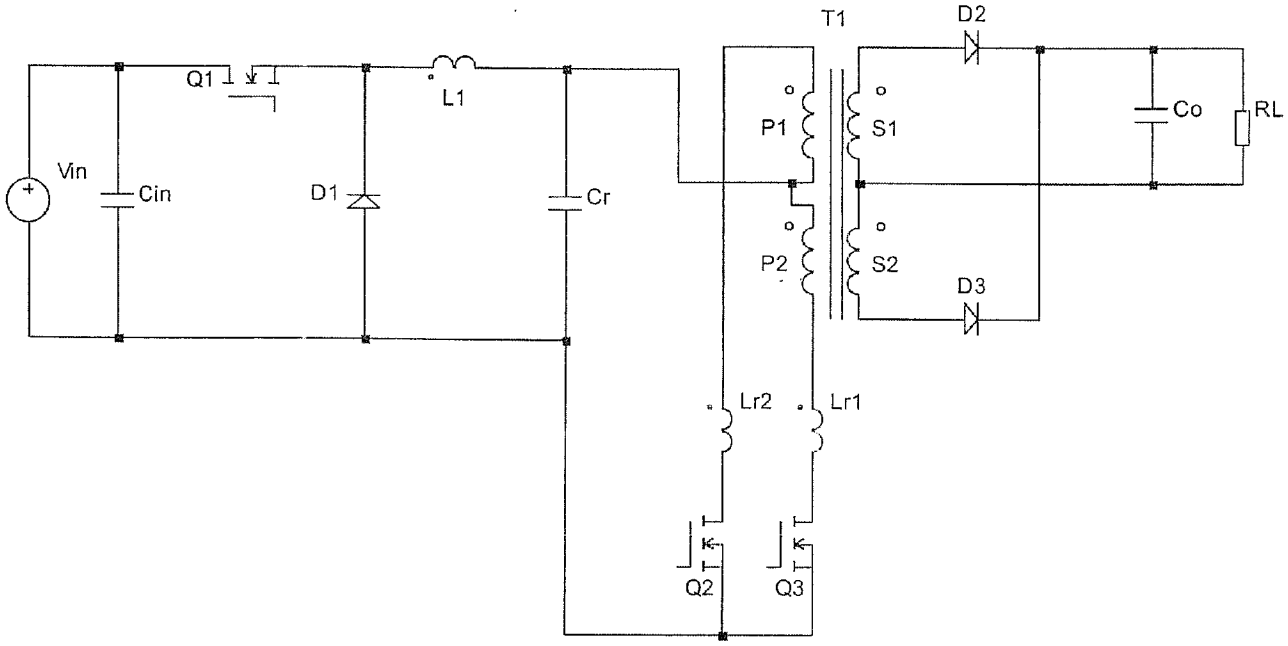

Figure 1

The invention is about a DC/DC converter topology, that transfers the input DC voltage Vin to a lower DC voltage output. Normally, the output need to be precisely regulated and input to output isolation is needed to meet safety requirement.

The invention discloses a two stage resonant DC/DC converter as shown in figure 1, the front stage includes Cin, Q1, D1 and L1, it is non-isolated and by controlling the duty cycle of Q1, we can regulated the output voltage of the converter. The second stage include Cr, Lr1, Lr2, T1,D2,D3 and Co, it is isolated but unregulated with 50% fixed duty cycle drive signals for Q2 and Q3 separately . A resonant tank consist of Cr and Lr1, Lr2 (Lr1 and Lr2 can be the leakage inductance of the transformer T1), which trim the voltage and current waveform in sinusoidal. By choosing appropriate switching frequency, the Switch Q2, Q3 and D2, D3 can work at zero voltage and zero current switching condition, reduce the switching losses and get a high efficiency.

Comparing with the prior art two stage converter, the new topology reduces an output inductance and a bulk link capacitor, simplify the current limit function and control of the second stage and increase the total efficiency by reducing the switching loss

c. Describe in general terms the prior art known to inventor(s) about the invention. Attach related printed publications, patents, if any are known to the inventor. If you cannot locate a hardcopy of the reference, identify the reference with particularity. (No need to initiate any searches here other than search through your files, memory and prior work product.)

