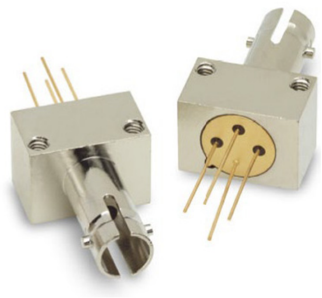
BROADCOM®

Data Sheet

AFBR-POC306A5

Optical Power Converter: 975 nm, 3W, ST Port



Description

The AFBR-POC306A5 belongs to the Broadcom® Power Components product family. The device converts optical power to electrical power for applications that require complete electrical isolation in highly demanding industrial environments. It is an excellent choice for powering electronic circuitry where electrical wired solutions are not feasible due to high voltage, electromagnetic interference, or strong magnetic fields.

The AFBR-POC306A5 is based on the patented Vertically Integrated 'VEHSA' Monolithic GaAs Power Converter, covering wavelengths from 960 nm to 990 nm at voltage output levels of up to 5 VDC for a range of applications.

The AFBR-POC306A5 provides up to 3 watts of electrical power by converting optical input power from a high-power laser diode at, for example, an output wavelength of ~980 nm. The device shows a nearly linear response to high optical input power over a wide temperature range.

Smart thermal design simplifies system integration.

The AFBR-POC306A5 is optimized for integration with efficient coupling of multimode (MM) fibers with various numerical apertures (0.2 < NA < 0.28) and core diameters (50 µm to 400 µm). The AFBR-POC306A5 is available with an optimal response peaking between 960 nm to 990 nm. The device will still operate at 940 nm but with a somewhat reduced conversion efficiency.

Features

- RoHS compliant
- Fully isolated power over fiber (PoF) solution that efficiently converts optical power to electrical power
- Electrical output power up to 3W
- Operating case temperature range: –40°C to +85°C
- ST optical port for use with MM fibers with an NA of ~ 0.22 and a wide range of fiber core diameters
- Easy heat sink mounting for thermal management
- Ideal for pairing with the wide variety of 980-nm lasers developed for Telecom and other applications and renowned for their extended lifetimes and dependability

Applications

The following are typical fields of application for the optical power converter (OPC):

- High-voltage current sensors and instrument transformers
- E-Field and H-Field probes (aka optical probes)
- 100% galvanically isolated powering of gate drivers for high-voltage IGBTs and SiC MOSFETs
- Power conditioning circuitry
- Wireless transmitters
- Isolation transformers for breaking switches

Package

The AFBR-POC306A5 is packaged in a medium brass 4-pin package for board mounting with standard heatsink technology for thermal management.

The RoHS-compliance package can be integrated with various solutions.

The #2-56 tapped screw holes allow easy board mount integration with flexible geometries for fast and secure connection to standard ST optical connectors.

Handling Information

CAUTION! The pn-junctions in the design of these components increase the components' susceptibility to damage from electrostatic discharge (ESD). Take appropriate static precautions in handling and assembling these components to prevent damage, degradation, or both that may be induced by ESD.

Good system performance requires clean port optics and cable ferrules to avoid obstructing the optical path. The optic components are hermetically sealed in a TO header with a glass window.

Any particles of dirt in the optical path can reduce the conversion efficiency.

Do not attempt to focus the input light onto the device surface. Focused light can burn and irreversibly damage the device.

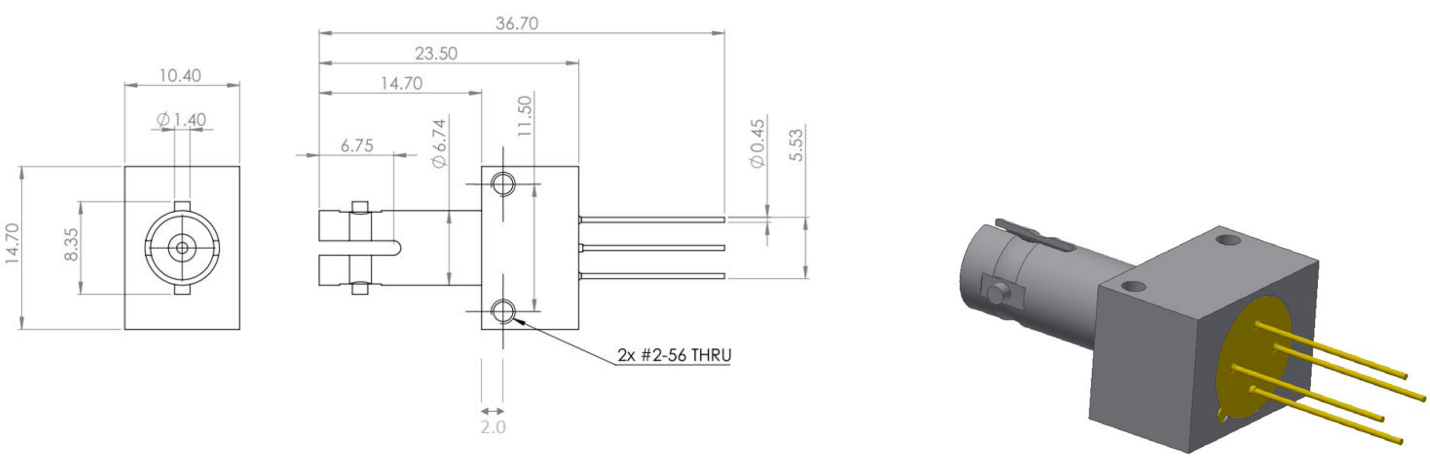
As a general rule, it is recommended to attach the photo-converter units to the board after soldering the other components.

