LASER RF LINK OVER MULTIMODE FIBER ANALYSIS AND CHARACTERIZATION

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LATÉCOÈRE

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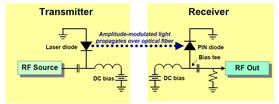
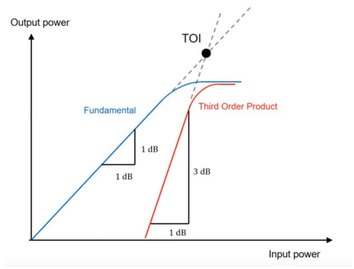
RF Links

- RF links are electromagnetic signals primarily used for communication application.
- These signals are analog and their integrity over the transmission distance is very important.
- On commercial aircraft, RF links are implemented using coaxial cable (copper wire) [1].



Output Third -Order Intercept Point (OIP3)

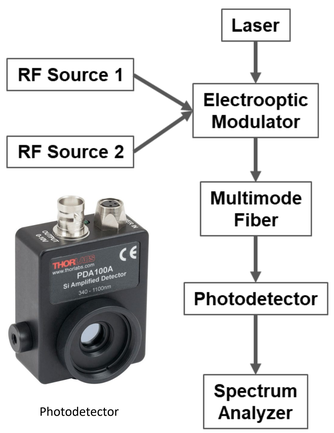
- When 2 or more signals propagate through a nonlinear medium, the signals and their harmonics combine and produce new signals, which can make the output noisy.
- The most troublesome product is the 3rd order intermodulation because it cannot be filtered.
- OIP3 is a measure of this 3rd order product and is therefore, a measure of the device's linearity [3].



Experimental Design and Features

- The laser source would have been an 850 nm single-mode laser. The laser would have been attached to polarizing-maintaining fiber to keep the laser polarized for the electrooptic modulator
- The electrooptic modulator (EOM) would have been the standard Mach-Zehnder.
- The RF sources would have been approximately 4 MHz apart in the 2-4 GHz range.
- After the signals are combined in the EOM, they would have been sent over multimode fiber to a photodetector for light to electricity conversion.
- From the photodetector, a spectrum analyzer would have read the electric signals.
- A good OIP3 value would have been 15 dBm.

Pigtailed Single-Mode Laser



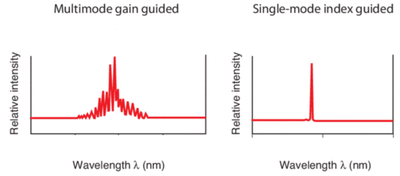
Photodetector

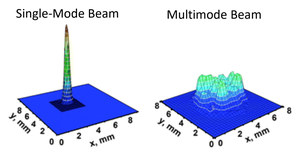
Lasers for RF Links

- To increase data transfer speed, RF links are modulated using lasers over fiber optic cabling.
- The fastest and most efficient method of implementing RF links is by modulating the signals over a single-mode fiber using a single-mode laser, operating at approximately 1,550 nm.
- However, single-mode fibers consume a lot of power and are not necessary for commercial aircraft, which has a maximum link distance of 100 meters.

Single-Mode Laser vs. Multimode Laser

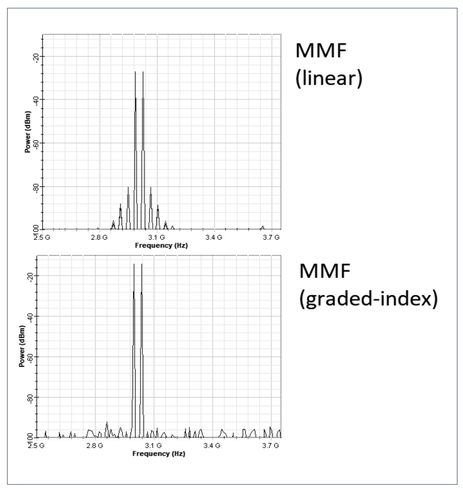
- Multimode Laser: These lasers have a higher output power than single-mode lasers. However, RF links do not need a high-power laser source. Multimode lasers also do not have good beam quality. A good RF link needs good beam quality [4].
- Single-Mode lasers: Have a single transverse mode but may not have a single longitudinal mode. These lasers have a low power output and a good laser beam, which makes them ideal for RF links [4].
- We would have used a stabilized single-mode laser source, which has a single transverse mode AND a single longitudinal mode [4].





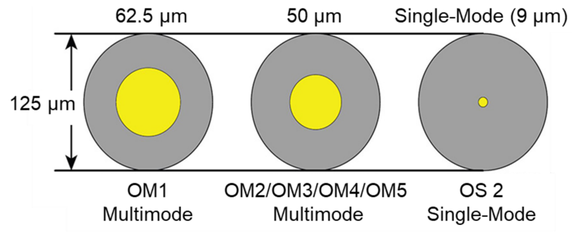
Single-mode Laser over Multimode Fiber OIP3 Simulation

- The link was simulated in OptiSystem software from OptiWave
- 2 RF signals (3 and 3.04 GHz) are sent into the system over a 100m fiber
- Important 3rd order signals:
  - 2*f1 - f2 = 2.96 GHz
  - 2*f2 - f1 = 3.08 GHz
- RF spectrums of the output signal are presented (MMF - multimode fiber)
- The amount of noise (3rd intermodulations in particular) depends on the power of the input signal (laser beam) and nonlinearities of the system (material or propagation properties of light in a medium)
- Graded-index MMF produces less noise and at 100m its output characteristic reaches the quality of single-mode fiber systems

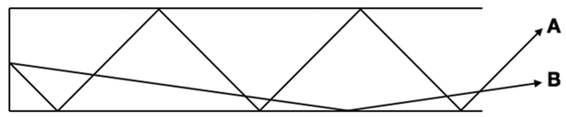


Single-mode Laser over Multimode Fiber

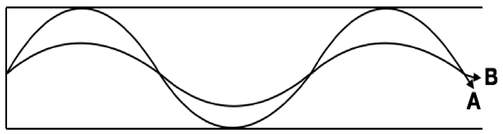
- To make the laser-modulated RF links capable for commercial aircraft, a multimode fiber must be used.
- Multimode fibers are easy to setup and are an ideal candidate for local connections made on aircraft [2]. However, multimode fiber suffers more from dispersion.
- The multimode fiber we would have used would have been OM4 multimode fiber, with a graded index of refraction to reduce the loss of the signal.
- OM4's resonating wavelength resides at approximately 850 nm. Therefore, an 850 nm single-mode laser would have been used.



[2]



Light propagation in a step index fiber.



[2]

Light propagation in a graded index fiber.

Future Work and References

- Reorder all the equipment and run the OIP3 experiment
- Compare the multimode fiber OIP3 performance to the industry standard
- Write MATLAB code to model light propagation through the multimode fiber

[1] "Wiring Installation – Wire Types," Flight Mechanic. [Online]. Available: http:// www .flight- mechanic.com/wiring - installation- wire - types/ . [Accessed 09 - Mar- 2020].
[2] H. Venghaus & Grote, Norbert, Fibre optic communication: Key devices (Springer series in optical sciences, 161). New York: Springer, 2012
[3] "What is IP3?," What is IP3? - everything RF. [Online]. Available: https:// www .everythingrf.com/community/what - is- ip3. [Accessed 21 May- 2020].
[4] "Lasers 101 - Laser Selection Guide," RPMC [Online]. Available: https:// go.rpmclasers.com/lasers- 101 laser- selection- guide. [Accessed 21 May- 2020].

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