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Power supply design optimises capacitors

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Microprocessor-based devices require a regulated power supply unit that detects the loss of input power and continues to supply power for the length of time it takes to complete a memory backup.

One approach to designing for continuous power is to generate a higher output voltage and use a linear regulator to produce the lower voltage actually required. The capacitance at the input of the linear regulator is used to provide the hold-up time.

Unfortunately, this approach degrades the overall power supply efficiency because it requires a secondary linear regulator. This drives the need for a bigger transformer and larger components with a higher power rating on the primary side of the power supply circuit.

Another technique is 'on-time extension' which can be combined in ICs with an on/off control function to provide voltage regulation. The two techniques replace conventional pulse-width modulation (PWM) control and eliminate the need for some additional circuitry.

Memory backup power requirements
Applications that require critical data to be stored prior to shutdown frequently use EEPROM memory and require a regulated supply voltage to be available for the time it takes to complete the memory write cycles.

A standard practice to provide adequate write cycle time is to reduce power consumption during the power-down sequence by turning off any peripherals and non-essential additional loads. The power converter stage needs to use energy stored in the input filter capacitor to maintain the output voltage within regulation limits.

The flyback converter is the topology of choice for most low power applications and two versions allow us to see the effectiveness of on-time extension and its impact on capacitor selection: DCMFF (discontinuous conduction mode – fixed frequency) converter versus an on-time extension implementation of a DCMDE (discontinuous conduction mode – duty cycle extension) converter.

The 21.25W designs are assumed to operate at 100kHz. The same transformer is used for both designs and the value of the primary inductance has been calculated to reach a peak current of 1A maximum with a 50 per cent duty cycle at the minimum DC bus voltage of 100Vdc.

Power delivery at reduced input voltages
From these designs, it can be shown that the on-time extension scheme can enable the power converter to deliver much higher power at lower input voltages compared to a DCMFF design.

For a 50 per cent load on the output, the DCMFF converter can maintain regulation down to a bus voltage of approximately 69Vdc, whereas the DCMDE converter can maintain regulation to a voltage as low as 31.5V. The DCMDE method therefore enables the power supply to provide a much longer hold-up time for memory backup operation and makes better use of the stored energy in the input capacitor.

Input DC bus filter capacitance
The DC bus filter capacitor helps maintain the input voltage seen by the converter stage to a value equal to or higher than Vmin. A value of 90Vdc or 100Vdc is an optimum choice for the converter's minimum DC bus voltage.

Further reduction in the value of Vmin can help in reducing the value of the capacitance required at input, but this also results in significantly higher peak currents in the primary winding and requires over sizing of the switching elements in the circuit.

If a switching power supply has to remain in operation and provide regulated output voltage during periods of disturbance, its input capacitor must be selected to allow for a minimum input RMS voltage of 30 per cent below nominal.

For a 20W universal input power supply, designed to operate at a DC bus voltage as low as 100Vdc and operating at frequencies as low as 47Hz, the value of the input capacitor for normal operation will be approximately 100µF, assuming over 85 per cent efficiency.

If the regulated supply must be available for at least 35ms after input supply failure, then sufficient energy must be available in the capacitor required for completing power-down sequence.

If the load required during memory backup is 10W and the power supply uses a fixed 100kHz controller with a maximum duty cycle of 50 per cent, the required capacitor value will be 172µF.

If the power supply is modified to use on-time extension, the required capacitor value is reduced to 100µF. Therefore, the input capacitor will not have to be upsized to meet the extended power requirement.

Limitations of on-time extension
Though on-time extension can significantly improve the power delivery of a flyback power supply, care must be taken to ensure that the supply is not required to operate with extended on-time indefinitely. Any increase in on-time beyond normal limits will increase RMS currents and therefore power dissipation in both the Mosfet and the primary windings.

Power supplies need correctly sized input capacitors to ensure satisfactory operation during power-line disturbances. They are also needed to provide regulated supply for a sufficient amount of time after input failure is detected to allow for storage of critical data during shut down.

The size of the input capacitor for this application can be reduced significantly if an integrated switcher featuring on-time extension is used.

The DCMFF technique (without on-time extension) needs a higher input voltage to deliver the same amount of power as the DCMDE technique (with on-time extension), especially when operating below the design's minimum DC voltage.

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