A wide field-of-view receiver that incorporates fluorescent fibers and a SiPM.

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One approach to increasing the signal to noise ratio (SNR) of a visible light communications receiver, without restricting its field of view, is to use a fluorophore-doped optical element as an optical concentrator[1,2]. However, ideally the fluorophore's frequency response should not limit the receiver's bandwidth. The frequency response of a short section of a 0.25 mm^2 square Kuraray (SCSF-81J) fiber has therefore been measured, and shown to be consistent with a 3 dB frequency of 117 MHz.

A complementary approach to increasing the SNR of a receiver is to use a silicon photomultiplier (SiPM) as the photodetector. However, SiPMs are so sensitive to light that they should be protected from ambient light. Fortunately, fluorescence fibers also function as wide field-of-view optical filters to protect the SiPM from ambient light[3]. Furthermore, several of these fibers can be coupled to a 9 mm^2 30020 On-Semiconductor J-series SiPM whose bandwidth is 249 MHz.

The performance of an experimental receiver containing a 30020 SiPM coupled to the 28, 12 cm SCSF-81 fibers, shown in Figure 1 (a), has been investigated. When compared with a single fiber coupled to the same SiPM these fibers reduce the irradiance required to support OOK data rates between 200 Mbps and 1.4 Gbps by a factor of approximately 20. Furthermore, as expected these fibers reduce the impact of ambient light on the receiver. In particular, as shown in Figure 1 (b), illuminating the receiver with 500 lux of light from a white LED increases the irradiance required to support data rates between 200 Mbps and 1.4 Gbps by less than 4.5 dB. Alternatively, the SiPM can be protected from ambient light by an absorption filter. The results in Figure 1 (b) show that for data rates higher than 800 Mbps the fluorophores bandwidth means that, at normal incidence, it is better to protect the SiPM using a well-chosen absorption filter.

Another important characteristic of a receiver is its field of view (FoV) and so the FoV of a planar receiver, a single fiber and the 28 fibers are shown in Figure 1 (c). The unexpected FoV characteristics of a single fiber arise because the area exposed to the transmitter increases as the square fiber is rotated. Figure 1 (a) shows that the 28 fibers are widely spaced and so this phenomenon contributes to the FoV of the 28 fibers. However, eventually fibers within the group start to shadow each other and the performance of these fibers decreases rapidly between 70^{o} and 90^{o}.

The impact of the different FoVs on a representative application has been calculated assuming that the transmitter's output power is 270 mW and its beam is

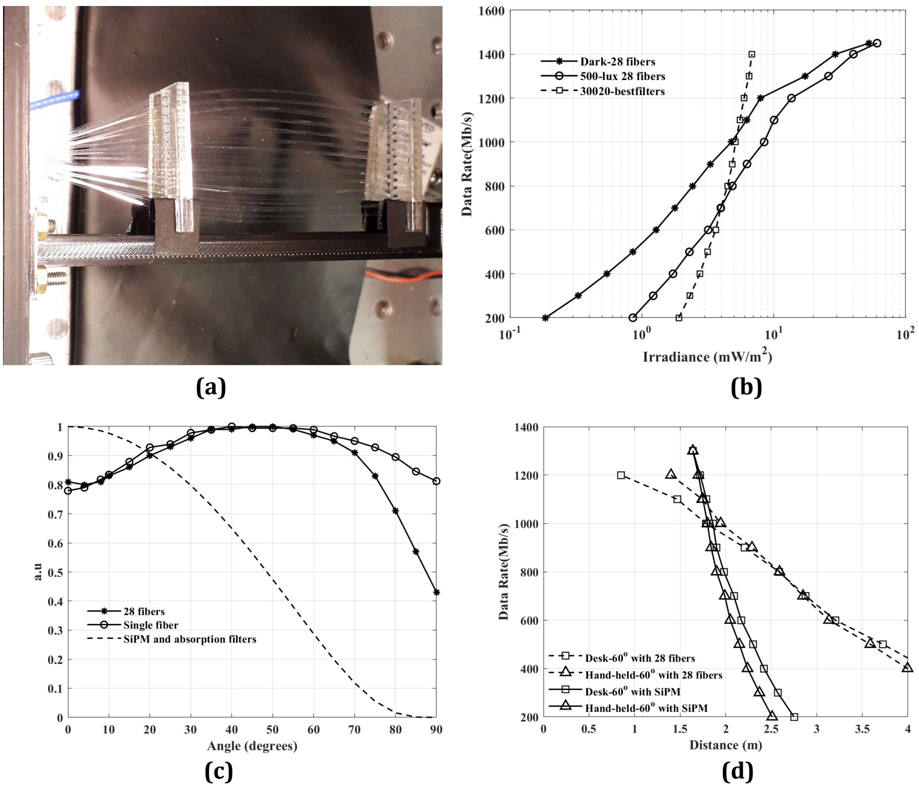

Fig. 1 (a) The 28 fibers that were coupled to a 30020 SiPM to create a receiver. (b) The irradiance required to transmit data to receivers containing a 30020 and either the 28 fibers or an absorption filter. (c) The field of view of a planar receiver and receivers containing either one fiber or the group of 28 fibers. (d) The expected performances of a planar receiver formed from a SiPM and an absorption filter and a receiver formed from a SiPM and the 28 fibers at two different heights in a 3m high room.

Lambertian. The results in Figure 1(d) show that the data rate supported by the SiPM and the 28 fibers is less sensitive to the horizontal distance between the receiver and the transmitter than the data rate supported by the same SiPM and an absorption filter.

It has been shown that fluorescent fibers limit the impact of ambient light on SiPMs. Furthermore, they allow receivers to be made with a wide FoV that will provide a more uniform quality of service to users. Further work is required to improve the coupling between the fibers and the SiPM and to determine the best designs for receivers containing multiple fluorescent fibers for different applications and host systems.

References

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