

AFBR-FS13B25

Strategies to Mitigate the Effect of Unwanted Reflection in Systems with the AFBR-FS13B25 Optical Wireless Transceiver

Overview

For optical wireless, full-duplex, free-space transceivers, optical reflections cannot be avoided completely. These optical reflections have the potential to cause bit errors from optical cross talk, especially if one direction is not active and the transmitter can detect its own (reflected) data signal.

There are various sources of optical reflections, which strongly depend on the actual application and the environment. These can be objects like optical lenses or transparent panels, which are placed in the optical path between the two components. If the light has to propagate through two optical materials with different refractive indices, there will be a reflection and a refraction. A portion of light will propagate through the material, but some light will be reflected.

Additionally, the board where the opposite transceiver is mounted, as well as the transceiver itself, may cause reflections.

This application note describes ways to both avoid and mitigate the impact of reflections in a system consisting of AFBR-FS13B25 transceiver and receiver components for optical wireless communication (OWC).

For instance, reflections can be avoided by carefully evaluating the monitor current photodiode (I_{mon}), a tilted optic between the transmitter (Tx) and the receiver (Rx) of the optical link, or by altering the distance between them.

Evaluating the I_{mon} Signal

Assume that we have two evaluation boards as shown in [Figure 1](#). When the optical link is running, on the receiver side we have the following two signals:

- A strong signal coming from the opposite transmitter.
- A weak signal coming from reflections.

These two signals reach the receiver at the same time. On the receiver, there is a trans-impedance amplifier and a limiting amplifier. A limiting amplifier is not a linear amplifier. The difference between strong and weak input signals is severely increased at the output, which means that the effect of the reflections are reduced. At the output of the limiting amplifier, we see just one signal: the light coming from the strongest transmitter. The weaker reflection signal fades away. In a situation where a transmitter on the opposing side is not operational, only external reflections are present. If they are intense enough the receiver can be triggered, causing a false signal.

Monitoring the I_{mon} signal can help to understand and possibly eliminate the effect of reflections. The I_{mon} signal is just a photodiode current replica and it is generated by a current mirror with a 1:1 ratio. If the photodiode current is bigger than 2 microamperes, then the I_{mon} tolerance is $\pm 15\%$, otherwise it is not guaranteed. The I_{mon} signal depends on several parameters. Some examples include the following:

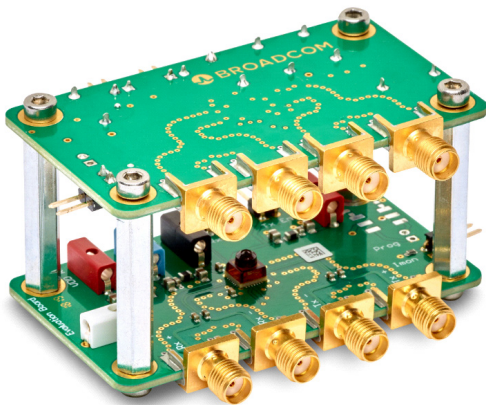
- Distance and physical misalignment between Tx and Rx
- Optical deviation
- Physical deviation
- Propagation losses due to light scattering and absorption

I_{mon} values range from 0 to 150 microamperes, if the distance between transmitter and receiver is greater than 20 mm:

$$0 \mu A < I_{mon} < 150 \mu A$$

The I_{mon} threshold to guarantee a stable link strongly depends on the data rate. If the data rate is 1.25 Gb/s (Gigabit Ethernet), then 5 μA can be enough to set a reliable link. Other parameters have some influence on link reliability too, such as V_{cc} noise and rise/fall time. A higher data rate can require a stronger I_{mon} signal. For example, 5 Gb/s may need 10 μA to guarantee a reliable link.

Figure 1: Evaluation Kit AFBR-FSEK50B00E



One simple method to eliminate the effect of reflections is to monitor the I_{mon} signal. If the I_{mon} signal is lower than 5 μA (at 1.25 Gb/s), then the Rx signals are not trustworthy. You can either ignore them or disable the receiver.

Voltage measurement is often more convenient than current measurement. A 1k resistor at I_{mon} signal can be used to drive millivolts from microamperes. If the I_{mon} signal is not used, the I_{mon} pin can be left floating in order to save power.

