



Critical Benefits of Cooled DFB Lasers for RF over Fiber Optics Transmission

Provided by

OPTICAL ZONU CORPORATION

Application Note

Cooled DFB Lasers in RF over Fiber Optics Applications

BENEFITS SUMMARY

- Practical 10 dB Improvement of SFDR
- Stable Gain over Full Operating Temperature Range
- Flat Frequency Response
- Higher IP3

DFB Laser with Integral TEC

Transmission of RF and Microwave Signals via waveguides or coaxial cable suffers high insertion loss and susceptibility to interference (EMI). Single Mode Fiber Optic Analog RF (aka RFoF) Transceivers provide an excellent alternative for this type of application. Fiber Optic transmission offers significant advantages for the reliable transport of RF signals in their native format over many types of optical networks and across a broad range of frequencies. For analog type signals, especially at high frequencies, in which premium performance at high Spurious Free Dynamic Range (SFDR) is desirable, there are but few methods to achieve this.

One method, which is relatively low cost and yields high performance, is to use an integral Thermoelectric Cooler (TEC) with DFB Lasers. This technology assures a high level of Laser stability and assures excellent RF performance, over a wide range of temperature variations, not otherwise possible. Optical Zonu RFoF links achieve such performance with the OZ1600 7 GHz Ultra Broadband RFoF Transceiver Module which utilizes state-of-the-art Ultra Linear Cooled DFB Lasers, packaged with an Integral Thermoelectric Cooler (TEC) device, and an optical isolator, to deliver the highest level of RFoF performance.

Effects of Slope Efficiency

The typical cooled DFB Laser has a high “slope efficiency” which means that the Laser is highly sensitive and requires a *lower modulation current* in order to achieve the usual *high modulation index*.

In all Lasers the slope efficiency parameter is very temperature sensitive. As the Laser temperature changes, so does the slope efficiency of the Laser, and consequently, all of the other critical Laser parameters such as Gain, OMI, NF, IP3, etc. The temperature characteristics of the Laser diode are such, that as the threshold current increases, the slope efficiency of the Laser device decreases, and an increasing Laser temperature results. This phenomenon makes the Laser less efficient, thus reducing the RF signal Gain and increasing the link Noise figure, as well as causing additional degradation in the Laser linearity.



Advantages of Thermal Stabilization

Since the analog RF characteristics of a Laser depend upon the temperature of the Laser diode device itself, Transmitters which utilize a TEC demonstrate a significant performance improvement over un-cooled versions. The TEC locks the temperature of the Laser at a constant level, and consequently, stabilizes the Laser wavelength, slope efficiency, optical output power and Relative Intensity Noise (RIN). Optical Zonu's state-of-the-art integrated TEC controller provides stable thermal operation over a broad range of temperatures (-20°C to +65°C), otherwise not possible.

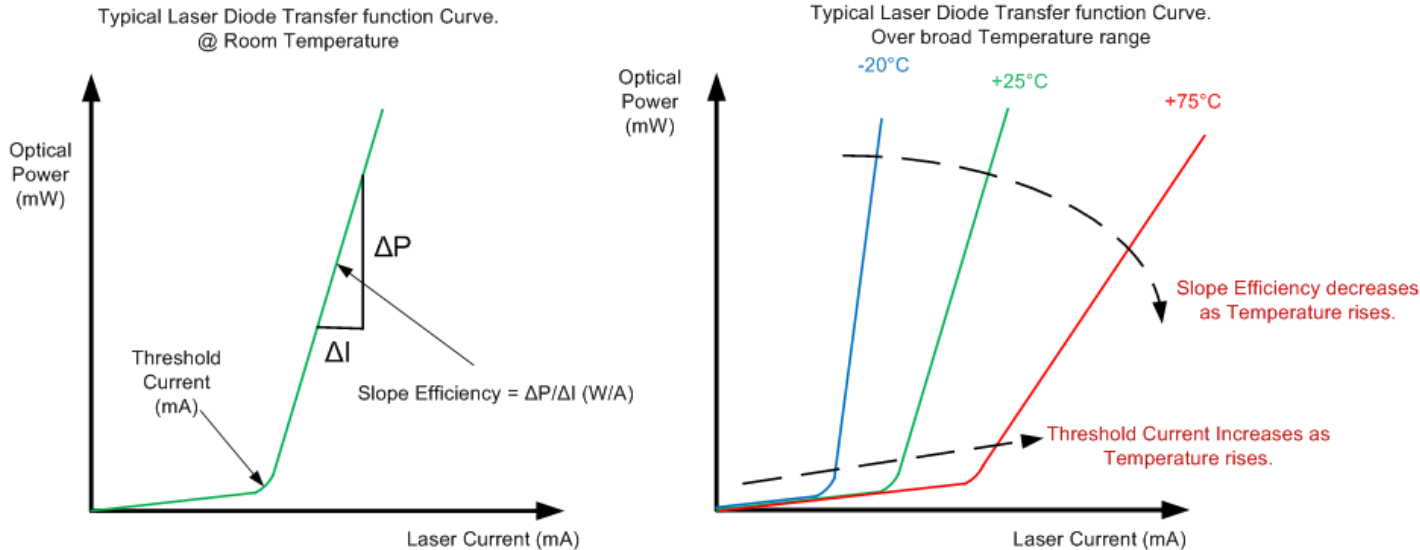
Integrated TECs

The construction of the cooled DFB is such that inside the Transmitter module, the Laser diode itself is mounted on a substrate, which is then further mounted onto the TEC. The TEC uses the **Peltier Effect** to heat and cool the Laser diode, as needed, to keep the temperature of the diode within a few degrees of its optimum operating point.

