A Novel Non-Isolated Full Bridge Topology for VRM Applications

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Presentation Outline

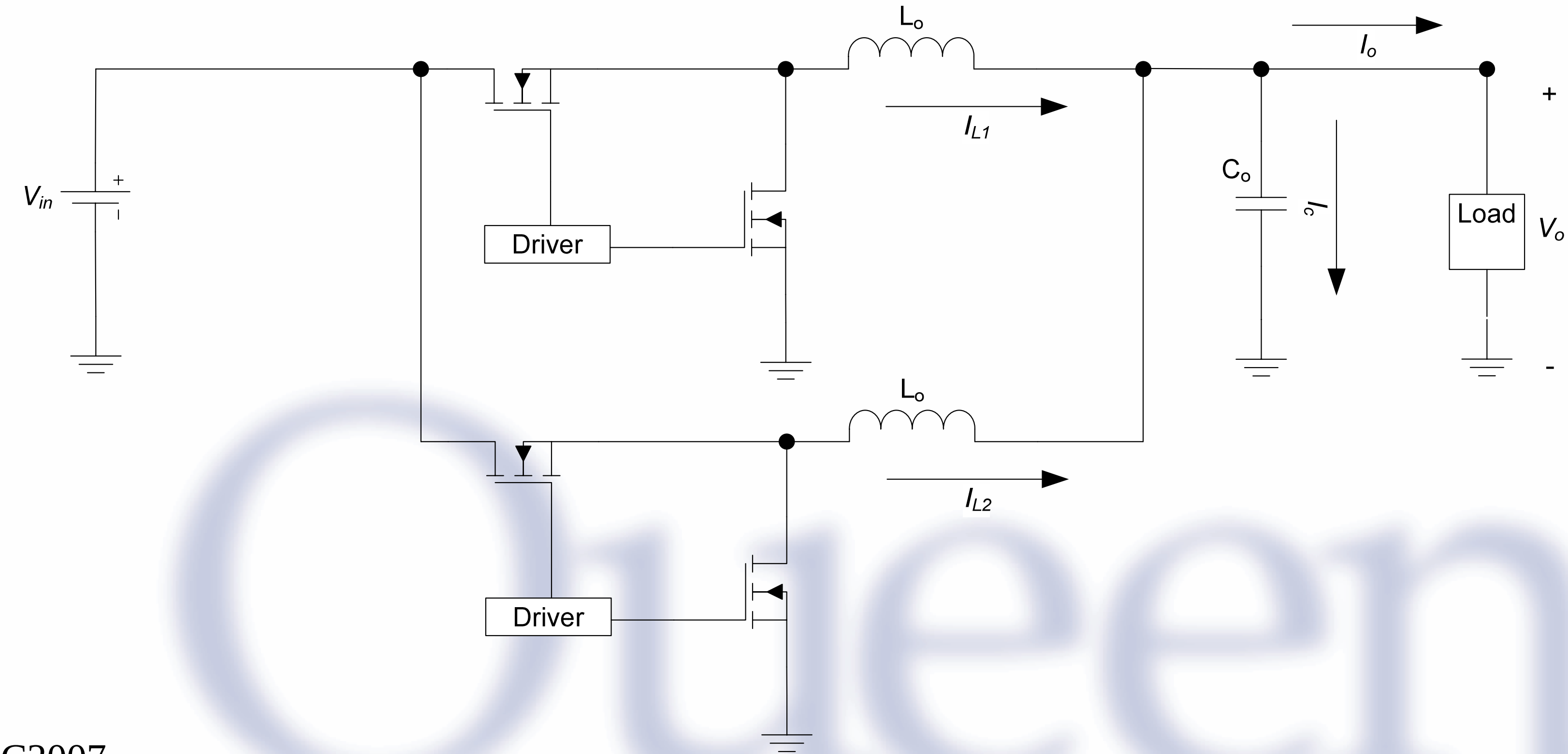
- Drawbacks of existing VRM topologies
- Proposed new VRM topology
- Operation and Loss analysis
- Experimental results
- Conclusions

VRM Requirements

- **High efficiency at high switching frequency**
  - **High power density**
- **Fast dynamic response**
  - **Small inductor and output Cap**
- **Low component cost**
  - **Low components count**

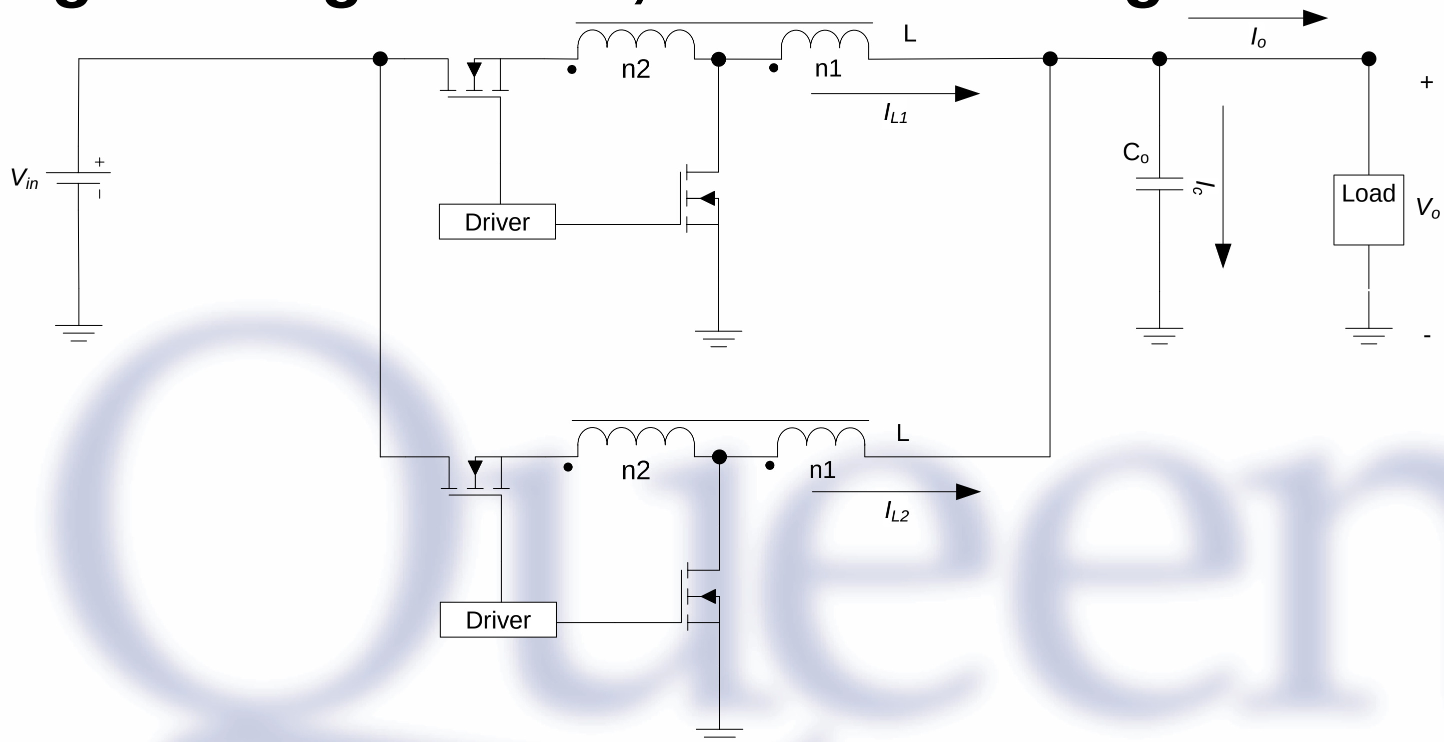
Drawbacks of Existing Buck Based VRM Topologies

