# Vibration Test Report

**MEMS Fiber-Fiber™ Switches**

3-16-2022

# 1 Overview

The Fiber-Fiber[s] Series of optical switch is based on a patented MEMS technology that self-aligns a fiber directly to another fiber with a tiny gap that is filled with an index-matching liquid. The breakthrough technology enables light to propagate in a continuous medium without interruptions, consequently eliminating the need for lenses and AR coating and reflections from internal surfaces. It offers unparalleled advantages of a nearly lossless low loss of about 0.2dB for all ports (below 0.01dB with special order), broad wavelength operation from 200nm-4000nm, little back-reflection, amicable to any fiber types, vibration insensitive, and high optical power handling. It is also the lowest cost solution in the industry. We offer two platforms: MEMS for fiber count up to 8 and motor-driven for large fiber port count up to 300. The Fiber-Fiber ™ optical switches have a broad customer base ranging from optical measurements/testing systems, spectroscopy (including Raman and fluorescence), industrial production and process control, telecommunications, as well as in biomedical.

We are specialized in producing MEMS at the in-house 150mm wafer fabrication facility located at Woburn headquarters. This capability allows us to reduce the fabrication cost through tight control of manufacturing yield and quality and continuously improve the performance of our MEMS-based products through the combination of design and process improvements. Moreover, we have developed vision-based automatic wafer testing tools that ensure each MEMS chip's dynamic performance and quality.

Our MEMS switches are based on single crystalline silicon, exceptional material that does not deform, fatigue, or wear out over time, and its dimensions and mechanical properties are immune to stress unless a critical fracture stress level or a permanent deformation is high temperature is reached. Data results from testing show that Photonwares MEMS switches and VOAs still work within specifications after many billion cycles.

We have performed vibration tests on 1x2 broad wavelength MEMS driving Fiber-Fiber™ optic switch. This switch connects optical channels by redirecting an incoming optical signal into a selected output optical fiber.

This report briefs the vibration (20G & 25Hz) results in operation about the Fiber-Fiber™ family of fiber optical switches. All of the Fiber-Fiber™ switches have switch cores with the same design and process and similar package design and manufacturing processes. Thus, it is not necessary to run the vibration tests for each family product. The SM28 1x2 Fiber-Fiber™ was selected for the vibration tests in operation. By similarity, the other products of this family will be automatically qualified with this module, including all available configurations (1xN, Nx1, 2x2, etc.), wavelength range options, and input/output fiber and connector options.

A schematic and functional diagram of the Fiber-Fiber™ 1x2 switch is shown in Figure 1 below. The light propagation direction is near the Z-axis. The switching operations perform at the X-Z plane. Two plates limit the space along Y-axis to about 1 micron larger than the fiber diameter. MEMS cantilevers push the two output fibers (Port2 and Port3) against to two alignment sides of MEMS frame. At off status, the input fiber is pushed by a MEMS cantilever against to the side parallel to Port2 fiber. The output port is Port2. At on status, the input fiber will be pushed by the cantilever against to the side parallel to Port3 fiber. The output port will become Port3.