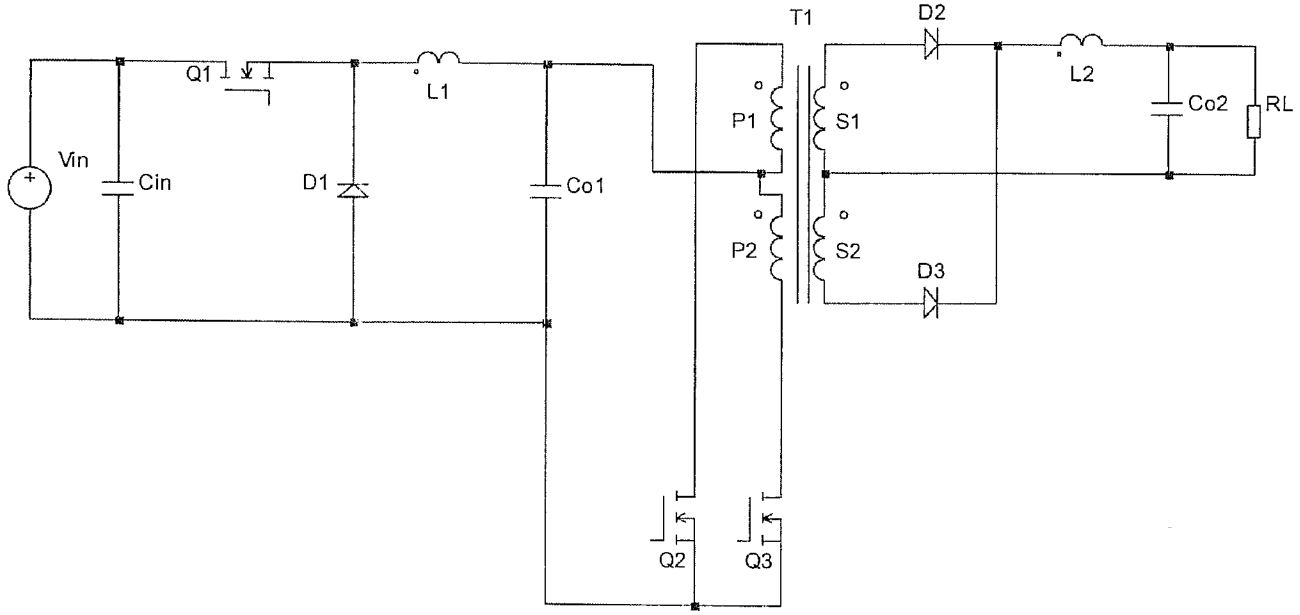

Figure 2a

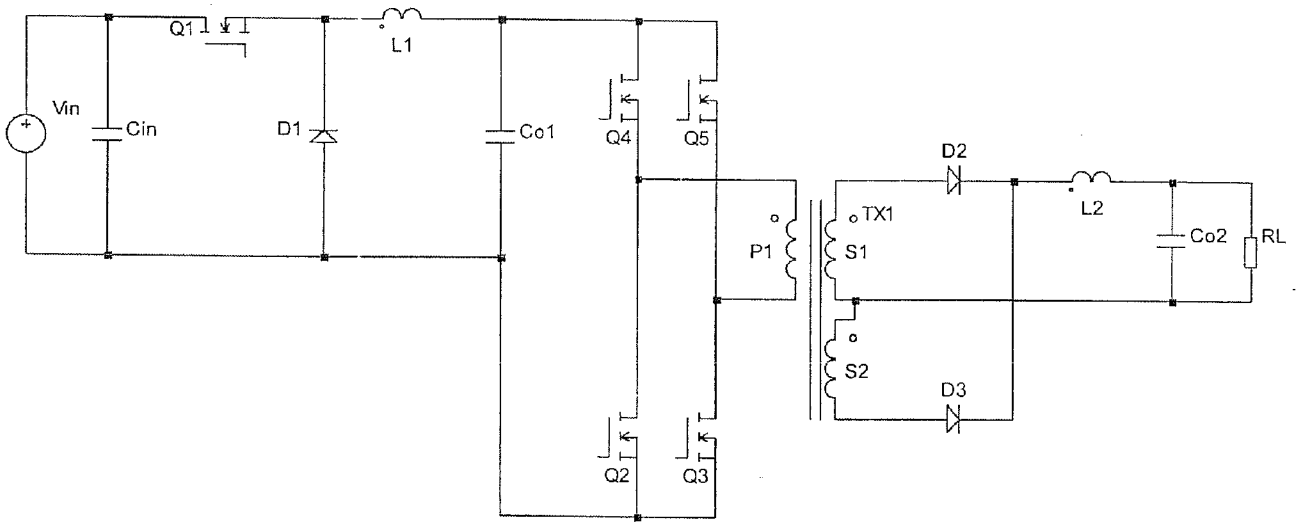

Figure 2b

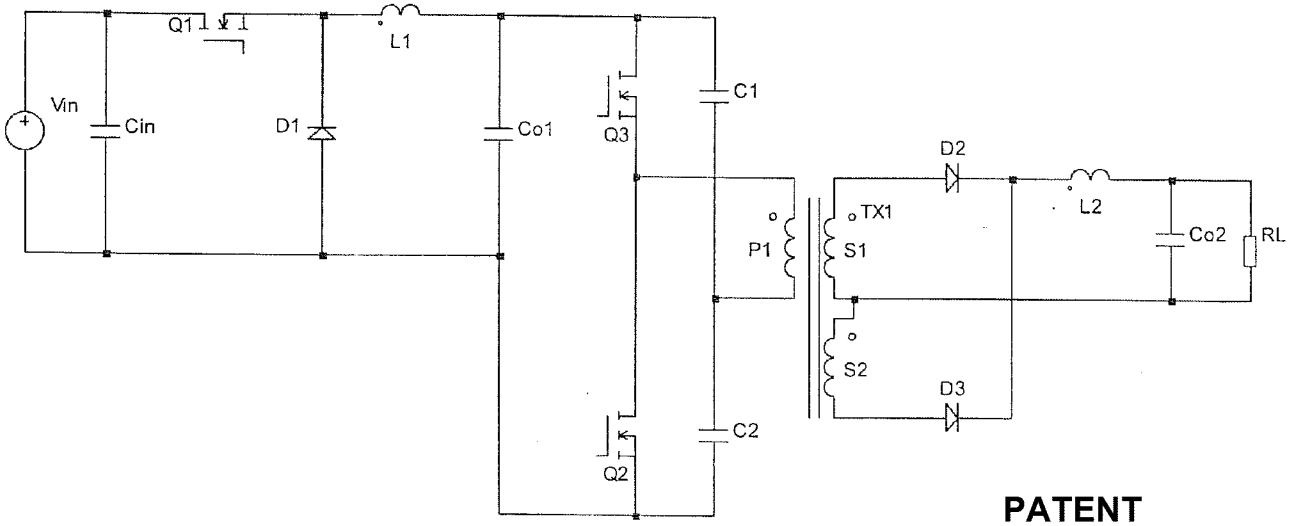

Figure 2c

Figure 2a, 2b, 2c show some prior art two stage converters, the common characteristic is that first stage is a non-isolated buck converter, it link to the second stage by an bulk capacitor Co1, by changing the duty cycle of Q1, the voltage of Co1 can be changed, the second stage is an double end converter, its driving signals normally are fixed at 50%, and the voltage transfer ratio is determined by the transformer turns ratio.

d. Describe shortcomings in the way that current technologies address this problem.

In prior art technology, an DC-link bulk capacitor Co1 and output inductor L2 is need for the voltage transfer function, these two component normally are big size.

The switches of the second stage work under "hard" switching condition, switching losses are high, that affects the total efficiency and limited the switching frequency.

The DC-Link capacitor Co1 can be considered as a voltage source to link the two stage, second stage need an over current limit circuit to limit the current during abnormal conditions, say, output short circuit, that increase the complexity of the control circuit

e. Describe the new way that your invention addresses this problem.

Although the new topology also use two stage structure, the DC-link capacitor Co1 and output inductor L2 can be removed.

By adding a resonant tank, the switches of the second stage can work under zero voltage and zero current switching condition, the switching losses can be reduced.

Instead of using a voltage source to link the two stage, a equivalent current source is adopted to link the two stage and current limit of the second stage is no need any more, that simplify the control circuit and add system robustness.

f. Describe how your invention overcomes current technology shortcomings in addressing this problem.