The AFBR-POC306A5 is a photovoltaic device.

Do not apply external voltage to the device.

Mechanical Dimensions – ST Port

Figure 1: AFBR-POC3xxAx (4 Pins)



NOTE: Dimensions are in mm.

Regulatory Compliance

Feature	Test Method	Performance
Electrostatic Discharge (ESD) to the Electrical Pins Human Body Model	ESDA/JEDEC – JS-001-2012	Min. ± 750V (Other similar product variants are typically min. ± 750V.)

CAUTION! The pn-junctions in the design of these components are susceptible to damage from electrostatic discharge (ESD). It is advised that precautions be taken in handling these components to prevent damage and/or degradation that may be induced by ESD.

Assembly Process and Compatibility

Parameter	Symbol	Min.	Typ.	Max.	Unit
Solder Environment	T_{SOLD}	—	—	260[a]	°C
	t_{SOLD}	—	—	10[b]	sec

a. Maximum temperature refers to peak temperature.

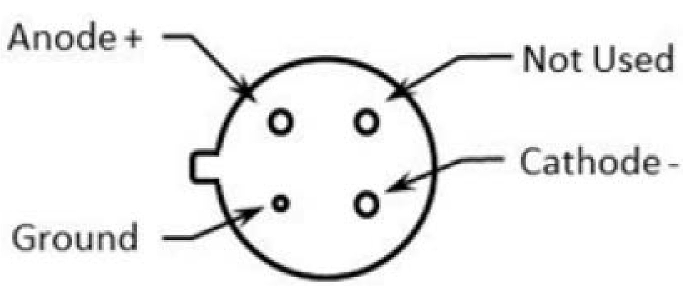
b. Maximum time refers to time spent at peak temperature.

The device can be secured with #2-56 screws for easy integration with the power board and the chosen heatsink design.

Sufficient heatsink performance is highly recommended to avoid high operating temperatures and to maintain good performance. It is also recommended to select a good-performing thermal interface material (TIM) to mount the device on the heatsink. For example, at 7W of input power with an external load utilizing one half of the input power, a heatsink performance of better than 10°C/W is required to maintain a chip temperature of 35°C above ambient.

Pin Description

Figure 2: AFBR-POC3xxAx (ST Port, 4 Pins) – Backside View



Details about the AFBR-POC306A5

The AFBR-POC306A5 is a photovoltaic device.

The device is a multi-junction compound semiconductor, which works as a power source without applying external bias while providing electrical power to a load when illuminated. Unlike a standard photovoltaic device, such as a solar cell, which is a large semiconductor pn-junction, the power converter is small. Typically, the device is illuminated by light emanating from an optical fiber; therefore the light is highly concentrated. The AFBR-POC306A5 devices are uniquely designed to handle these concentrated light levels, which helps to maintain high output of both voltage and current.

Do not apply external voltage to the device.

The Anode "+" and Cathode "-" indicate the current flow from "+" to "-" when a load is connected to the pins and light is coupled into the device.

The AFBR-POC306A5 operates without applying additional external voltage.

Use of voltage regulators is recommended for a stable, efficient, and controlled power extraction from the AFBR-POC306A5.

Typically, photovoltaic devices, such as solar cells, do not have a continuous operating point. To reach the highest conversion performance, the load must be adapted accordingly. This adjustment is primarily due to the influence of the optical input power to the device output. Therefore, a fixed load power extraction is not an optimal method for power harvesting with solar cells.

Conversely, the Broadcom optical power converters operate with controllable laser light coupled into optical fiber, which results in stabilized output of the AFBR-POC306A5 device. For most applications, combining the device with a voltage regulator, such as a DC/DC converter, is sufficient. Integration of ICs that provide automatic maximum power point tracking (MPPT) can be done but is typically not needed.