- **Conventional Multi-phase buck**
  - ➢ **Simple, Low cost**
  - ➢ **Narrow duty cycle, high switching loss**



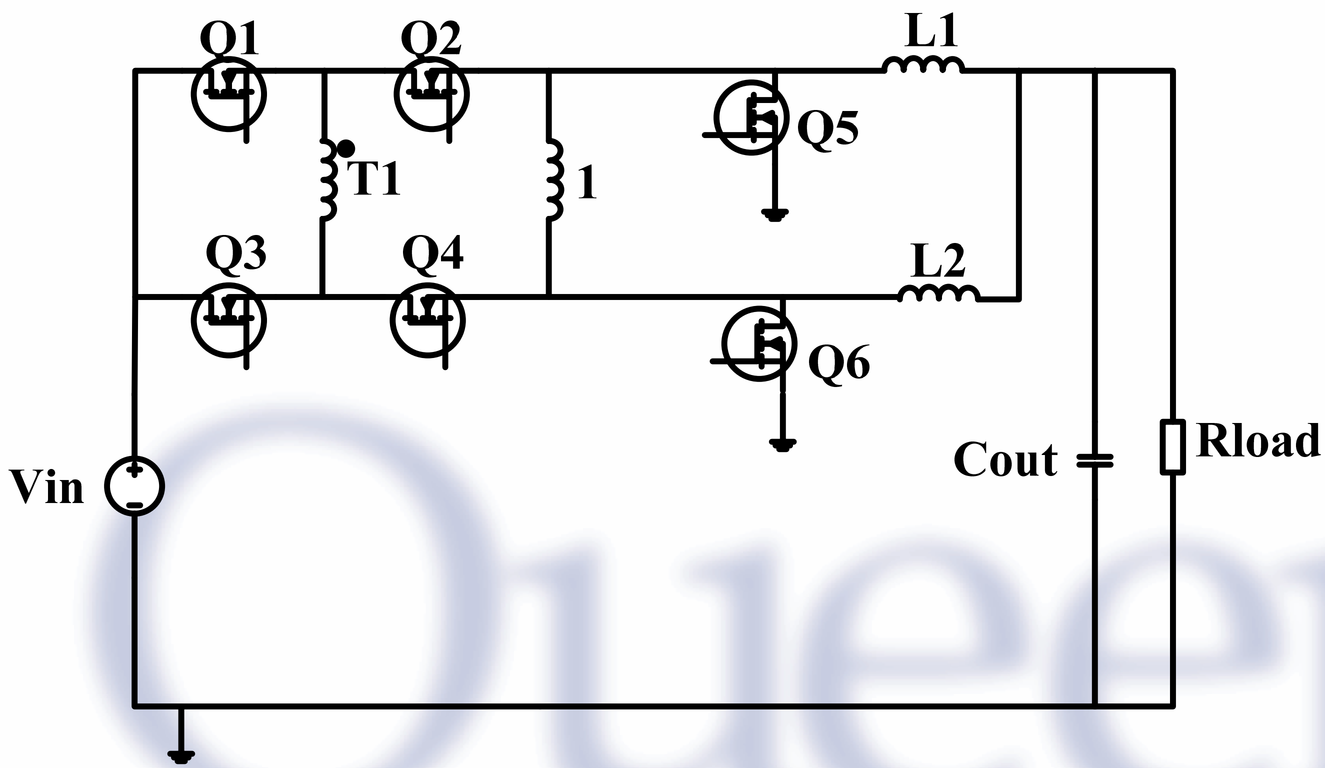
Drawbacks of Existing Buck Based VRM Topologies (cont.)

- **Buck based topologies with coupled-inductor**
  - ➢ **Simple, Low cost, Extended duty cycle**
  - ➢ **High voltage stress, hard switching**