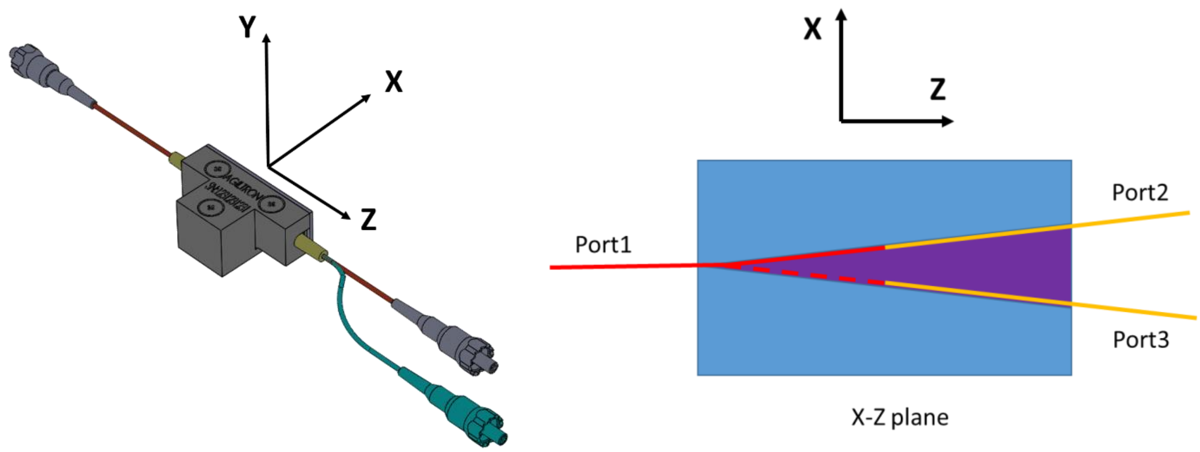



*Figure 1: Schematic and functional diagram of Fiber-fiber™ 1x2 Switch*

**2 Test Orientation**

Experimentally, it was verified 1) Neglectable impaction of vibration on insertion loss along Z because the vibration is parallel to the fibers, which will not change the gap between the two fibers that partially mounted on the holder; 2) Misalignment caused by the vibration at this direction will be the same for the switch operating at on and off statuses.

So, the vibration tests were performed along the X-axis at on and off status and Y-axis at off status.

Vibrations mainly cause the changes of lateral misalignment. Along X-axis, the fibers are held by MEMS edges and cantilevers at on and off statuses. The misalignment caused by X-axis vibration could be smaller than that by Y-axis vibration. It can be calculated that the insertion loss variation caused by the lateral misalignment ($\Delta y$) change will be smaller than 0.05dB for a maximal lateral misalignment ratio $\eta_y$ (= $2\Delta y$/MFD of fiber) smaller than 0.1.

