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Assembly of the fiber-based modular device

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This document explains the assembly of photonics devices. Sensorica is an OVN (open value network), designing, producing and distributing optical fiber-based sensors.Assembly of the fiber-based modular device.

See document with different layouts for the Mosquito.

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Optical connectors

In the first version of the Mosquito we use an **ST-UPC connector**. Connectors come in two forms, APC and UPC. The major physical difference between APC and UPC connectors is the endface geometry. The APC ferrule endface radius is polished at an 8° angle while UPC connectors are polished at a 0° angle. The significance of this 8° angle becomes apparent when addressing return loss issues, which will be discussed later in this paper.

> Whenever a connector is installed on the end of fiber, loss is incurred. Some of this light loss is reflected directly back down the fiber towards the light source that generated it. These back

reflections, or Optical Return Loss (ORL), will damage the Laser Light Sources and also disrupt the transmitted signal. Various polish profiles are used, depending on the type of fiber and the application. For singlemode fiber, the fiber ends are typically polished with a slight curvature, such that when the connectors are mated the fibers touch only at their cores. This is known as a "physical contact" (**PC**) polish. A typical hand polished connector will measure at –30dB.
To reduce the back reflection of a connector, it can be polished to **SPC** (Super Physical Contact) polish or **UPC** (Ultra Physical Contact) polish. Industry standard is a minimum of –40dB for SPC back reflection measurement and –50dB for UPC back reflection measurement.
If even less back reflection is required, an **APC**, or Angled Physical Contact polish, might be necessary. An APC connector has an 8º angle cut into the ferrule. These connectors are identifiable by their green color. An APC polished connector has an Industry Standard Minimum f –60dB ORL measurement. APC fiber ends have low back reflection even when disconnected.

The rationale behind our choice for ST-UPC is that for the fabrication of our transducers we can only cut the fiber at a right angle.

Optical couplers and splitters

Fiber optics couplers and splitters

See wikipedia page: A fiber optic coupler is a device used in optical fiber systems with one or more input fibers and one or several output fibers. Light entering an input fiber can appear at one or more outputs and its power distribution potentially depending on the wavelength and polarization. Such couplers can be fabricated in different ways, for example by thermally fusing fibers so that their cores get into intimate contact. If all involved fibers are single-mode (supporting only a single mode per polarization direction for a given wavelength), there are

certain physical restrictions on the performance of the coupler. In particular, it is not possible to combine two or more inputs of the same optical frequency into one single-polarization output without significant excess losses. However, such a restriction does not occur for different input wavelengths: there are couplers which can combine two inputs at different wavelengths into one output without exhibiting significant losses.

There are *single window* (single wavelength with a narrow wavelength window) fiber optic couplers and *dual window* (two wavelengths with a wide wavelength window for each.) fiber optic couplers.

For the first version of the Mosquito the coupler needs to be compatible with our Infinicor 300 MM glass fiber from Corning, which is our delivery fiber, and needs to be terminated with ST connectors. We work at 1550 nm.

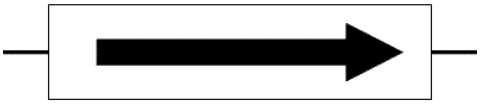
Some types of the fiber-optic splitter are actually able to work in either direction. This means that if the device is installed in one way, it acts as a splitter and divides the incoming signal into two parts, sending out two separate outputs. If it is installed in reverse, it acts as a coupler, taking two incoming signals and combining them into a single output. Not every fiber-optic splitter can be used this way, but those that can are labeled as reversible or as coupler/splitters. In the first version of the Mosquito we use the reversible coupler/splitter.

Free space splitters and couplers

Wikipedia page: A beam splitter is an optical device that splits a beam of light in two. It is the crucial part of most interferometers.
In its **most common form**, a rectangle, it is made from two triangular glass prisms which are glued together at their base using polyester, epoxy, or urethane-based adhesives. The thickness of the resin layer is adjusted such that (for a certain wavelength) half of the light incident through one "port" (i.e., face of the cube) is reflected and the other half is transmitted due to **frustrated total internal reflection**.
Polarizing beam splitters, such as the Wollaston prism, use birefringent materials, splitting light into beams of differing polarization.
Another design is the use of a **half-silvered mirror**. This is a plate of glass with a thin coating of aluminium (usually deposited from aluminium vapor) with the thickness of the aluminium coating such that part, typically half, of light incident at a 45-degree angle is transmitted, and the remainder reflected. Instead of a metallic coating, a **dielectric optical coating may be used**. Such mirrors are commonly used as output couplers in laser construction. A half-silvered mirror used in photography is often called a pellicle mirror. Depending on the coating that is being used, reflection/transmission ratios may differ in function of the wavelength.
A third version of the beam splitter is a **dichroic mirrored prism** assembly which uses dichroic optical coatings to divide an incoming light beam into a number of spectrally distinct output beams. Such a device was used in multi-tube color television cameras, in the three-film

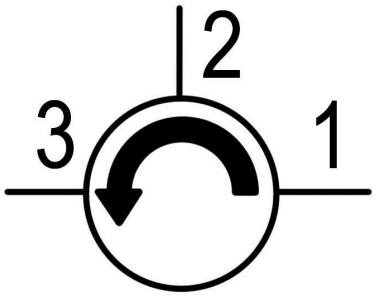
Technicolor movie cameras as well as modern, three-CCD cameras. It is also used in the 3 LCD projectors to separate colors and in ellipsoidal reflector spotlights to eliminate heat radiation. Beam splitters are also used in stereo photography to shoot stereo photos using a single shot with a non-stereo camera. The device attaches in place of the lens of the camera. Some argue that "image splitter" is a more proper name for this device. Beam splitters with single mode fiber for PON networks use the single mode behavior to split the beam. The splitter is done by physically splicing two fibers "together" as an X.

Optical isolators



From Wikipedia: An optical isolator, or optical diode, is an optical component which allows the transmission of light in only one direction. It is typically used to prevent unwanted feedback into an optical oscillator, such as a laser cavity. The operation of the device depends on the Faraday effect (which in turn is produced by magneto-optic effect), which is used in the main component, the Faraday rotator. There are *Polarization dependent isolators* and *Polarization independent isolators*.

Optical circulators



From Wikipedia: An optical circulator is a special fiber-optic component that can be used to separate optical signals that travel in opposite directions in an optical fiber, analogous to the operation of an electronic circulator. An optical circulator is a three-port device designed such that light entering any port exits from the next. This means that if light enters port 1 it is emitted from port 2, but if some of the emitted light is reflected back to the circulator, it does not come out of port 1, but instead exits from port 3. Circulators can be used to achieve bi-directional transmission over a single fiber. Because of its high isolation of the input and reflected optical powers and its low insertion loss, optical circulators are widely used in advanced communication systems and fiber-optic sensor applications. Optical circulators are non-reciprocal optics, which means that changes in the properties of light passing through the device are not reversed when the light passes through in the opposite direction. This can only happen when the symmetry of the system is broken, for example by an external magnetic field. A Faraday rotator is another example of a non-reciprocal optical device.

[See examples from Thorlabs]

SM (Single Mode), BroadBand and PM (polarization maintaining)