Figure 3: Illustration of an I-V Curve of Optical Power Converters

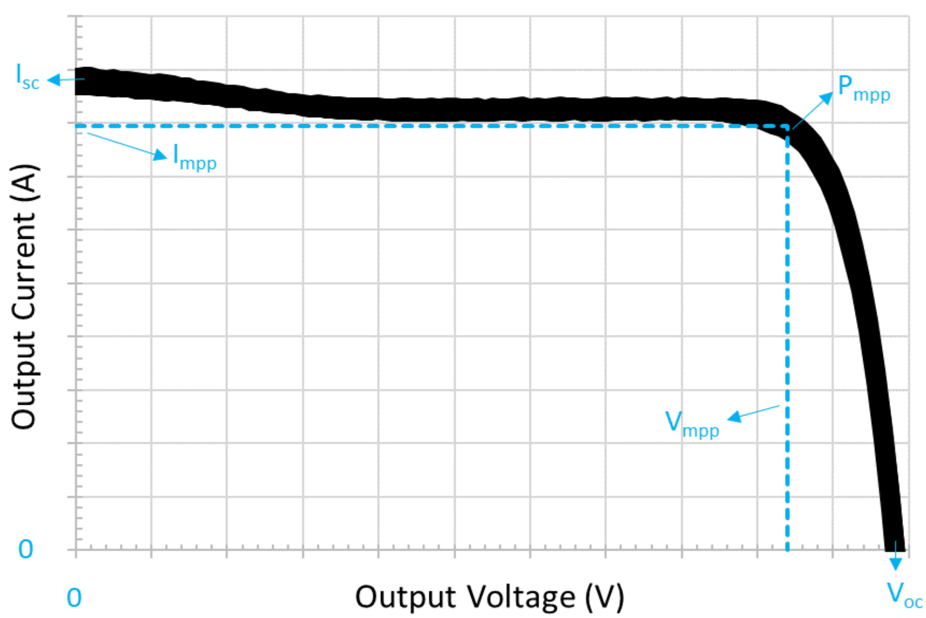


Figure 3 illustrates the output current vs. output voltage characteristics of a typical optical power converter. At short circuit, the current output (I_{sc}) is at its maximum, but no power is delivered. At open circuit (V_{oc}), the voltage is at its maximum; however, no power can be extracted. In between, a maximum power point exists (P_{mpp}), which is the product of the current (I_{mpp}) and the voltage (V_{mpp}) at that specific point. Ideally, the external load should be tailored to allow the device to operate near V_{mpp} and I_{mpp}, that is, for a load $R_{mpp} \sim V_{mpp}/I_{mpp}$. Note that R_{mpp} will vary with the input power (P_{in}).

Absolute Maximum Ratings

Absolute maximum ratings are those values beyond which damage to the device may occur if these limits are exceeded other than for a short period of time.

Parameter	Symbol	Min.	Typ.	Max.	Unit
Storage Temperature	T_S	–40	25	85	°C
Operating Case Temperature	T_C	–40	—	90	°C
Relative Humidity	RH	5	—	95	%
Maximum Optical Input Power[a] AFBR-POC306A5	$P_{opt\ IN}$	—	—	7	W

a. Proper heatsinking is highly recommended. Lower-performance heatsinking can affect the maximum optical input power value because the operating case temperature can be exceeded at higher powers if the heatsink design does not properly extract the excess heat.

Fiber Specifications

The input fiber should be protected by a sleeve or ceramic ferrule during handling.

Parameter	Symbol	Min.	Typ.	Max.	Unit
Core Diameter[a]	D	—	Typically no significant impact between 40 µm and > 400 µm	—	µm
Numerical Aperture[b]	NA	0.20	0.22	0.28	—
Fiber Length[c]	—	—	Application specific	—	meter

a. The device typically performs well with most types of fiber; and there is a lot of flexibility on the choice of the input fiber minimum and maximum fiber core diameter that can be used with AFBR-POCxxx products. The device performance is more specifically linked to the fiber's numerical aperture value rather than the core diameter choice. Typically, fibers with a core diameter from 40 µm to 400 µm match with the specified NA range (0.2 to 0.28).

b. NA values smaller than 0.22 can result in lower than optimal output power for the higher input power conditions near the specified maximum optical input power. Conversely, if the NA is too large, part of the beam may hit outside the chip aperture inside the device and the performance may decrease due to lower currents (wasted input optical power ending up outside the clear aperture). It is worth noting that the actual laser diode NA might be different than its nominal NA if the laser fiber pigtail is relatively short (Laser diodes with nominal fiber NA = 0.22 are sometimes observed to actually have an NA closer to 0.1x for 1m or 2m pigtails).

c. Fiber length depends on application requirements and mainly depends on specific fiber attenuation.
As an example, a typical GI-MM 62.5/125-µm fiber has an attenuation of around 3.5 dB/km at 830 nm.