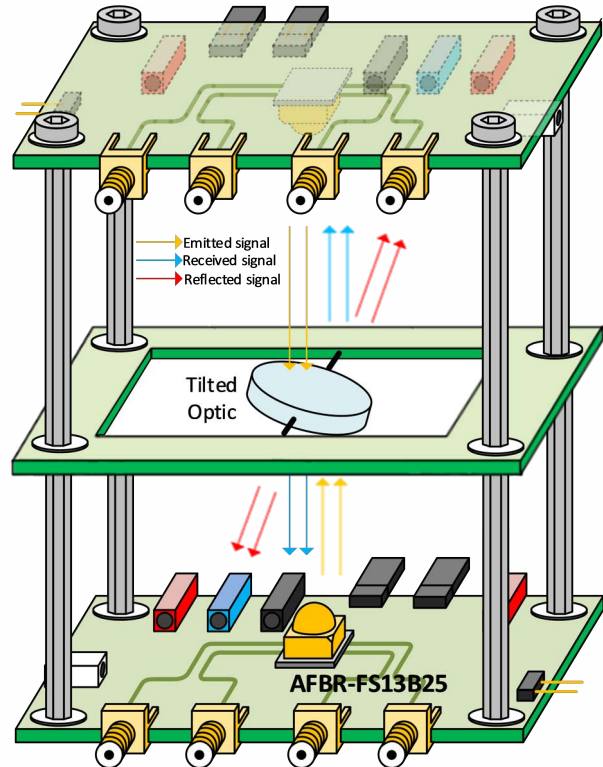
Use of Tilted Optics

In certain applications, a tilted optic is inserted between the Tx and Rx. The following figure shows the principle of this architecture. Due to different refractive indices between the optic and the surrounding medium, reflections are generated. If reflections are strong enough, false signals are generated on the receiver. The I_{mon} monitoring method mentioned in the previous paragraph is also valid when tilted optics are used. By using optics, you have an additional option to reduce reflections, for example, by tilting these optics (lenses) a few degrees.

Unfortunately, there are no criteria to select a minimum angle, as it depends on many factors like optical material and the polishing grade of the optical surface.

Broadcom lab experiments show that just two degrees of tilt was enough to mitigate the reflections.

Figure 2: Evaluation Kits with a Tilted Optic in between



If more than one optic is inserted, both optical elements should be tilted.

The following table shows the benefits of a tilted optic.

Conditions	I _{mon} Top	I _{mon} Bottom
Both Links ON Optic parallel	37.1 μ A	40.4 μ A
Tx Top OFF Tx Bottom ON Optic parallel	33.8 μ A	2.4 μ A
Tx Top ON Tx Bottom OFF Optic parallel	1.9 μ A	33.5 μ A
Tx Top OFF Tx Bottom ON Optic tilted	35.6 μ A	0.3 μ A
Tx Top ON Tx Bottom OFF Optic tilted	0.2 μ A	35.4 μ A

When the optic is parallel, you can observe I_{mon} signals due to reflections in the range of 2 μ A (2.4 μ A and 1.9 μ A). This value is enough to trigger the receiver. However, if the lens is tilted, the I_{mon} signal caused by reflections can be up to 10 times smaller, which will prevent the triggering of the receiver. In this experiment, the optic was tilted as little as 2°, but the angle can vary from application to application.

Increasing the Distance

By increasing the distance between the transmitter and receiver, the reflection will be attenuated. At the same time, increasing the distance also attenuates the transmitter signal.

At longer distances, the reflection can be much weaker than the transmitter signal and therefore below the receiver's triggering threshold.

If necessary, all three methods explained in this application note can be combined to achieve optimal performance.

Copyright © 2022 Broadcom. All Rights Reserved. The term “Broadcom” refers to Broadcom Inc. and/or its subsidiaries. For more information, go to www.broadcom.com. All trademarks, trade names, service marks, and logos referenced herein belong to their respective companies.

Broadcom reserves the right to make changes without further notice to any products or data herein to improve reliability, function, or design. Information furnished by Broadcom is believed to be accurate and reliable. However, Broadcom does not assume any liability arising out of the application or use of this information, nor the application or use of any product or circuit described herein, neither does it convey any license under its patent rights nor the rights of others.

