Application Note

Optical Power Components

Optimizing Optical Power Converter Output

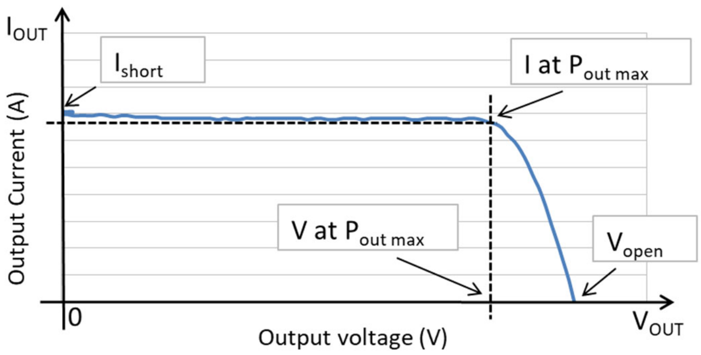
Introduction

To address the growing need for powering sensors in high-voltage and magnetic-field environments, Broadcom® offers a unique and enabling optical power converter, OPC. The device converts laser light, typically delivered over optical fiber, which is 100% immune to external electromagnetic noise. The resulting power is more than adequate for most electronic sensors, as well as data links, that provide high-speed information from the sensor. With the increasing use of composite materials, conventional shielding is no longer guaranteed, and power-over-fiber is entering new application areas as the most convenient and reliable solution to achieve full galvanic isolation. Batteries often serve as a preferred "electrically isolated power source" in combination with data transmission over optical fiber. The OPC is capable of trickle-charging a battery, but most frequently, the battery can be eliminated and replaced by this emerging technology.

Optical Power Converter – the Fundamentals

The OPC is a photovoltaic semiconductor device, similar to a solar cell, but designed to convert high-intensity light, typically from a laser, into useful electrical power. The OPI is a current generator in parallel with a diode exhibiting the same current-voltage behavior as a solar cell. Under load, the device is forward-biased, leading to a current opposing the light-generated current. At a high enough voltage, the two opposing currents balance. This is the open-circuit voltage point, shown as Vopen in Figure 1. At a somewhat lower voltage, the product of the voltage and current reaches its maximum, $P_{out\ max}$. Just as with any solar cell, this value, divided by the input light power, defines the conversion efficiency. Due to the monochromatic nature of the laser light, no light is lost, and the conversion efficiency is double, or even triple, that of most solar cells.

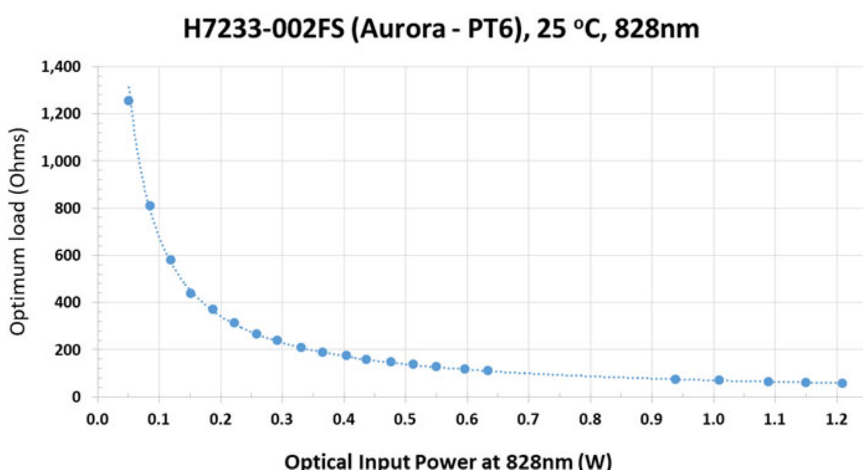
Figure 1: OPC Current-Voltage Characteristics



For a given laser light illumination level, the $P_{out\ max}$ is a unique point at which the power output is maximized. At that point, there is only one particular combination of current and voltage and therefore, only one optimum load resistance. Hence, if an application has a varying load, the power converter will not be optimized, certainly not all the time. This is shown in Figure 2, which depicts a series of optimum load resistance values as a function of incident laser light power. This is effectively the impedance versus the laser light behavior of the optical power converter.

Given this unique nature of photovoltaic devices, the challenge faced by a design engineer incorporating the OPC as a power source is two-fold: (a) regulating the voltage and (b) operating at, or close to, $P_{out\ max}$. Voltage regulator ICs, buck as well as boost mode, can readily provide the proper voltage, typically 5.0V or 3.3V. As for tracking the maximum power point, MPPT, also sometimes called energy harvesting, recently developed ICs are now available from Linear Technology and Texas Instruments. They are intended for solar cell optimization, and also work well for power converters as will be described in a future application note.

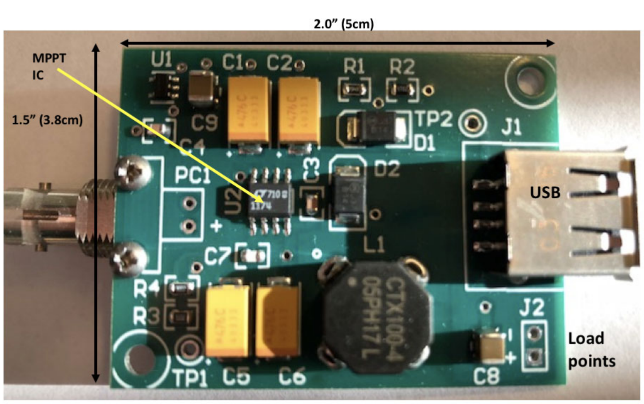
Figure 2: OPC Optimum Load Resistance versus Laser Light Input Power



Regulating the OPC Power Output

A simple circuit incorporating a buck/boost is shown in Figure 3 (for the reference design, contact Broadcom). Here, it serves as a buck converter ensuring that a fixed voltage, in this case 5V, is maintained. The combination with the LT1174 ensures the most optimum operation. Broadcom is willing to share details of this generic buck converter design upon request.

Figure 3: Voltage Regulator Optimized for OPC Operation



Summary

Broadcom's family of optical power converters, AFBR-POCxxx, provide 100% galvanic isolation for power delivery over optical fiber. In many cases, a regulated voltage is preferred along with the most optimum operating conditions. Implementing a commercially available buck voltage regulator results in a fixed voltage output from the OPC. The current delivered is solely determined by the input laser light. With 1.5W of laser light incident on the POC, up to 120 mA of current can be extracted at an operating voltage of 5.0V and a total power delivery of 600 mW. A future application note will describe a circuit design involving feedback from the POC to the laser enabling the laser current to be optimized to provide just the right amount of light and avoid overdriving the laser. This is the ultimate form of energy harvesting while also ensuring the most optimum operating conditions.