Operating Characteristics

All specified parameters are valid for operations at a case temperature of 25°C.[a]

Parameter	Symbol	Min.	Typ.[b]	Max.	Unit
Recommended Optical Input Spectrum Range[c]	λ_{IN}	960	975[d]	990	nm
Optical Input Power = 3.0W					
Maximum Electrical Output Power[e]	P_{out}	—	1.4	—	W
Output Voltage at Maximum Electrical Output Power	V_{OUT}	—	4.6	—	V
Output Current at Maximum Electrical Output Power	I_{OUT}	—	0.3	—	A
Optical Input Power = 7.0W					
Maximum Electrical Output Power[e]	P_{out}	—	3.0	—	W
Output Voltage at Maximum Electrical Output Power	V_{OUT}	—	4.3	—	V
Output Current at Maximum Electrical Output Power	I_{OUT}	—	0.7	—	A

a. Insufficient heatsinking can result in lower device performance due to increased case and device temperatures. Quick testing at the start of illumination or in pulse mode is a good method to confirm that the heatsinking is adequate.

b. Typical values are average values *measured at a 25°C case temperature*.

c. The product can be safely used outside the recommended range, but the performance will be lower.

d. The AFBR-POC306A5 is normally optimized around a spectral input of 975 nm by default. The device will still operate at 940 nm, but with a reduced conversion efficiency.

e. Verified with light emitted by a laser at 975 nm coupled into an MM fiber with an NA = 0.22. Power measured with a large area detector at the output of the fiber.

Figure 4: Current/Voltage Behavior for 3W Optical Input at 975 nm for the AFBR-POC306A5 at a Case Temperature of 25°C

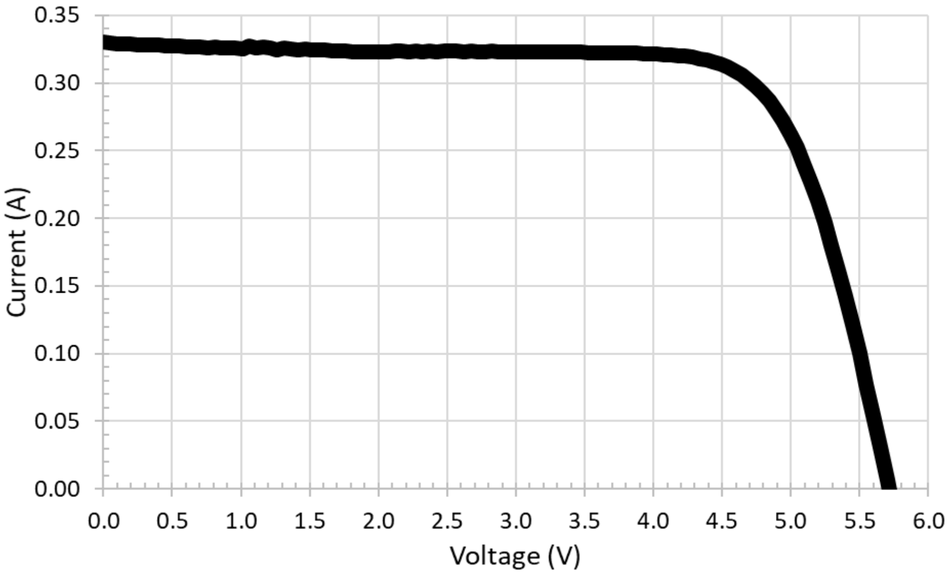


Figure 5: Current/Voltage Behavior for 7W Optical Input at 975 nm for the AFBR-POC306A5 at a Case Temperature of 25°C

