1 Block Diagram
2 Featured Circuit Schematic: GaN Stage Converter
Calculation: Switch Frequency for a Buck Converter

For \( Q \) on, \( Q' \) off

\[ V_{in} - V_o = V_L \]

For \( Q' \) on, \( Q' \) off

\[ V_o = V_L \]

\[ \frac{(V_{in}-V_o)D}{f_{sw}} = V_o \left(1 - \frac{D}{f_{sw}}\right) \]

\[ (V_{in} - V_o)D = V_o - V_o D \]

\[ D_{vin} = V_o \]

\[ \frac{V_o}{V_{in}} = D \]
4 Simulation Plot: Buck Converter
5  Featured Block Description: 2\textsuperscript{nd} Stage Stepdown (GaN)

Since the first stage is primary side regulated and isolated, the control isn't as fast and the output isn't as clean as it should be for a bench supply. The 2nd stage uses a buck design to lower the voltage again to the final output, but with a faster response since it doesn't use opto-isolator or transformer. This stage uses GaN transistors to further improve the output characteristics by allowing a faster switching frequency. GaN transistors have lower gate capacitance than MOSFETs so they can switch on and off faster without as much switching loss. Higher switching frequency allows us to use smaller capacitors, which is important in constant current mode. In constant current mode, if a device suddenly draws much more current than the set-point, the output capacitors can discharge themselves through the device bypassing the current control. With higher frequency transistors, the microcontroller can control the output precisely without as much of an output filter. This also allows for smaller inductors, providing faster transient response.

Specifications: 2 MHz switching frequency, 200 W, 0 – 40 V, 5 A

6  Requirements & Verification for Featured Module

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<th>Module</th>
<th>Requirement</th>
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<tr>
<td>2\textsuperscript{nd} Stage (GaN) Stepdown</td>
<td>Output must be within 1% of voltage set point</td>
<td>Power 2nd stage input from an external DC power supply. Power 3.3 V line from an external DC supply. Program microcontroller to set test output of 10V. Verify with an oscilloscope that open circuit voltage of the output is 10V ± 1%. Connect 10 Ω resistor across the outputs. Verify that the voltage is still within range after at least 1 ms from connecting the load.</td>
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<td>Connect power as in part a. Program the microcontroller to set test output of 10V with a current limit of .5A. Check with the current measurement function of a multimeter that the current is .5A ± 3%.</td>
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7 Safety Statement

In building a power supply, we recognize that there are inherent precautions that we have to consider in order to ensure our own safety and that of others using the design lab. Potential risks from such a project include electric shocks from using 120VAC power and fire from short circuits or component failure. We will make sure that all components are within their voltage and current ratings to prevent them from failing. We will use a thermal fuse to prevent fires in the case of short circuits. We will also make sure that all hardware components are secure and that all high voltage areas of the circuit are barred from the experimenter. We realize that even in areas of low voltage, large power output is possible, so we will have the microcontroller programmed for overcurrent shutdown to prevent fire and smoke. We will provide transformer isolation for all user outputs to protect from hazards on the AC line.

8 Citations

