Vibration registration system

The uniqueness of the technology is that it consists of a single wire and it does not require a single sensor, so it is very easy to install. The wire technology is based on optical fiber and therefore it is resistant to any electromagnetic fluctuations. As a result, the technology is very convenient in the aerospace field.

To register vibrations, it makes sense to use optical fiber: the oscillation of the fiber stretched along the structural element will cause a fluctuation in the path length of the laser pulse and the angle of reflection of the pulse inside the fiber (Figure 1).

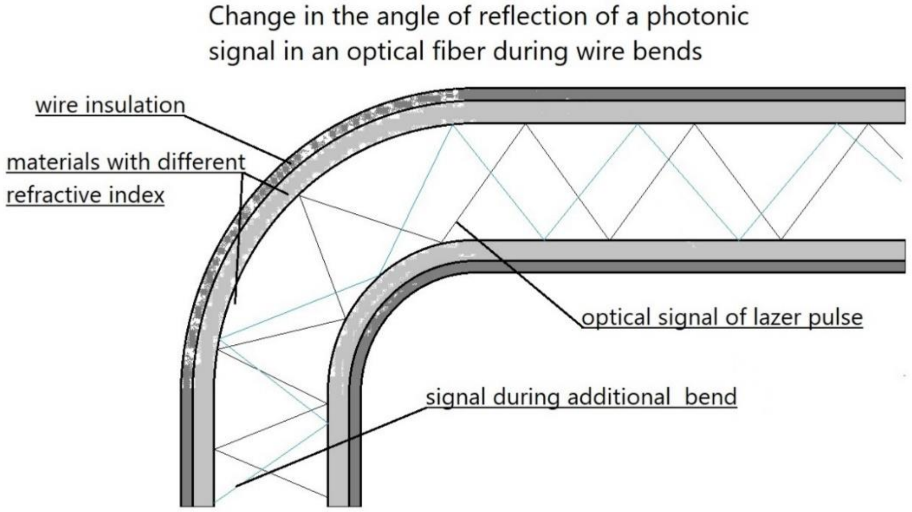

Figure 1

Along the structural element, it is necessary to stretch two optical fibers in a common braid, optically isolated from each other. The first cable is a single mod; the second is a multi mod without an insulating coating, around which a single mod is wound in a spiral, made of materials that are transparent to light coming from outside (Figure 2).

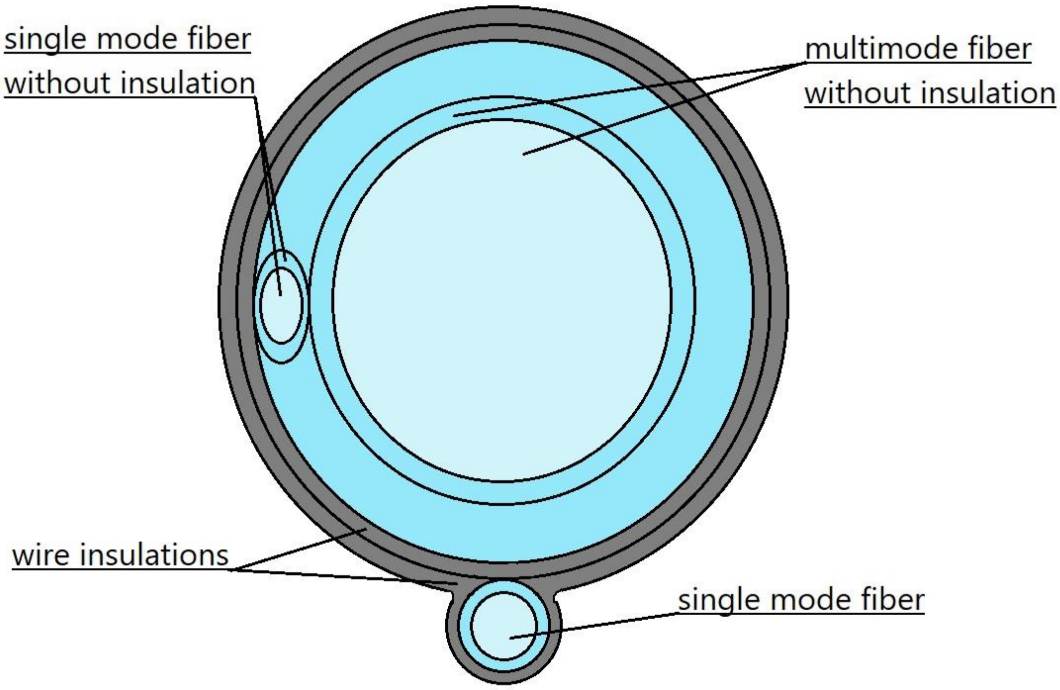

Figure 2

The emitter is connected to the first and second optical fibers from the common end of the circuit, the spiral fiber is connected at one end to the receiver 1, the other end to the mirror (Figure 3). This receiver converts an optical signal into an electrical one.