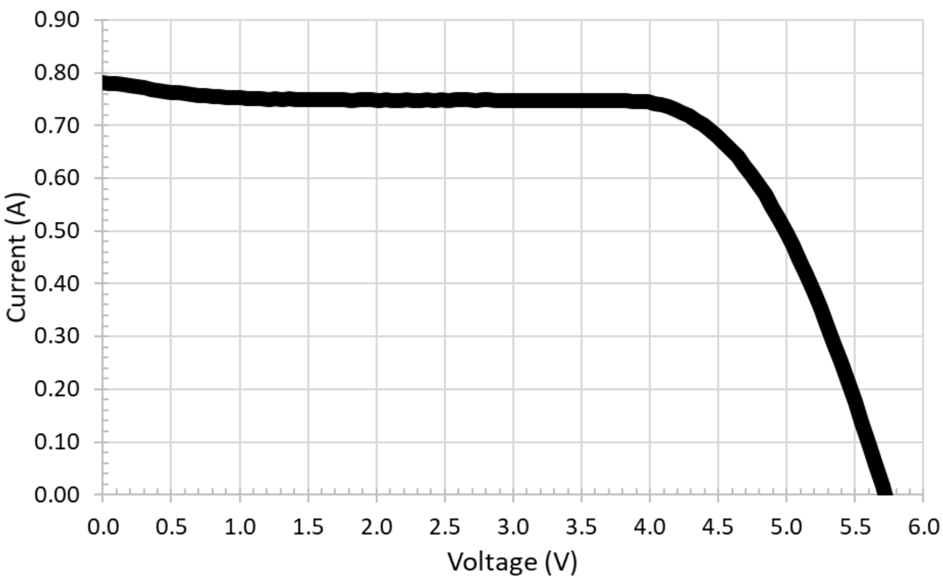
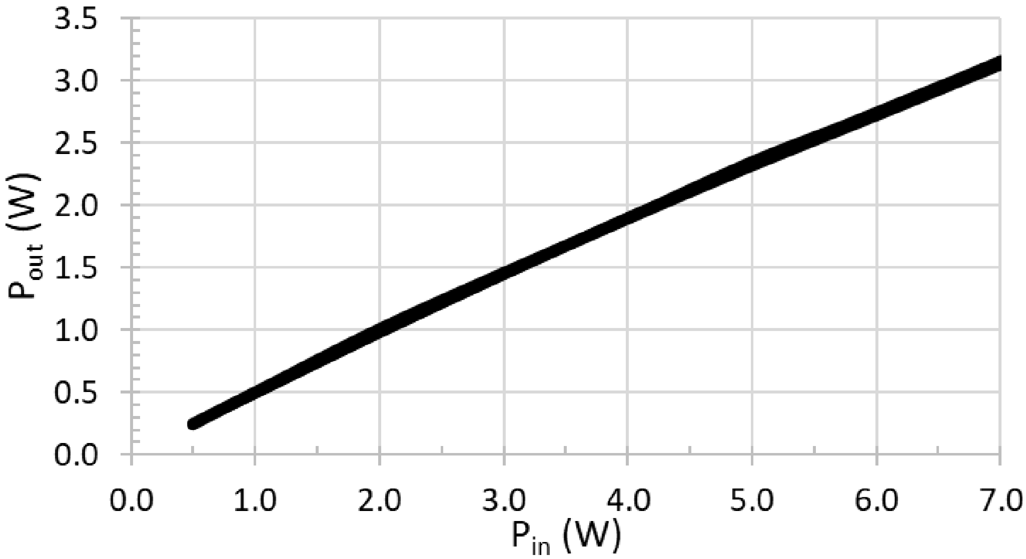


Figure 6: Input Power Dependence of the Maximum Power Point Output Power (P_{mpp} or Optimal P_{out}) at a Case Temperature of 25°C for P_{in} at 975 nm for the AFBR-POC306A5



Broadcom uniquely offers multi-junction OPC products with manageable optimal external loads, whereas single-junction devices require optimal loads R_{mpp} << 1 Ohms for such high output powers.

Figure 7: Optimal Load Value (R_{mpp}) at a Case Temperature of 25°C for the AFBR-POC306A5 vs Input Power at 975 nm

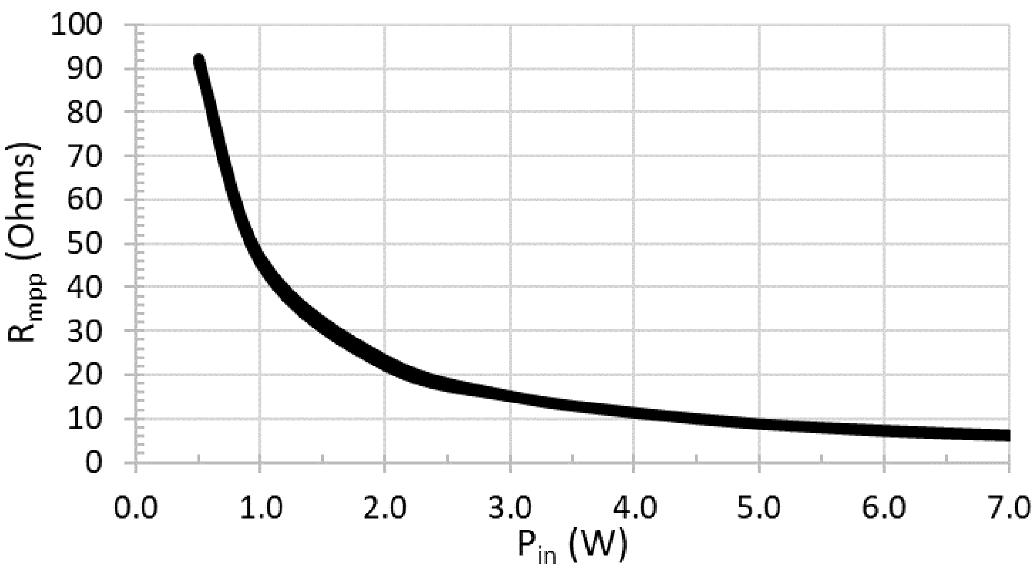


Figure 8: Output Voltage (V_{oc} & V_{mpp}) at a Case Temperature of 25°C for the AFBR-POC306A5 vs Input Power at 975 nm