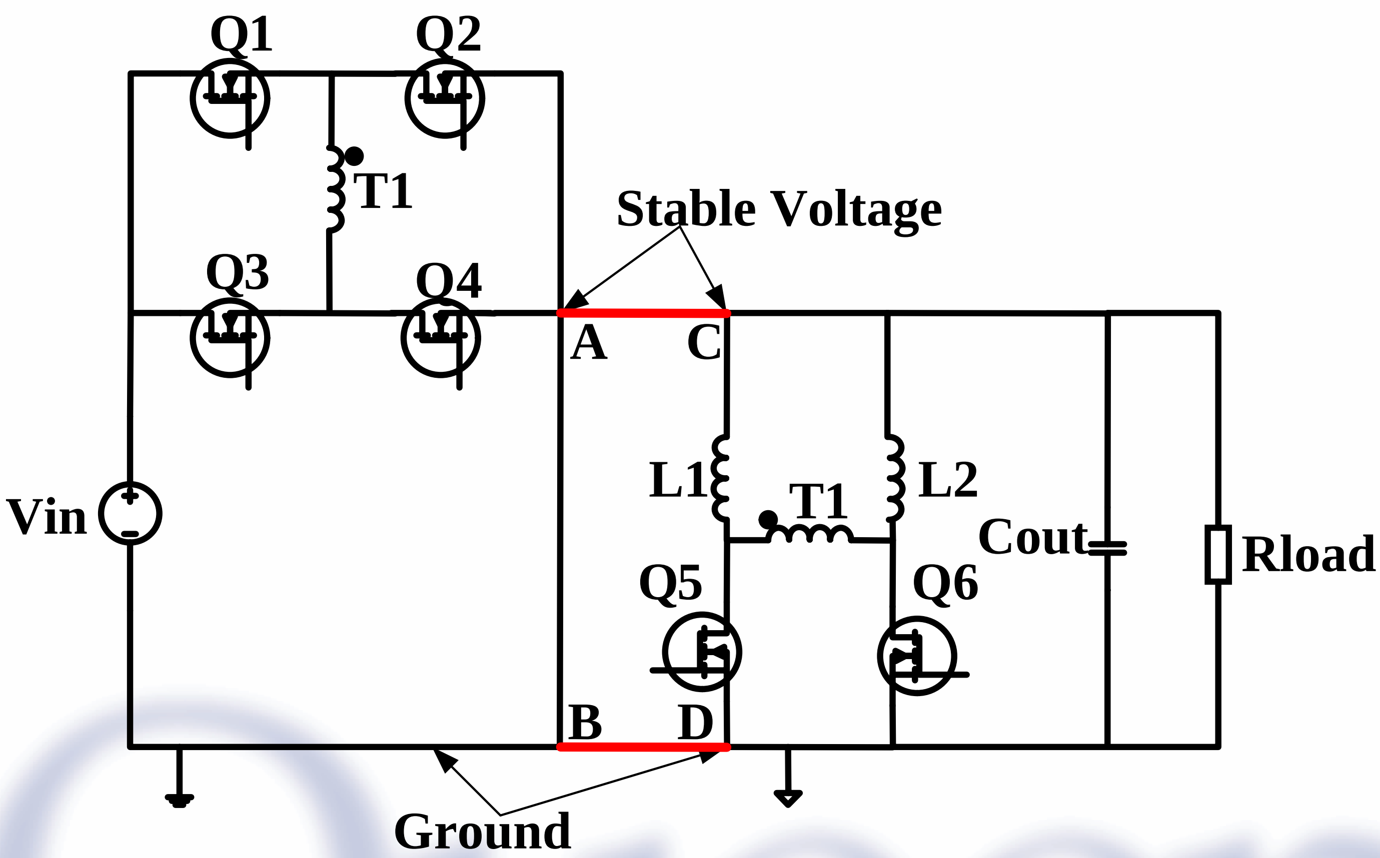


Drawbacks of Existing Transformer Based VRM Topologies

- **CPES proposed NFB**
  - ➢ **Input current conducts through the output inductors**