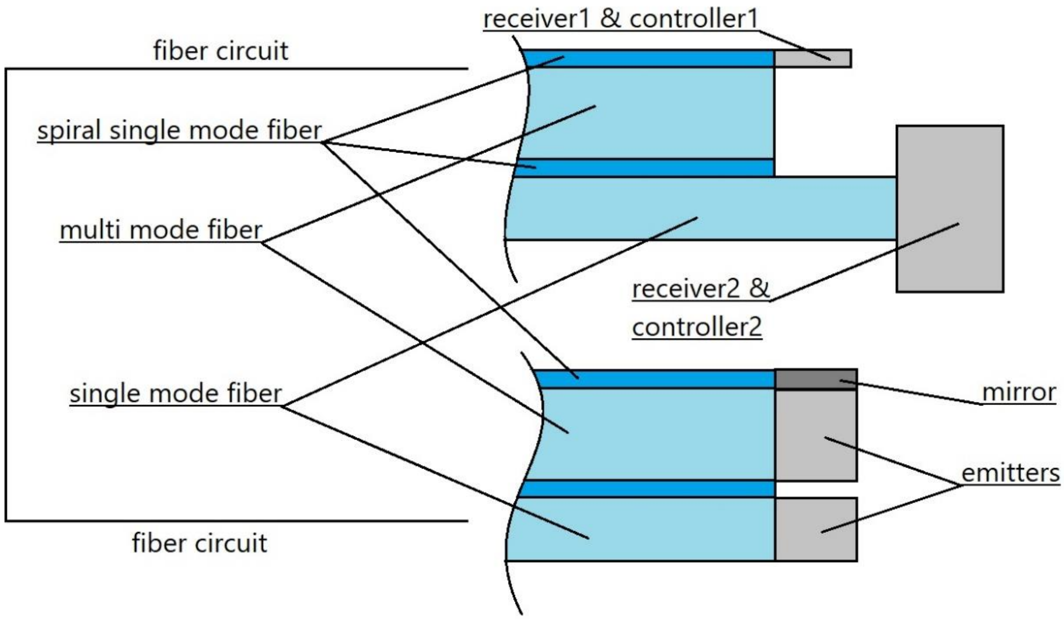

Figure 3

I noticed that the bend of the fiber–optic wire (photos 1, 2) begins to glow - these are losses in the fiber. Thanks to this phenomenon, it is possible to register the place of bending, which means the place of unwanted vibrations. To enhance this effect, it makes sense to use a multi mod. The signal from the bend will be transmitted to a single mode fiber twisted in a spiral, propagated along it in one of two directions and recorded by receiver 1.

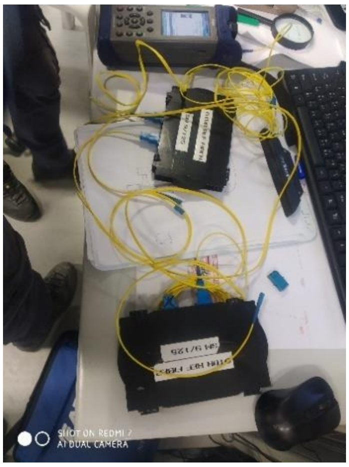

Photo 1 Photo 2

A receiver in a conventional single mode fiber consists of a mirror, a receiver and an optical element (or a membrane of material) that reflects rays falling on its surface not at right angle (Figure 4).