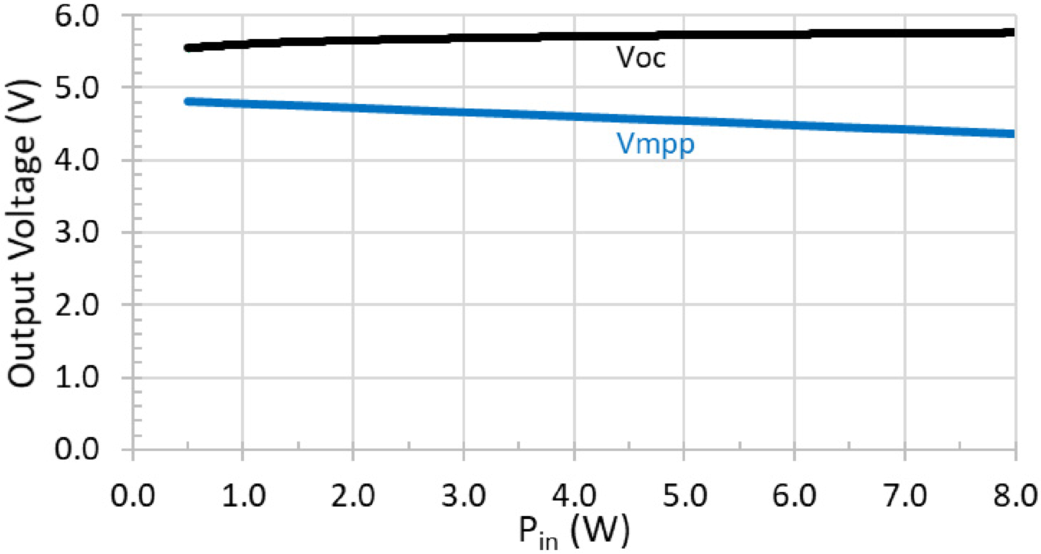


Figure 9: Output Current (I_{sc} & I_{mpp}) at a Case Temperature of 25°C for the AFBR-POC306A5 vs Input Power at 975 nm

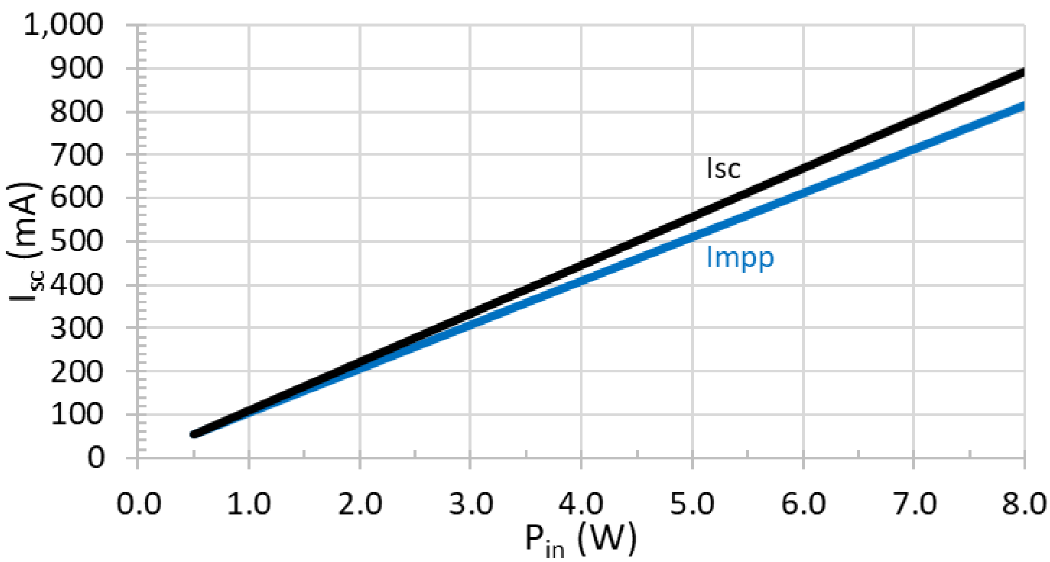


Figure 10: Output Power (P_{mpp}) vs Case Temperature for the AFBR-POC306A5 at 977 nm