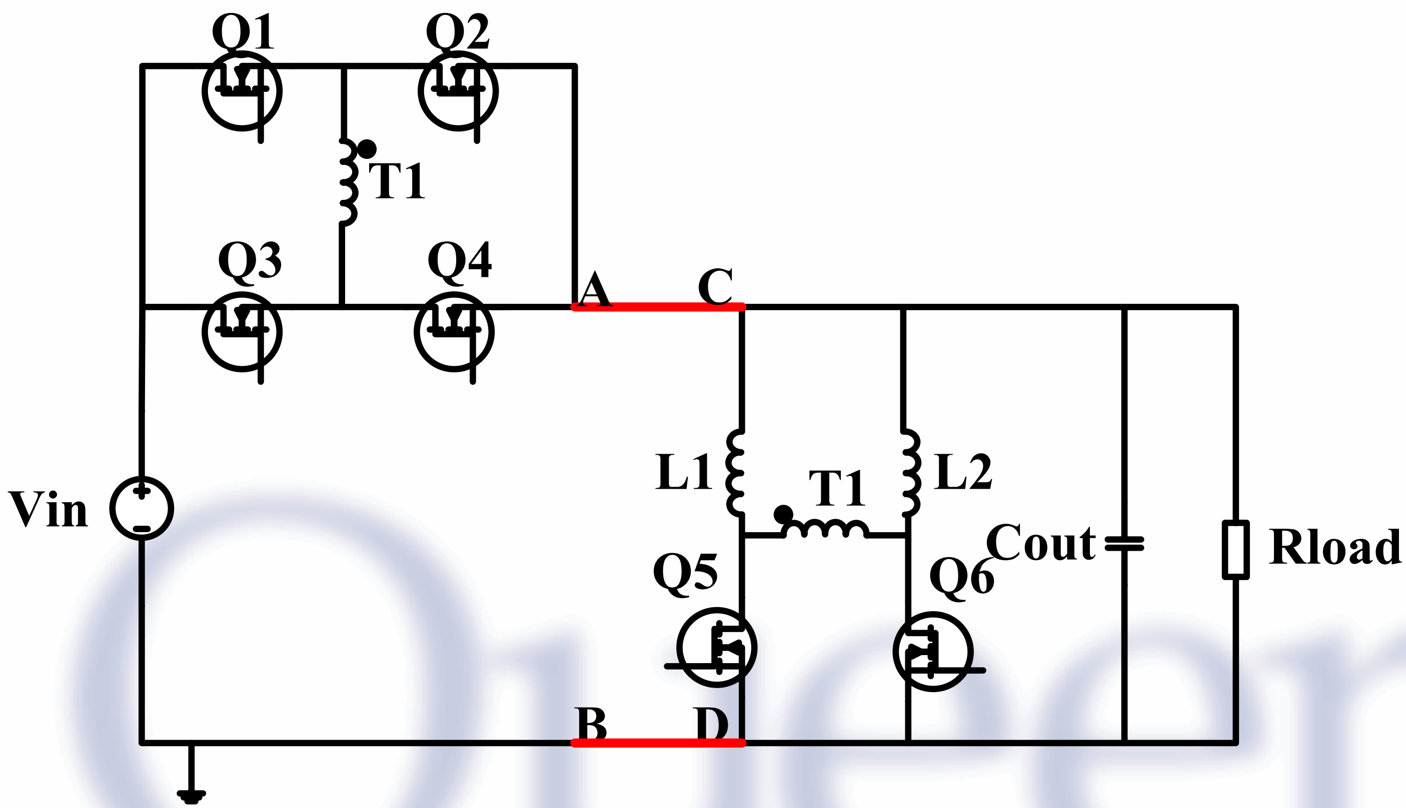


Evolution from the conventional FB to New Non-Isolated FB



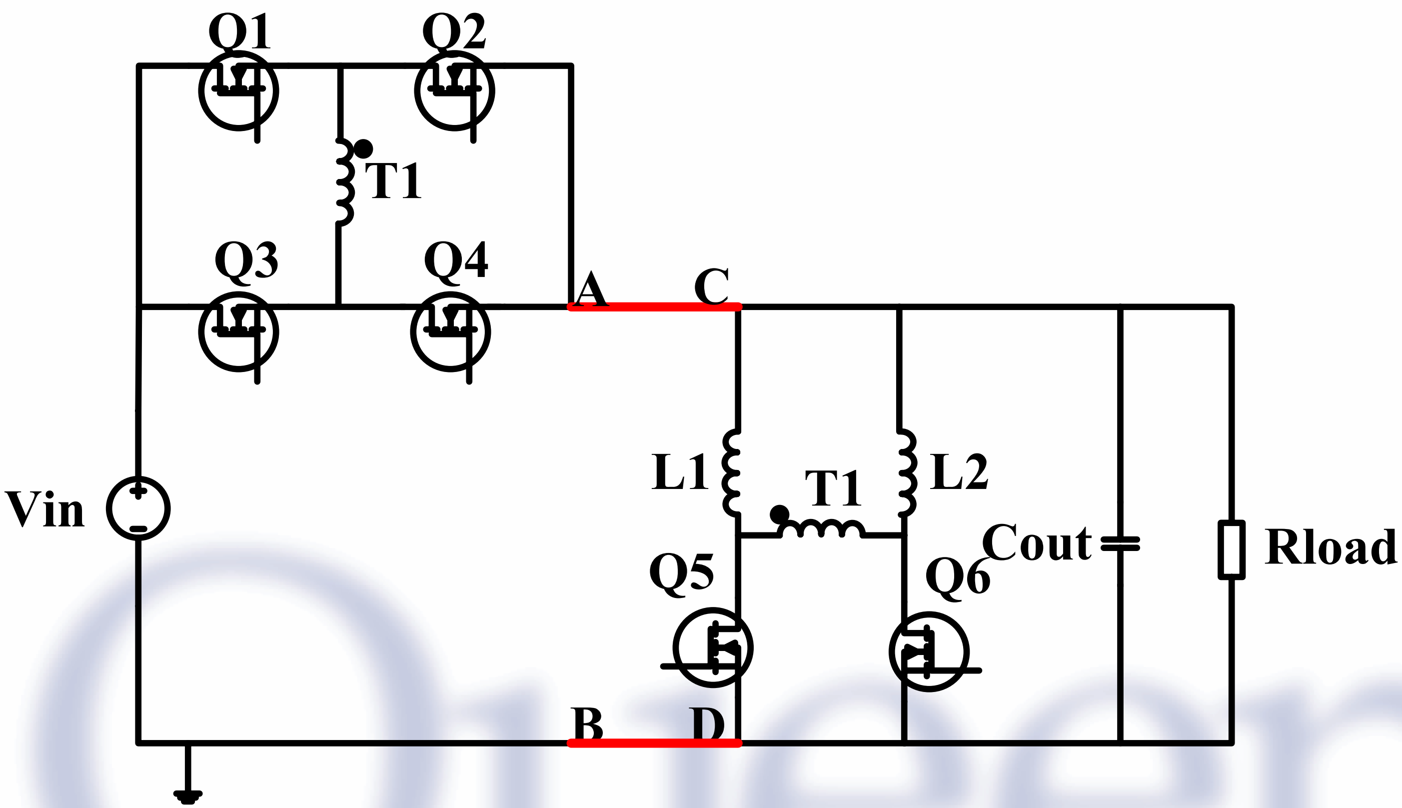
Benefits of the NFB

- **Input current goes to the load side directly**
  - **Current stress of SR and inductors is reduced**
  - **Transformer related loss reduced**



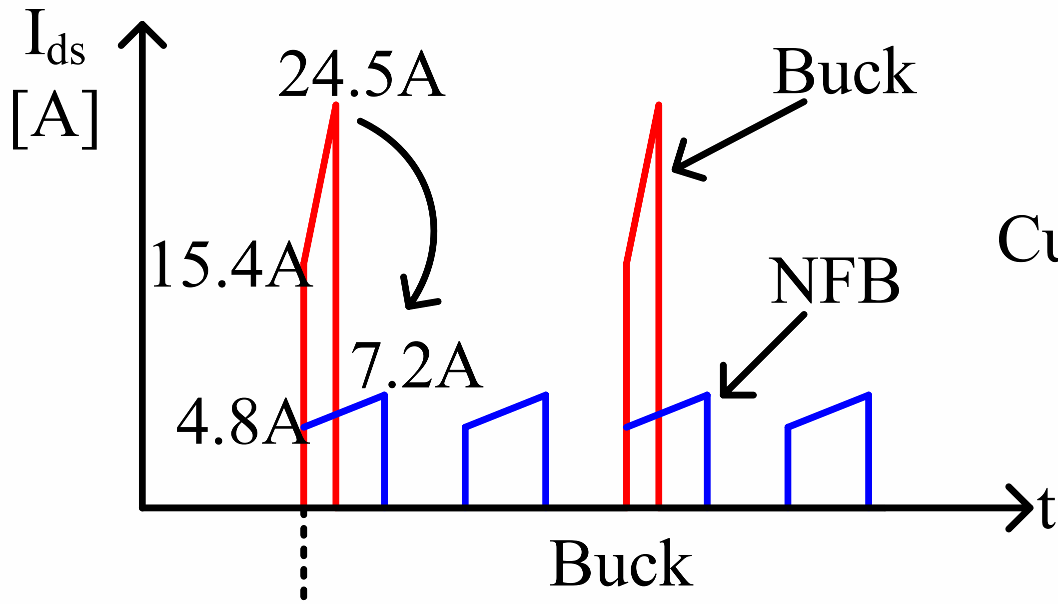
Benefits of the NFB

- **Q2, Q4 turned off at negative voltage**
  - ➢ **Turn off Switching loss reduced**



