Buck-Boost Converters Solving Power Challenges in Optical Modules

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This application note gives a short introduction to optical modules and the need of an optimized power tree in them and then concentrates on the use cases and benefits of four-switch and inverting buck-boost converters inside optical modules.

Introduction to the Importance of the Power Tree in Optical Modules

An optical module translates electrical into optical information and back. The optical information is transmitted through a fiber optic cable which has the advantage of supporting high data rates at minimized latency. Especially for high data rates and long distances an optimized power tree design helps to increase data rates, avoid data corruption, stay within the available power budget or reduce the power consumption, and make the module more robust against external influences.

In several instances in the power tree, four-switch or inverting buck-boost converters are a good solution to achieve these targets.

Power Tree of an Optical Module

Figure 1 is an example block diagram of how all the necessary blocks in an optical module can be powered. Not all necessary power supplies are shown in detail, but it gives a good overview. The use cases for buck-boost converters are highlighted in red.

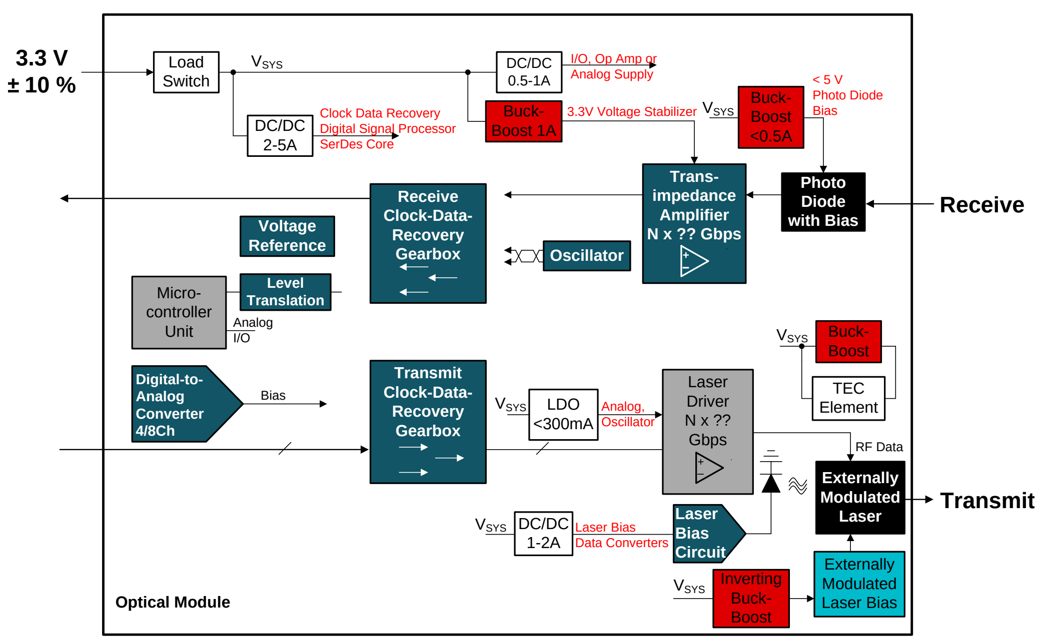

Figure 1. Block Diagram Example of an Optical Module

Application of Buck-Boost Converters in Optical Modules

An important feature of four-switch buck-boost converters is the true disconnection of the input from the output voltage during shutdown due to the high-side switches before and after the inductor with their parasitic back-gate diode connected back to back. Especially at hot-plugging, a true disconnect enables voltage sequencing without any hiccups.

Below, you can find more details on the four highlighted examples for the use of buck-boost converters in optical modules.

1. Voltage Stabilizer

Optical modules are normally supplied from 3.3 V. Since these modules can be hot plugged, you need to limit the inrush current, which is often achieved via a load switch. Load switches are typically low resistance transistors, but nevertheless, there is some voltage drop across them. The trans-impedance amplifier (TIA) on the receive side of the optical module is normally supplied by 3.3 V, but due to the initial inaccuracy of +/-10% on the 3.3-V supply of the optical module and the voltage drop on the load switch, this supply might not be accurate enough to guarantee the functionality and performance of the TIA.