The proposed converter bases on figure 2a, but removes the DC-link capacitor Co1, and output inductor L2, adds a resonant tank Cr1 and Lr1 and Lr2. For prior art shown in Figure 2a, Co1 and L2 are normally big size capacitor and inductor, for the new converter in figure 1, resonant capacitor Cr1 are small size capacitor and so are Lr1 and Lr2, actually Lr1 and Lr2 can use the leakage inductance of the transformer T1, so the total size and cost of the converter can be reduced.

Instead of using Co1 as a voltage source to link the two stage, the new converter using L1 as a current source to link the two stage, in first stage, control circuit can sense and limit the current though L1, the current limit of L1 can protect the abnormal condition such as output short circuit and switches failure of the second stage, that simplify the control of the second stage

By adding a resonant tank circuit the second stage works under zero voltage and zero current switching condition, the switching loss can be reduced, higher switching frequency can be choose or conversion efficiency can be improved.

g. Describe the invention, showing the changes, additions and differences from the prior art.

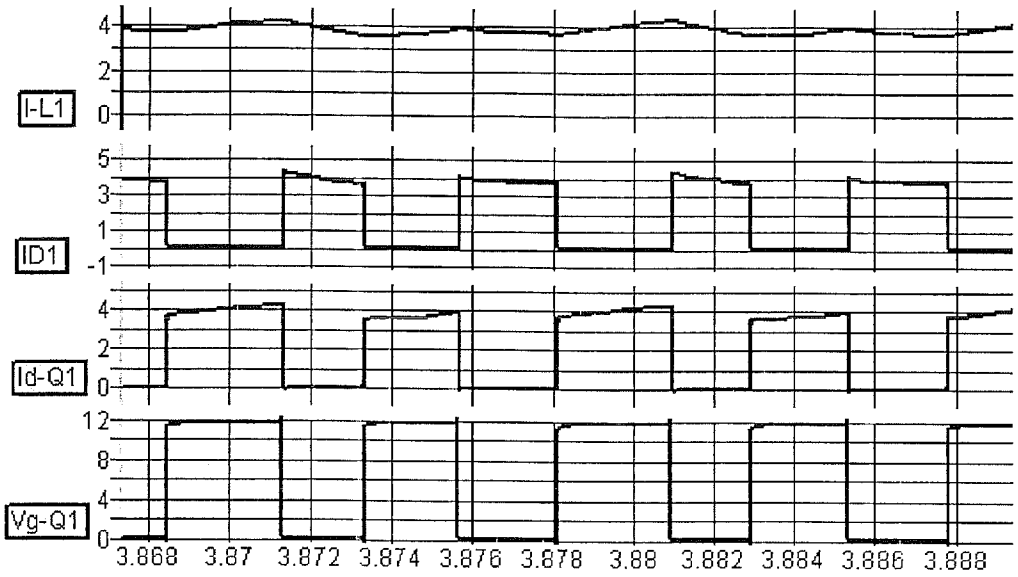

Figure 3

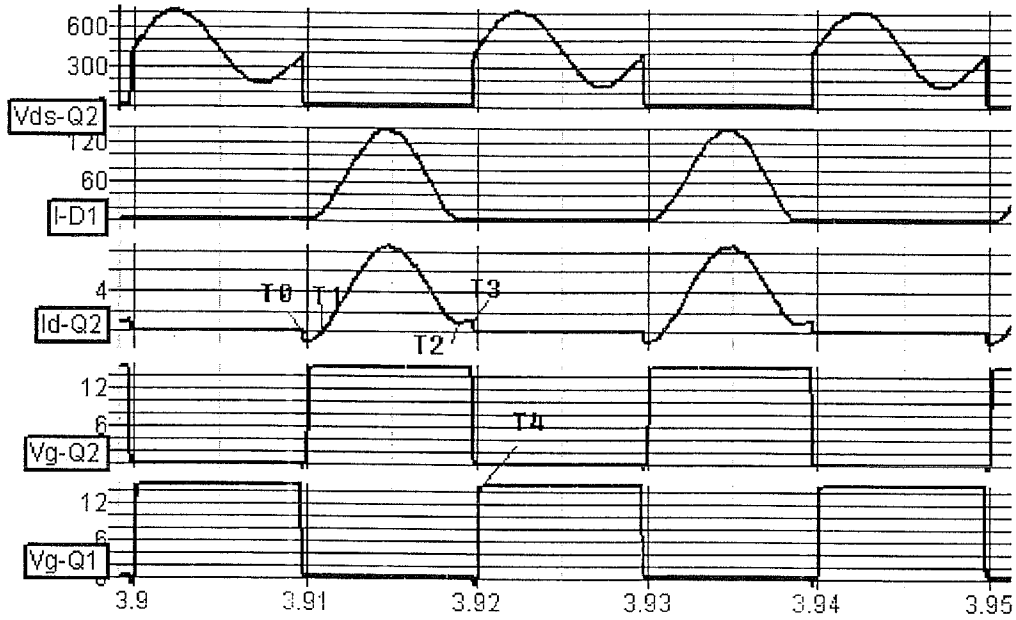

Figure 4

The waveform of stage one is shown in figure 3, the signal from bottom to top are gate drive of Q1, drain current of Q1, diode current I-d1 and inductor current I-L1, when Q1 is on the input voltage is apply to L1 and the current of L1 increase after Q1 turns off, the diode D1 conduct the inductor current and the inductor current decrease.