Reduced Switching Loss

1MHz, 12V input, 1V/40A load, 3:1 turns



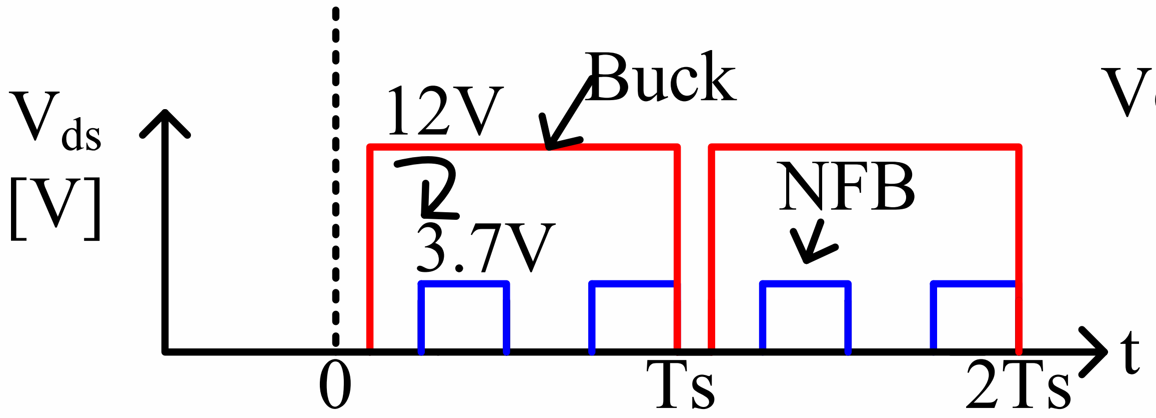
Current through high side MOSFETs

1. **Peak turn-on and turn-off currents reduced by extended duty cycle**
2. **ZVS turn-on**

e.g. Buck switching loss: 5.527W

NFB switching loss: 1.584W; 3.943W savings with NFB!

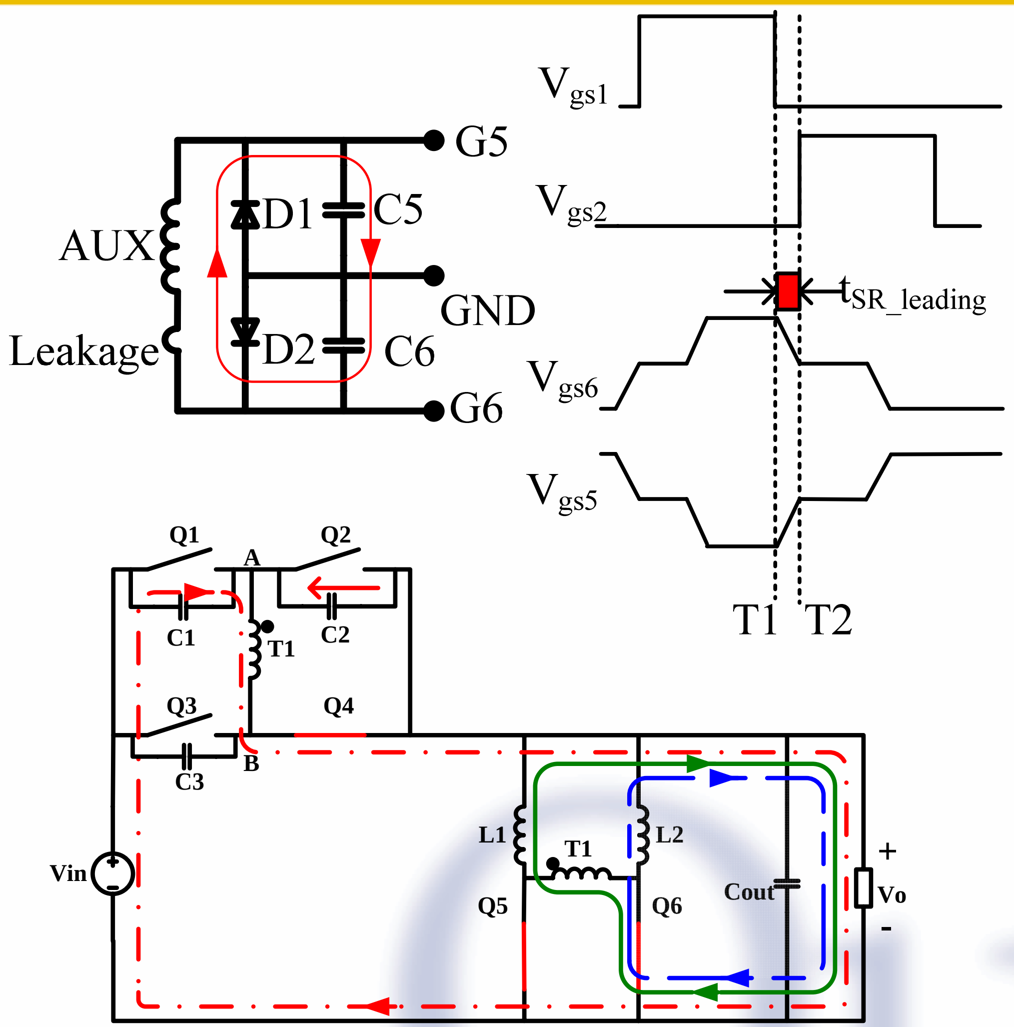
Reduced SR Voltage Stress



Voltage stress of synchronous Rectifiers

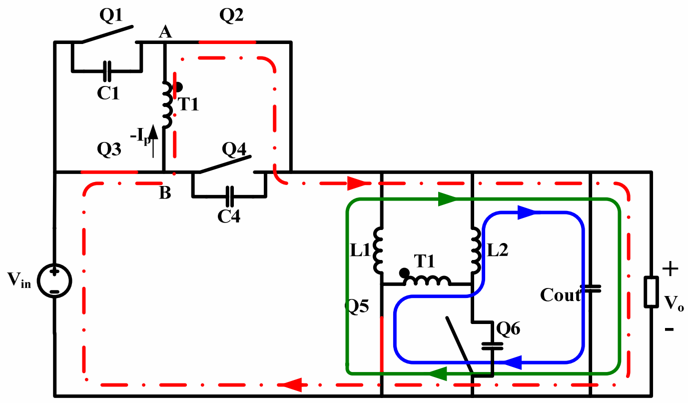
- **30V SR MOSFETs required for Buck**
- **8V SR MOSFETs can be used for NFB**
- **Lower Rdson MOSFETs can reduce conduction loss**

