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MEMS Technology for Optical Switching

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Abstract

Over the last ten years, microelectromechanical systems (MEMS) devices have received attention in many application areas such microwave, wireless, and optical networks. Especially in optical networks, MEMS technology is employed to provide the advantages of large switch matrix size with low loss at an optimum cost [1,2]. Therefore, optical switches based MEMS technology are now widely used and are considered a good option for optical switching networks. Moreover, they also provide wavelength insensitivity, polarization insensitivity, scalability, and very low crosstalk [3-5]. MEMS optical switches provide fast switching speeds ranging from milliseconds to several hundred microseconds. In this article, MEMS-based optical switches are reviewed including their advantages and disadvantages.

Keywords: Microelectromechanical systems (MEMS), 2 dimensional MEMS (2D MEMS), 3 dimensional MEMS (3D MEMS), optical crossconnect (OXC), scalability

Introduction

MEMS are very small devices with a unit in the order of micrometers. They are generally made from silicon substrates by means of manufacturing process. Therefore, several MEMS devices can be produced using only one silicon substrate. The size of the devices is in the order of micrometers up to millimeters. For optical switches based MEMS technology, the positions of the mirrors determine the switching function of the switches. These positions can be changed by moving the mirrors [1,6,7]. Electrostatic or electromagnetic forces are used to alter the positions of these mirrors [8]. This indicates that the optical (or light) signals can travel from one place to another by deflection off the mirrors.

MEMS-based optical switches

This switch is one type of the mechanical switch called an "optomechanical switch" [6]. MEMS optical switches offer many advantages (such as scalability, insensitivities of wavelength and polarization, etc.) and hence, they provide various attractions in many areas, for example, research work, enterprise and manufacturing in telecommunication field. According to the fundamental operation mentioned in the previous section, MEMS-based optical switches can be categorized into three groups. These are MEMS optical switches based on micromirrors [1], membranes and planar moving waveguides [4]. The first two groups are called "free space switches" because of the use of free space as a guiding media [3,4]. The last one is a waveguide switch, which requires moving some parts of the switch once functioning [3,9-12]. The majority of the MEMS switches for optical switching are based on micromirrors [3], which can be categorized into two approaches, namely, 2D MEMS and 3D MEMS.

MEMS-based micromirrors switches

2D MEMS optical switches

There are two states for the positions of 2D MEMS optical switches. These are "ON" and "OFF" states. Thus, the switching function can simply be determined by these states. Several