The waveform of stage two is shown in figure 4, the signal from bottom to top are gate drive of Q1, Gate drive of Q2, drain current of Q2, secondary Diode D3 current and drain to source voltage of Q2.

At time point t0, At t0, Q2 switch on and Q3 off, the current in the transformer primary side is the magnetizing current, it flow though the body diode of Q2, Q2 ZVS turn on.

At t1, the magnetizing current reaches zero, the body diode of Q2 ZCS turn off and current change direction and shift to Q2 MOSET path.

From t1 on, the voltage of transformer primary winding P1 is clamped by the output voltage, the magnetizing current increase, at the same time, Cr resonant with Lr2, resonant current increase. Primary current Ip have two component, Ip=ILm+ILr, ILm is the magnetizing current, and ILr is the resonant current in leakage inductance, secondary current ID3 equals nILr, n is the transformation ratio.

At t2, the resonant current ILr2 back to zero, I-D2 ZCS turn off, in primary side, only magnetizing current is left, Ip=ILm

At t3, Q2 is turned off by drive signal, this is a nearly ZCS turn off, because only magnetizing current remains

From t3 to T4, Ip=ILm, Q2 is off and the magnetizing current charge Q3 output capacitor, in the meantime, Q3 is discharged, gradually the magnetizing current shift to Q3 and flow through the body diode.

At t4, Q3 is ZVS turn on, and the next half cycle repeat the similar work mechanism

h. Indicate any alternate ways that your invention can be practiced.