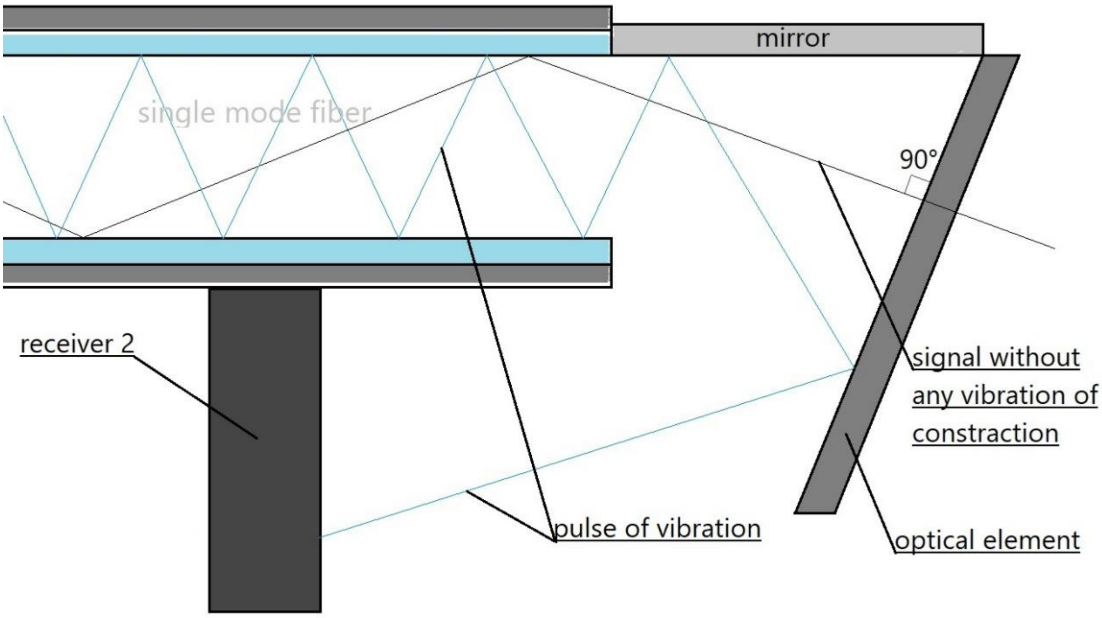

Figure 4

At rest of the system, the optical element is calibrated in its position in such a way that the signal coming out of the fiber falls on it at a right angle and is absorbed, receiver 2 does not receive a signal. Receiver 1 picks up a constant signal, since the installed fiber-optic wire has bends that repeat the structural elements.

When the engineering structure on which this system is installed starts working properly, the signal on receiver 2 begins to flicker with a certain frequency. The full period of this signal is recorded via a controller connected to the receiver. Similarly, the power of the signal received by receiver 1 changes, this signal is also recorded taking into account the direction in which the signal began to propagate: the signal transmission time over the entire circuit is constant.

When atypical vibrations appear in the structure, both signals differ from their recording. The main controller communicating with the controllers on the receivers receives a signal about the presence of unwanted vibrations. Since the length of the single mode wound in a spiral differs from the length of the single mode on receiver 2, the signal from vibrations at one point of the structure comes to the receivers at different times. By the length of this difference, you can calculate the place of the vibration that occurred, which means that you can write a program for the main controller, which, having received a signal about the presence of unwanted vibrations, compares the recordings of normal vibrations with the current signal. If the signal in the spiral fiber is reflected, then its delay time will be greater than the value known in advance and the coordinate of its position is also easily calculated. The differences in the recordings from the signals will be asynchronous (for several sources of vibrations occurring simultaneously), the signal at receiver 1 will always be late from the corresponding signal at receiver 2. So, the main controller will be able to calculate the time difference between each pair of signals.

But the technology has one important drawback: if the signal of the first vibration that occurred is at a greater distance than the second signal of the vibration that occurred, then the order of the signals may be confused. Receiver 2 receives the signal of the first vibration that occurred, then receives the signal of the second vibration; then receiver 1 receives the signal of the second vibration and receives the signal of the first vibration last in time. On a time interval of several periods of the sum of the fiber oscillations, it is possible to determine the true correspondence of the signals on the two receivers. On the other hand, it is possible to install each system on separate sections of the structure, where vibrations dangerous to the integrity of the structure may occur.

Instead of winding a single-mode fiber onto a multimode fiber, a multimode fiber can be covered instead of a braid with a material that converts photons incident on it into electrical signals. The exact coordinates of the vibration can be determined by the difference in registration time between photonic and electrical signals.