Sandia National Laboratories

Isolation of Voltage Mode-Controlled Flyback Converter

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Goals for Isolated Flyback

- Eliminate current flow between primary and secondary circuits of the flyback.
- Design alternative means for secondary-side voltage control without using direct electrical feedback. Control loop to be cut is shown in green in Figure 1.
- Design should accommodate the needs of charging the load capacitor (C_L) to 3.5 kV
- Note that C_L is the capacitor at the secondary-side of the flyback circuit. That is the main capacitor that requires voltage regulation.

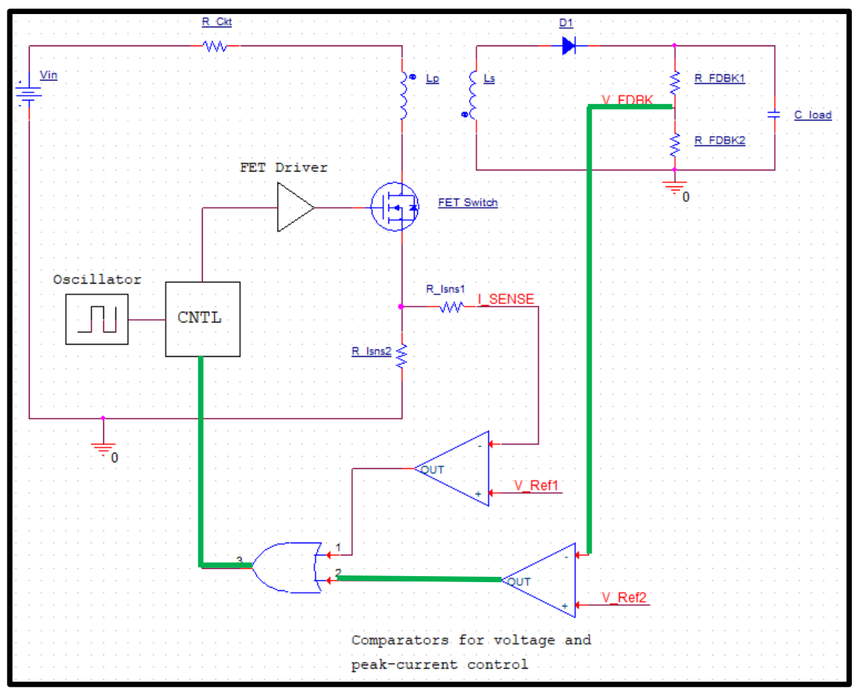

Figure 1. Flyback converter with both current and voltage mode-control. The control loop to be cut is highlighted in green.

Design Concept: Primary-side Sensing via Auxiliary Winding

- An auxiliary winding is used to track the secondary winding output voltage.
- Output voltage at the auxiliary loop is sensed using a resistor divider and fed back to the PWM controller for regulation, as shown in Figure 2.
- The PWM controller utilizes a 0.75 V reference with hysteresis comparator to sense when the output capacitor needs to be discharged or recharged again.

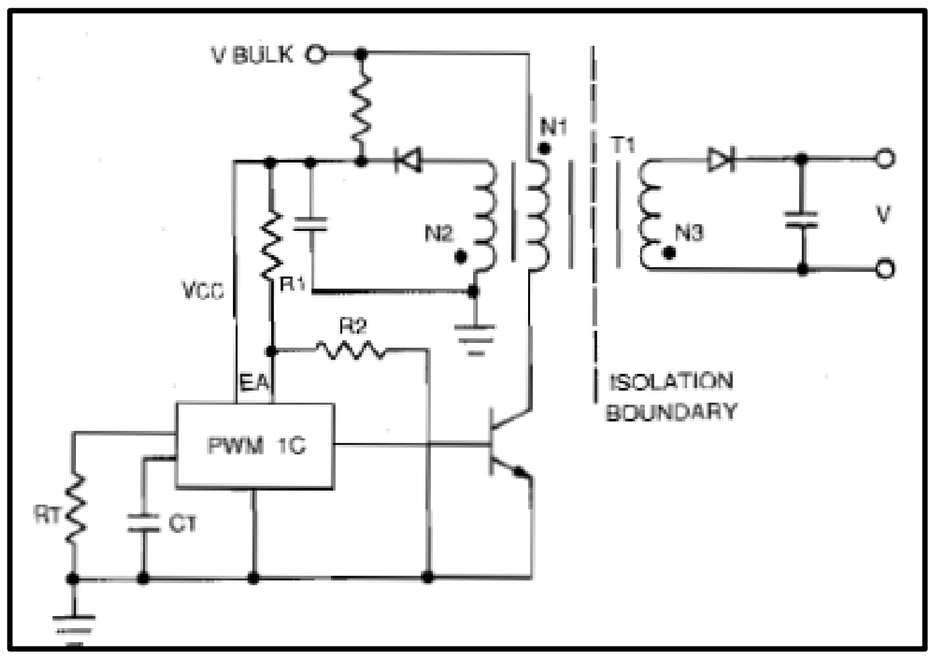

Figure 2. Flyback converter with auxiliary winding (N2) for primary-side sensing [1]. Secondary winding is denoted with N3.