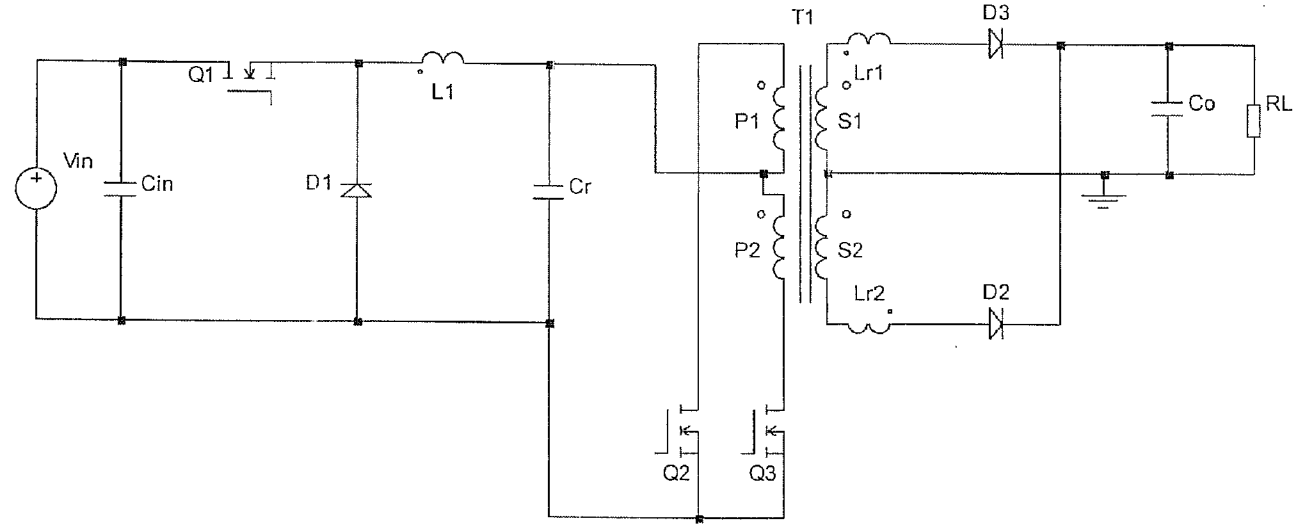

Figure 5a

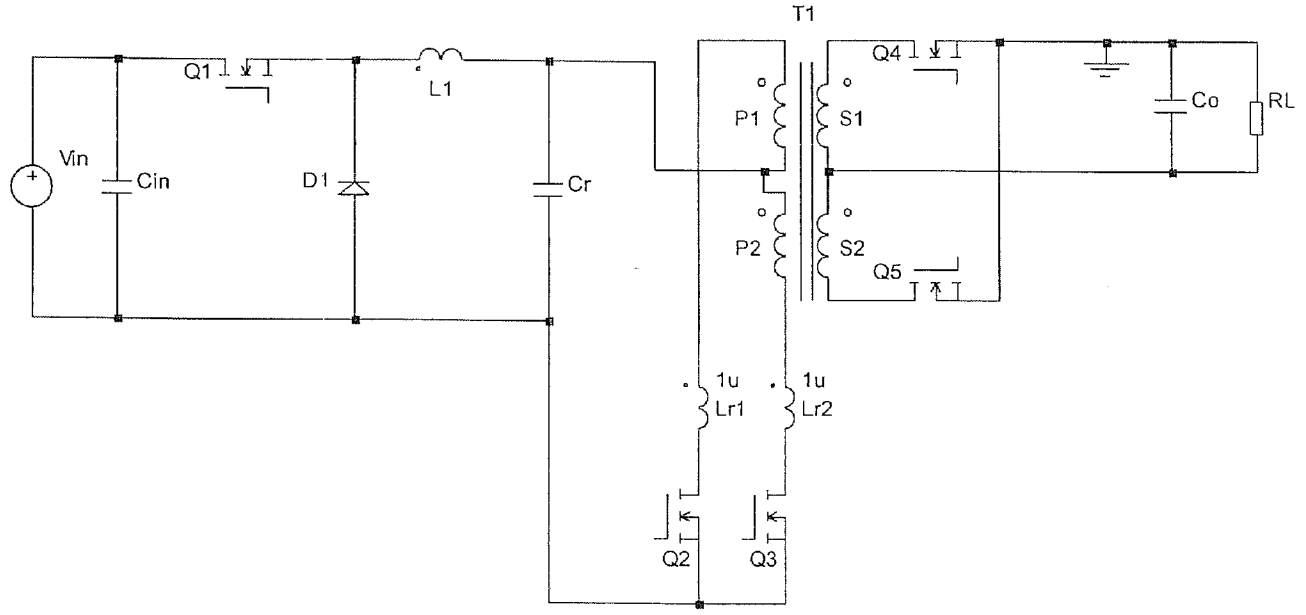

Figure 5b

The resonant inductance can also be placed on the secondary side of the transformer, as shown in figure 5a,

The D2 and D3 can be replaced by two active switches to further reduce the conduction losses, the synchronous rectifier circuit is shown in figure 5b

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12. OTHER TECHNOLOGY AREAS IN WHICH YOUR INVENTION MAY HAVE APPLICATION

(check one or more industry segment and applicable fields of use)

__Mobile Phones

__WAN __WLAN __PAN __GPS __ VoP __ VoIP

__Antenna Design _√_Power management __Industrial design __Thermal solutions

__Enclosure or mechanics __Software

__Infrastructure

__WAN __WLAN __Base Stations __VHF __UHF __TX or RX __VoN

__VoIP __Phys layer 1,2,3 switches and/or routers __Enclosures __Antenna

√Power Management __Thermal solution __Software

__Consumer electronics/medical

__ Printing & Imaging

__ Industrial Design

__ Silicon Design

__ Software

__ Manufacturing Process

__ Testing Process

__New Businesses (specify)

Inventor(s) _ **Date**

____Martin Liu_____ **Date __Jun 19, 2007____**