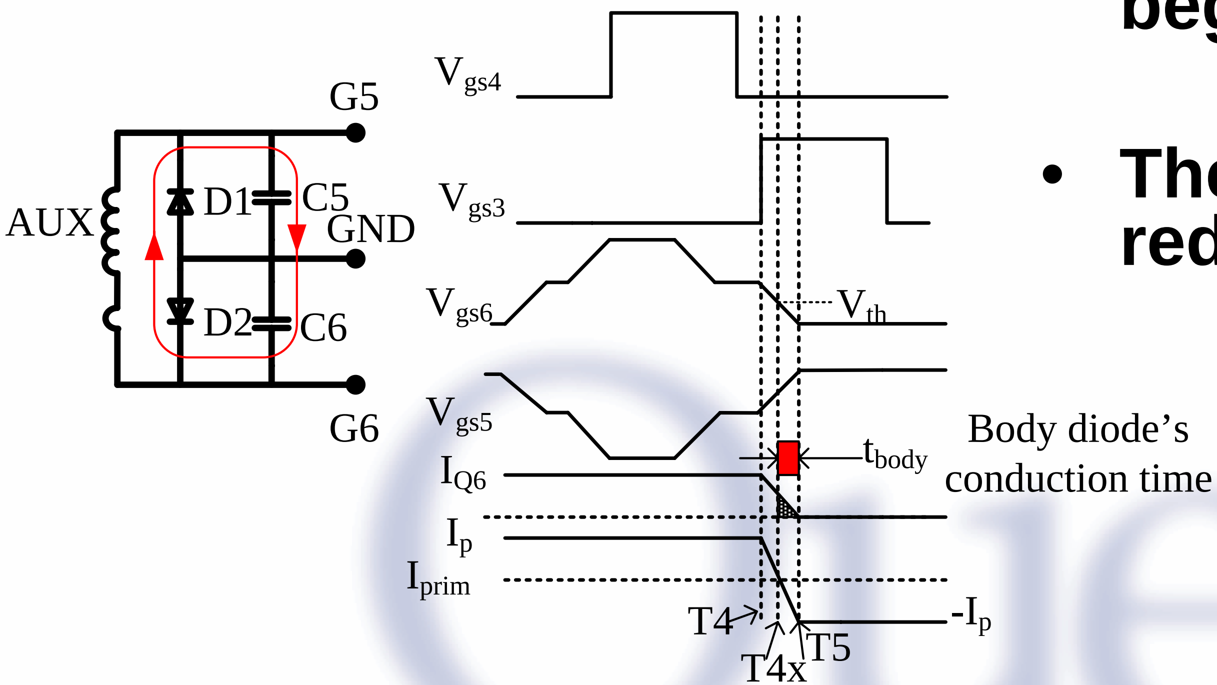
Body Diode Conduction Loss Leading Leg Transition



- **Timing is optimized with self-driven synchronous rectification**
- **Q5's body diode does not conduct during T1-T2**