Design Assessment and Preliminary Simulation Results

- Initial assessment: To obtain high accuracy, diode voltage drops at the secondary and auxiliary loop must be closely matched and transformer windings must be well coupled.
- Simulation results shown in Figure 3 supports the use of primary-side sensing via an auxiliary winding. The load capacitor is regulated to 3.5 kV by tracking the output voltage at the auxiliary loop.

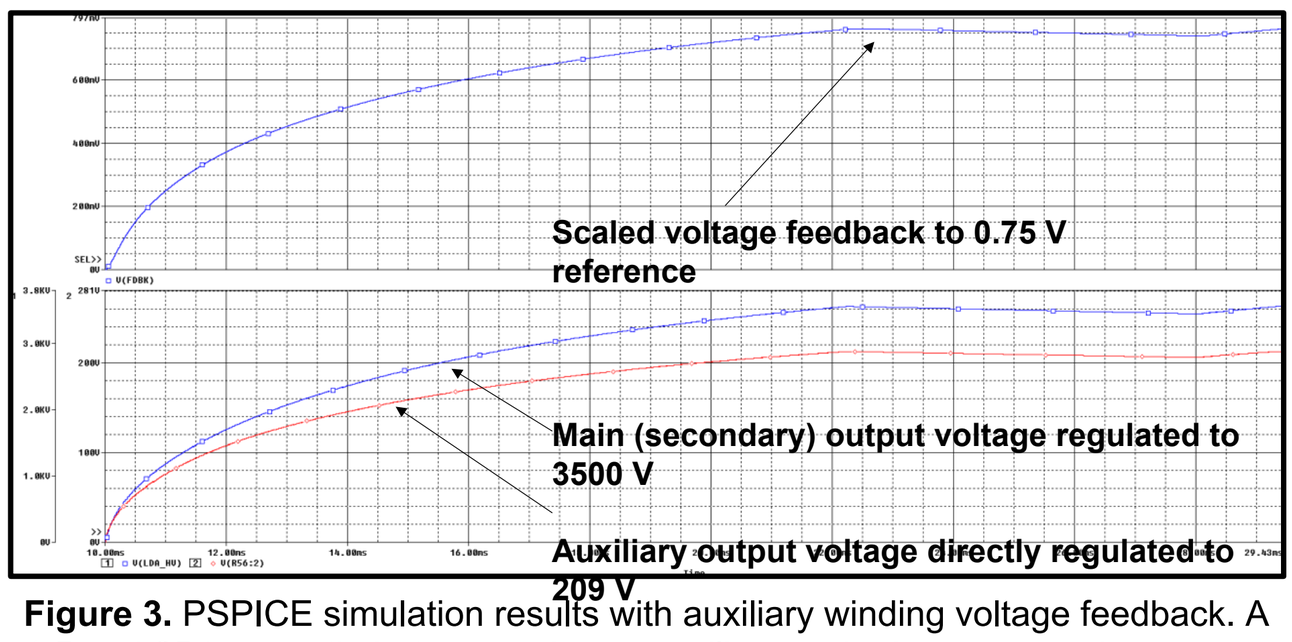

Figure 3. PSPICE simulation results with auxiliary winding voltage feedback. A 1.5 and 25 turns-ratio between primary-auxiliary and primary-secondary was used, respectively. Notice that the auxiliary voltage reaches 209 V when C_L reaches 3500 V. Resistor divider values are set so that C_L voltage is regulated at 3500 V.

<u>Alternative Designs Assessment</u>

- All alternative designs listed below will initially involve use of commercial system-on-chip parts (COTS SOC) that might not meet requirements for radiation tolerance. *Thus, the most realizable design option in the short-term is primary-side sensing via an auxiliary winding, which does not use COTS SOC.*

Primary-side Sensing by Monitoring Drain-Source Voltage (Vds) of FET:

- Vds must be sampled when no current is flowing through secondary winding. Requires integrated circuit with current mirror and oscillator.

Feedback via an Optocoupler:

- Potential issues are device aging, low bandwidth, and high variations in current-transfer ratio. This method will involve many additional components which increases areas of potential breakdown.

Feedback via an Isolation Transformer:

- Transformers can only transmit AC signals, so this method will require carrier modulation to transmit DC signal from the load capacitor over to the PWM controller at the primary-side.

Work Referenced:
[1] “Isolating the Control Loop,” Texas Instruments Incorporated, Dallas, Texas, Tech Rep., 2011

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