In order to maintain a constant operating temperature, the TEC acts as a semiconductor "heat pump", moving heat from one side of the device, to the other. Depending upon the direction of current flow through the TEC, it may either heat, or cool the Laser diode. For high SFDR, long reach applications, the ability of the Laser diode to perform well at elevated temperatures is of paramount importance. Simultaneously maintaining high linearity and low noise figure are critical. The TEC also increases the MTF of Laser since it lowers its operating temperature.

Controlling the Transfer Function

The following plots illustrate the fundamental Laser thermal characteristics.



Utilizing a TEC with the Laser allows operation under a fixed P-I transfer function due to stabilization of the thermal conditions. A typical control range (for a TEC heating and cooling a Laser) to maintain the Laser temperature close to a constant operating point is from -20°C to $+65^{\circ}\text{C}$. Average Automatic Power Control (AAPC) may be utilized for optimal optical power stability over the full temperature range of -40°C to $+85^{\circ}\text{C}$.

A Typical TEC control temperature dynamic range is around 80°C , which means a standard configuration will enable the fiber optic link to operate from -20°C to $+60^{\circ}\text{C}$ without any change in RF performance. OZ1600 series has an integrated Microcontroller which has the capability to not only monitor the Laser temperature, but also set the TEC temperature by adjusting the median set point to extend the optical link operation to the full temperature range of -40°C to $+85^{\circ}\text{C}$. This feature is unique in the sense that the RF characteristic change across the band will be minimal compared to the standard un-cooled version. For example, a typical un-cooled RFOF transceiver will have a gain variation of approximately 7 dB over the temperature range of -40°C to $+85^{\circ}\text{C}$, versus the cooled version (OZ1600 series) of less than 2 dB. This feature simplifies the end-to-end system design significantly and reduces the extra expense and complexity of designing follow-up compensation electronics.

Resulting Comparative Advantage

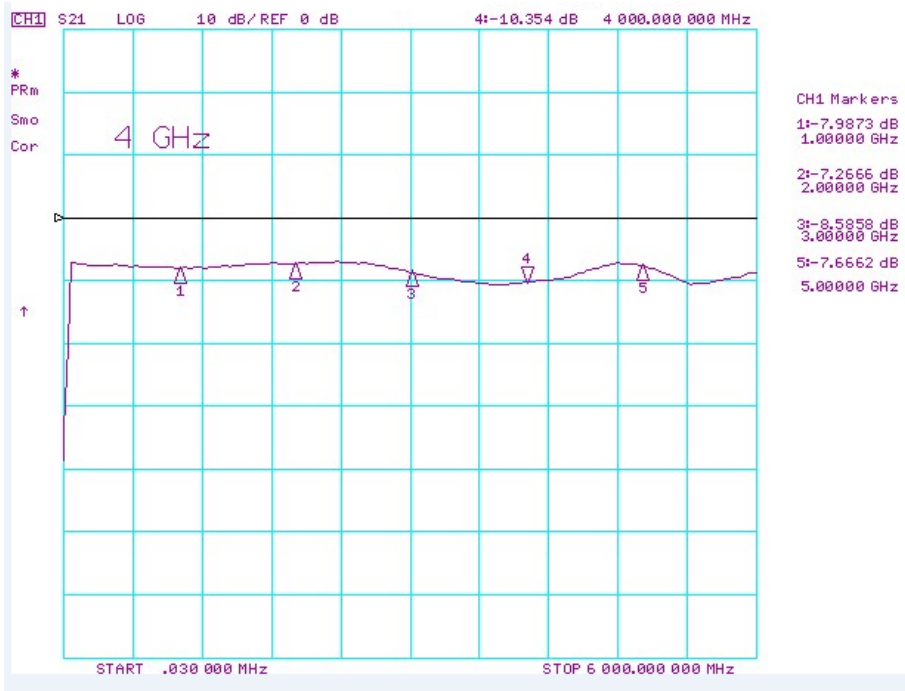
The table below illustrates what may be expected from a TEC- cooled DFB Laser RFOF link versus a non-cooled version.

RFOF LINK CHARACTERISTICS COMPARISON TABLE

Parameter	Non-Cooled	Cooled	Units	Notes
Spur Free Dynamic Range @ +25°C	110	116	(dB/Hz) ^{2/3}	1
Spur Free Dynamic Range @ +65°C	105	115	(dB/Hz) ^{2/3}	1
gain Variation from -20°C to +65°C	4	0.5	dB	
Input Noise Floor @ +25°C	-133	-136	dBm-Hz	1
Input Noise Floor @ +65°C	-130	-135	dBm-Hz	1
Input Third Order Intercept @ +25°C	31	38	dBm	1
Input Third Order Intercept @ +65°C	28	37	dBm	1

Standard OZ1600 frequency response is shown below. The 3 dB bandwidth is actually in excess of 6.3 GHz. A higher gain version is also available upon request.

Frequency Response Plot of OZ1606 Link from 20 MHz to 6 GHz



For more information please contact Optical Zonu Corp at 818.780.9701 ext. 23