Body Diode Conduction Loss Lagging Leg Transition

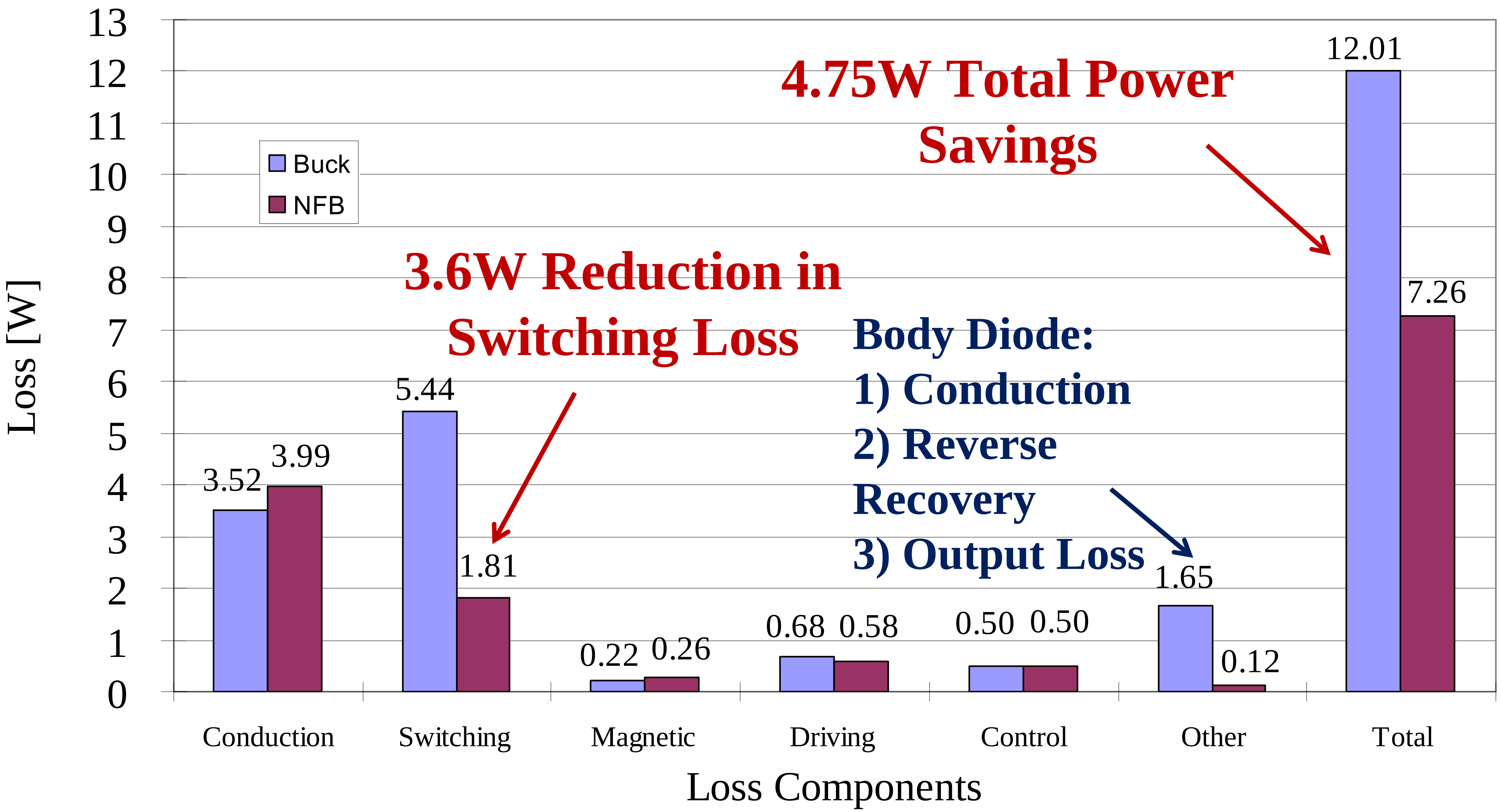




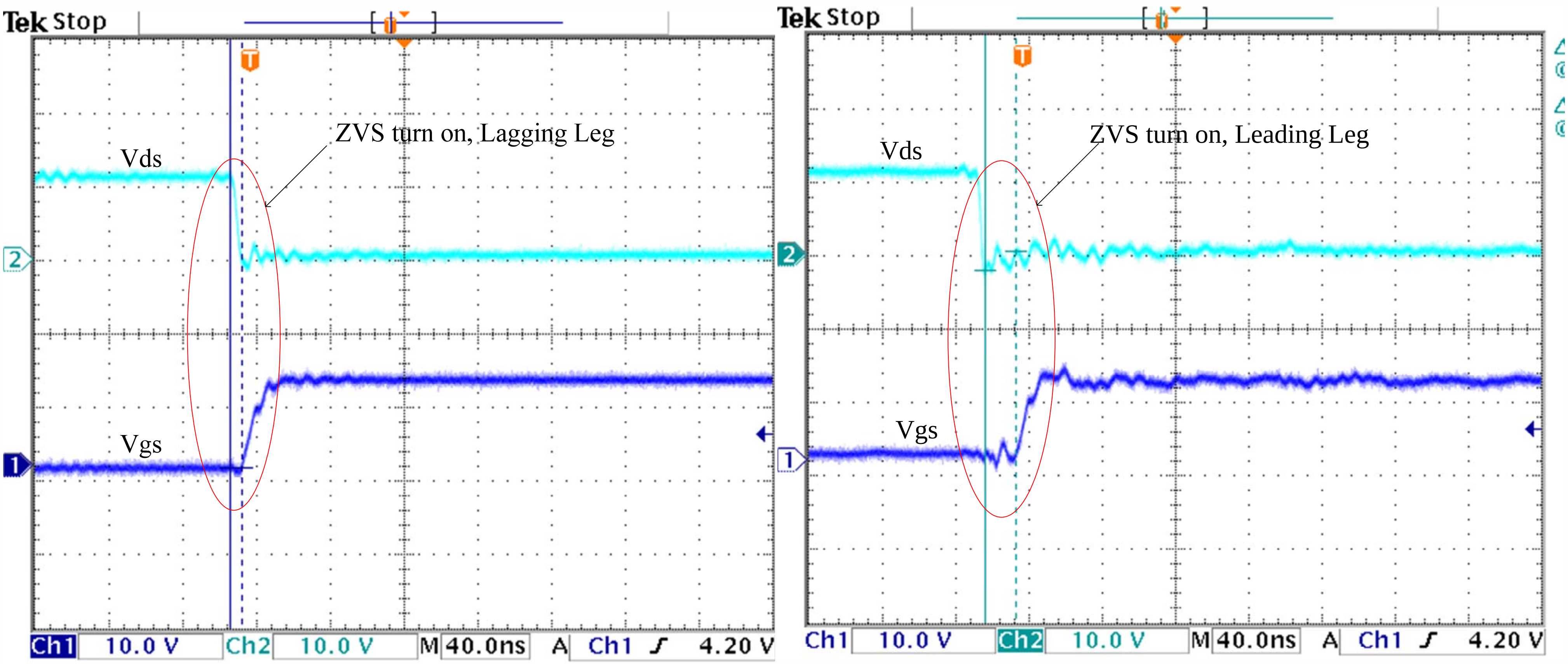
- **Primary side current begins to change direction at T4**
- **The body diode of Q6 begins to conduct at T4x**
- **The current in Q6 is reduced to zero at T5**