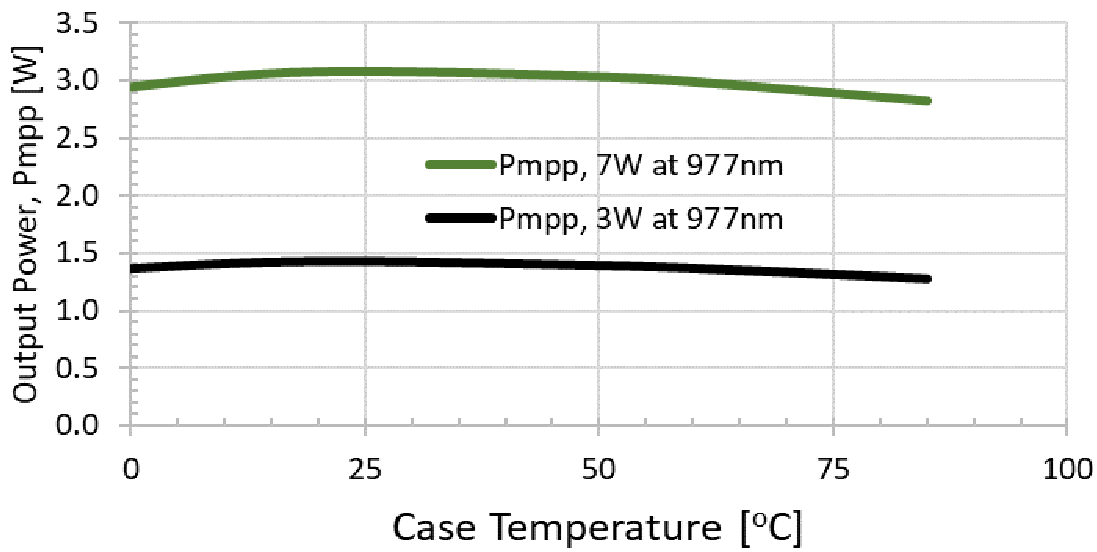


Figure 11: Optimal Load (R_{mpp}) vs Case Temperature for the AFBR-POC306A5 at 977 nm

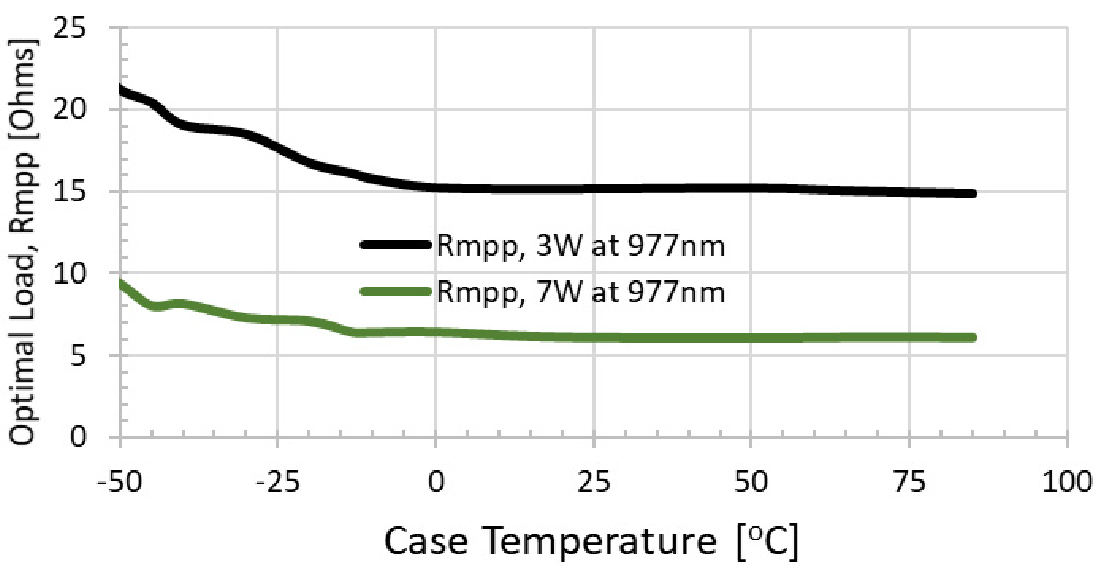


Figure 12: Output Voltage (V_{oc} & V_{mpp}) vs Case Temperature for the AFBR-POC306A5 at 977 nm

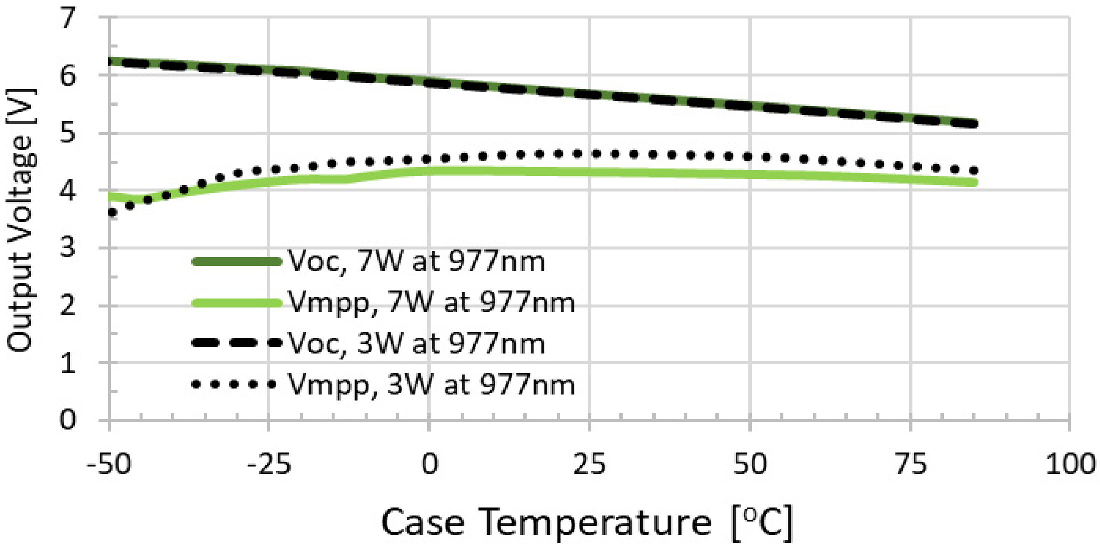


Figure 13: Output Current (I_{sc} & I_{mpp}) vs Case Temperature for the AFBR-POC306A5 at 977 nm