A 4-switch buck-boost converter is a simple solution for improving the accuracy of a given power supply. The *Use Buck-boost Converter for Voltage Stabilization Application Note* gives the details on selection criteria.

2. Bias Supply of Photo Diode

The supply voltage of the photo diode on the receiving side of the optical module is in the range of 3.5 V to 5 V. If the photo diode is supplied directly from the input of 3.3 V +/-10% (2.97 V – 3.63 V) the maximum input voltage is higher than the minimum output voltage, at which point a boost converter even with bypass cannot regulate. Buck-boost converters regulate properly, even when the input voltage is very close to the output voltage, which is the benefit over boost or buck converters.

In addition, the voltage might need to be adapted to the current temperature or power dissipation in the system, therefore, a simple way to change the output voltage of the used DC/DC converter is appreciated. In the *TEC Driver Reference Design for 3.3 V Inputs*, a simple way to adapt the output voltage of a buck-boost converter with a PWM signal from the microcontroller is described in detail.

3. Negative Supply for the Externally Modulated Laser (EML)

An externally modulated laser consists of an electro-absorption modulator (EAM) and a laser diode supplied by a constant current. The bias voltage on the EAM is typically a negative voltage between -2.5 V and -5 V. A classic inverting buck-boost converter is used to convert the positive 3.3 V input voltage of the optical module in the negative supply of the EAM used to modulate the laser diode frequency.

The *AN-2264 LMR70503 Demo Board User Guide* shows a very simple way to change the output voltage if necessary. For example, it shows how to reduce power dissipation if the full voltage span is not necessary on the modulator bias supply.

4. Thermo-electric Cooling (TEC) for the EML

EMLs are often optimized for a specific operating temperature to maximize transmission speed and/or distance. A TEC module can be used to keep the EML operating temperature constant. TEC modules use the Peltier effect to transfer the heat from one side of the module to the other side. This second side needs to be connected to a heat sink as thermal dissipating element.

The *TEC Driver Reference Design for 3.3 V Inputs* illustrates a way to keep the temperature on one side of a TEC element constant. The TEC element is connected to the TPS63802 between the 3.3 V input and the output voltage which can be adapted through a PWM signal coming from the microcontroller (the microcontroller already available in the optical module can be used). The microcontroller gets the temperature information through a negative-temperature-coefficient resistor thermally connected to the regulated side of the TEC element and adjusts the PWM signal to increase or reduce the output voltage of the TPS63802. The input to output voltage ratio defines if the current through the TEC module is heating or cooling the side connected to the EML.

Summary

Buck-boost converters can be used to help increase the transmission and receiving speed or distance through stabilizing the supply voltages of different parts of the optical module. As the amount of data transferred inside server farms, between computers, from computers to storage elements, as well as around the world, increases, the use of buck-boost converters can help to reduce the power dissipation per data package in these applications, keeping the total power consumption within the available power budget.

References

- *TPS63802 2-A, High-Efficient, Low IQ Buck-Boost Converter with Small Solution Size Data Sheet* (SLVSEU9)
- *TPS6302x High Efficiency Single Inductor Buck-boost Converter with 4-A Switches Data Sheet* (SLVS916)
- *Use Buck-boost Converter for Voltage Stabilization Application Note* (SLVAEA2)
- *AN-2264 LMR70503 Demo Board User Guide* (SNVU155)
- *TEC Driver Reference Design for 3.3 V Inputs* (TIDA-050017)
- *A Cost-effective 25-Gb/s EML TOSA Using All-in-one FPCB Wiring and Metal Optical Bench*, Young-Tak Han, Oh-Kee Kwon, Dong-Hun Lee, Chul-Wook Lee, Young-Ahn Leem, Jang-Uk Shin, Sang-Ho Park, and Yongsoon Baek, ©2013 Optical Society of America
- *100GBE- OPTICAL LAN TECHNOLOGIES*, Chris Cole, David Allouche, Frank Flens, Bernd Huebner, and Thelinh Nguyen, Finisar Corp., December 2017

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