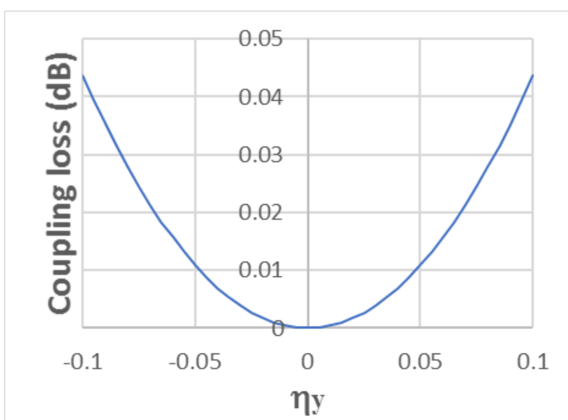


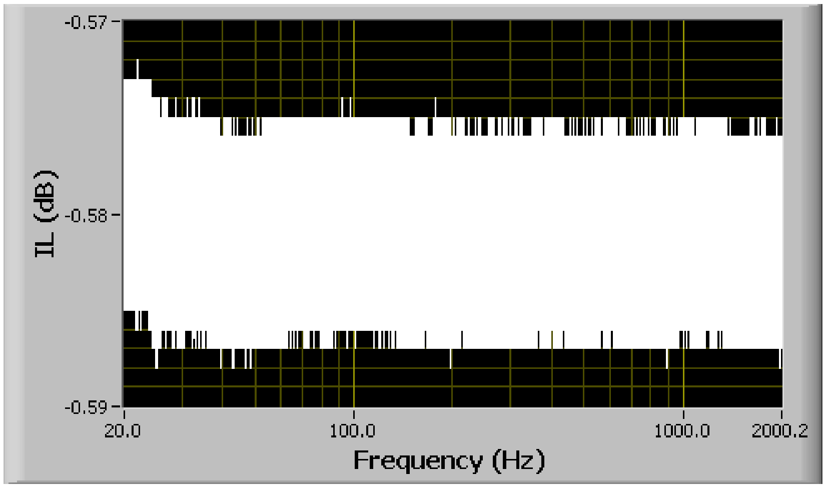

*Figure 2: The coupling loss caused by lateral misalignment.*

**3 IL Frequency Response**

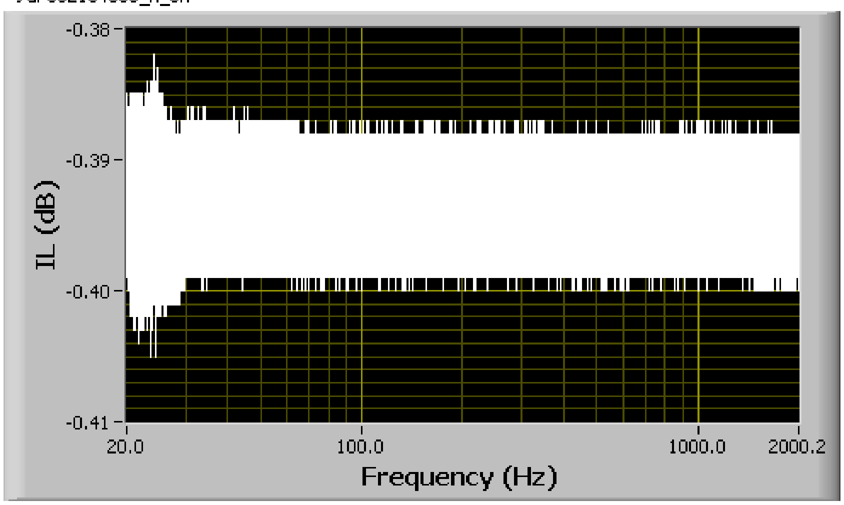
In order to assess the vibration impact on insertion loss (IL) in operation, IL was scanned first over the frequency from 20Hz to 2000Hz with the acceleration of 20G on the vibration test station. The typical results of the insertion loss (IL) vs. frequency of the switch off (0V) and on (5V) are shown in Figure 3. The frequency scale is in a log, and the IL scale is linear. The resonant frequency is

~21-24 Hz on X-axis, and 25- 40 Hz on Y-axis, depending on the mounting positions of the three fibers.

9GP582104365_X_off




9GP582104365_X_on




9GP582104365_Y_off

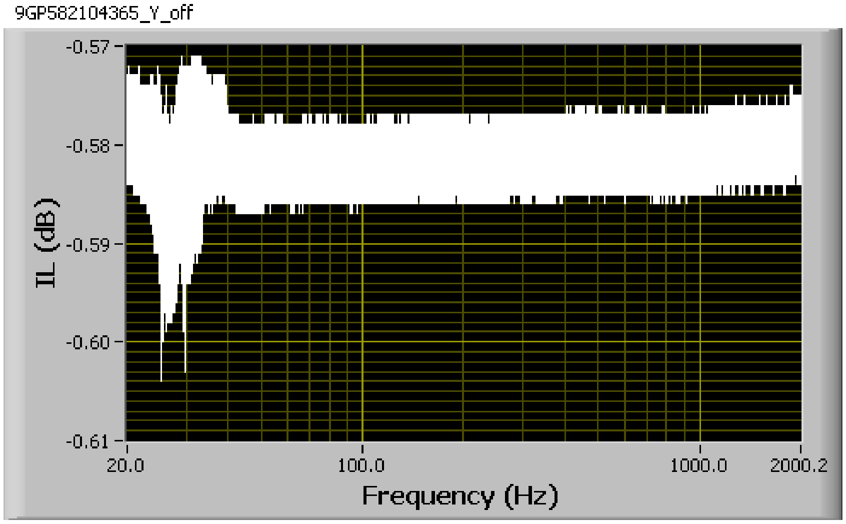


*Figure 3: Insertion loss vs. Frequency (SN: 9GP582104365). The IL in the figures consists of the insertion loss of a FC/APC connector.*

## 4 Operational IL in Vibration

The vibration test station measured the insertion losses (IL) and resonance frequency (fr) in vibrations. 2 samples were tested, and the variation of ILs was listed in the table below.

| **SN:** | | **9GP582104364** | **9GP582104365** |
|---|---|---|---|
| ΔIL (dB) | X on | 0.016 | 0.023 |
| | X off | 0.018 | 0.016 |
| | Y off | 0.025 | 0.033 |
| $f_r$ (Hz) | X on | 21 | 22 |
| | X off | Not found | 24 |
| | Y | 38 | 25 |

## 5 Summary

The insertion losses (IL) during vibration are measured < 0.04dB in the family of Fiber-Fiber™ switches. Therefore, this family of the switch is well suited for operation under vibration.