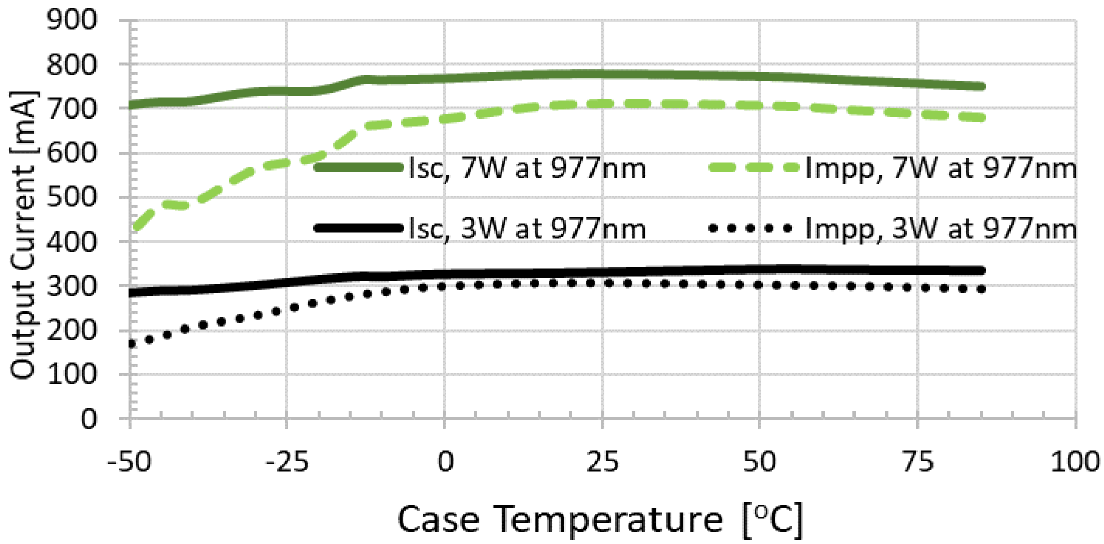


Table 1: Temperature Coefficients for the AFBR-POC306A5 for 7W of Input Power at 975 nm

Parameters (Medium Power PT6-97x)	**AFBR-POC306A5 7.0W – 97x nm**	**Comments**
P_{in} [W]	7	
Optimal Output Load Value [Ohms] (CW optical input, steady-state DC output)	6.0 (1)	(1) The optimal load depends on Pin and PTN values; Eff, I_{mpp}, V_{mpp}, and P_{mpp} are obtained near the optimal load value.
P_{mpp} at T_{case} = 25°C [W] (2)	3	(2) $T_{case} = T_{ambient}$ + Nonconverted Input Power (W) × Heatsink Performance (°C/W).
ΔEff/ΔT [abs% per °C]	–0.02	
$\Delta V_{mpp}/\Delta T$ [mV per °C]	–1.1	
$(\Delta V_{mpp}/\Delta T)/V_{mpp}$ [%]	–0.14	
$\Delta I_{mpp}/\Delta T$ [mA per °C]	–0.2	
$\Delta P_{mpp}/\Delta T$ [mW per °C]	–1.4	
$\Delta V_{oc}/\Delta T$ [mV per °C]	N/A	It is not recommended to run the device near I_{sc} or V_{oc} mode at P_{in} ~ 7W.
$\Delta I_{sc}/\Delta T$ [mA per °C]	N/A	It is not recommended to run the device near I_{sc} or V_{oc} mode at P_{in} ~ 7W.
Heatsink Performance Used [°C/W] (3)	6 to 10	(3) For indication purposes only; does not affect the preceding temperature coefficients.
Heatsink Type Used (3)	Passive, Aluminum fins	Thermal interface material with performance of 8.5W/(mK) was used for testing.
Max. Case Temperature [°C]	100 (4)	(4) It is recommended to adjust the heatsink performance to avoid extended operation durations with case temperatures above 95°C.
Fiber NA (5)	0.22	(5) NA values smaller than 0.22 can result in lower than optimal output power for the higher input power conditions near 6W.
Recommended Max. P_{in} [W]	7	
Fiber Connector	ST	
Package	Medium Brass	