Calculated Loss Break Down

Two-Phase Buck vs. NFB at 1MHz and 1V/40A Load

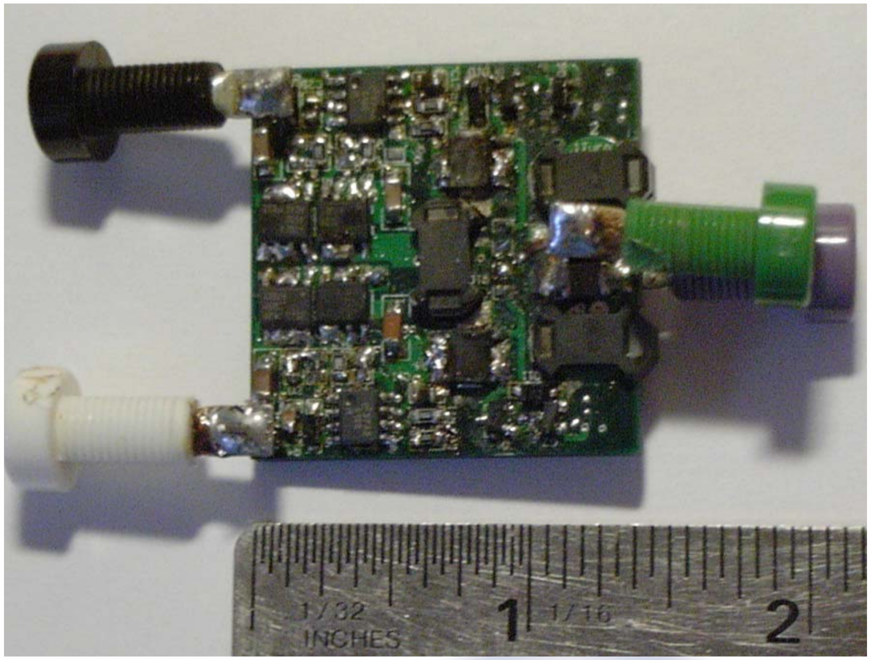


Zero Voltage Switching for Leading and Lagging Legs



- **ZVS turned on achieved at 20A load and 1MHz switching frequency**

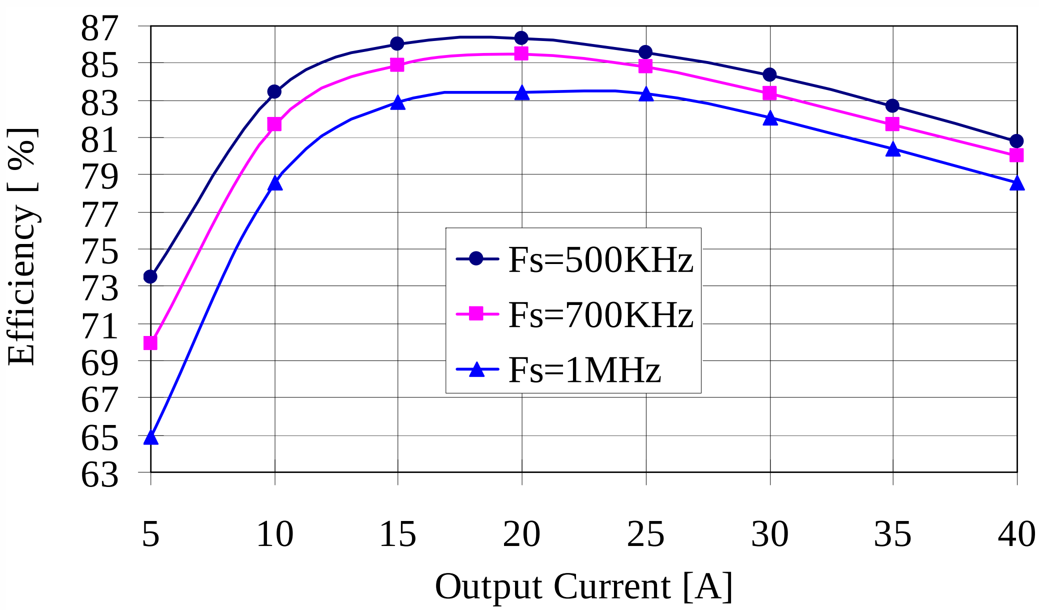
Experimental Results



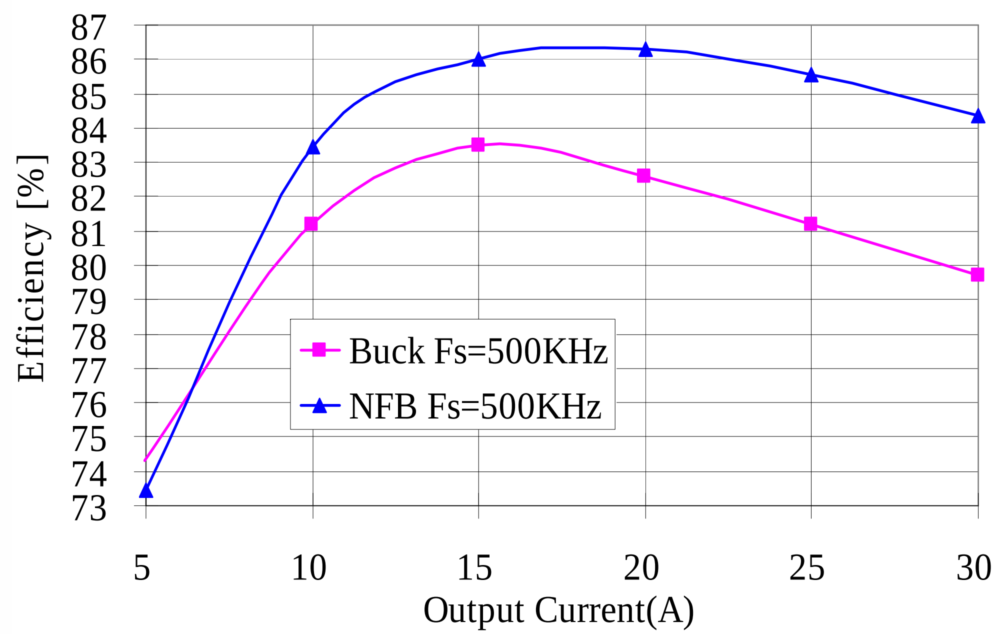
- 12V input, 1V/40A load
- 1MHz switching frequency
- 100nH output inductors
- Primary MOSFETS: International Rectifier IRF7812
- Synchronous Rectifiers: Fairchild FDS6162N7
- 12 layer, 2oz copper printed circuit board

Efficiency Comparison

NFB efficiency at 1V load



Comparison between the NFB and two-phase Buck at 1V load



- NFB achieves 82% efficiency at 1MHz, 3% more than the two-phase Buck operating at 500kHz (30A load)
- 5% efficiency improvement at 500kHz (30A load)

Conclusions

NFB Improvements:

- The input current flows directly to the load
  - ➢ Conduction loss is reduced
- Duty cycle is extended, zero voltage switching can be achieved
  - ➢ Switching loss reduced
- Capable of operating at much higher switching frequency
  - ➢ High power density
- Smaller output inductors
  - ➢ Fast dynamic response

Other interesting research material at:

www.queenspowergroup.com

Thank You! Questions?