MEMS-based 1x43 Wavelength-Selective Switch with Flat Passband

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Abstract *We propose a flat-passband 1x43 wavelength-selective switch by using a combination of anamorphic prism pairs and two-axis MEMS mirrors. The prototype successfully demonstrates a 1x43 switching with a transmission bandwidth of ±30 GHz.*

Introduction

For the support of dynamic provisioning and automated reconfiguration in WDM networks, reconfigurable optical add/drop multiplexers (ROADMs) and wavelength cross-connects (WXCs) are important. A wavelength-selective switch (WSS), as a subsystem integrated with demultiplexers/multiplexers and optical switches, can greatly simplify the structure of the WXC node [1, 2], because it can switch any incoming wavelength to any output port at individual wavelengths granularity. It is highly desirable to have a higher port count in a WSS: however, a WSS usually has a limited number of service ports, e.g., eight service ports in a 1x9 WSS. Among various switching engine technologies [3], micro-electro-mechanical system (MEMS) analog mirrors are the most promising for increasing port counts [4]. However, a high port count is likely to sacrifice the transmission passband and/or make the optics huge.

In this paper, we first demonstrate a 1x43 WSS using MEMS mirrors and bulk gratings. An optical design that maintains a flat and wide passband, which is crucial in WSSs, and the system performance of a prototype are discussed.

Design

The optical design of the proposed high port-count WSS is shown in Fig. 1. The MEMS device is a linear array of 40 micromirrors, corresponding to 100-GHz channel spacing. The micromirrors are actuated electrostatically with a maximum voltage of 90 V, resulting in tilting ranges of several degrees along the X- and Y-axis. A pair of anamorphic prisms is used to make the beam spots on the MEMS mirrors in the dispersion direction narrow enough to obtain a flat and wide passband. Since the prisms have no focusing power, the backward lightpaths reflected from the MEMS mirror are always parallel to the forward lightpaths, even when the MEMS mirror tilts on the Y-axis. Therefore, a two-dimensional array of fiber collimators can be allocated while keeping the flat and wide passband characteristics. A single resolution lens is used for both focusing and angle-to-offset conversion. This configuration is apparently simple but requires a higher dispersion element. We

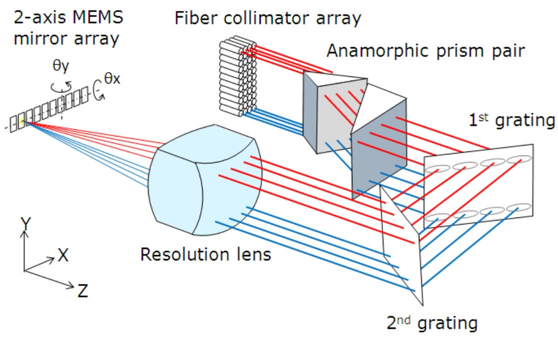

Fig. 1: Optical design of the proposed 1x43 WSS. Only 8 rays from the top (red) and bottom (blue) columns in the fiber collimator array are shown.

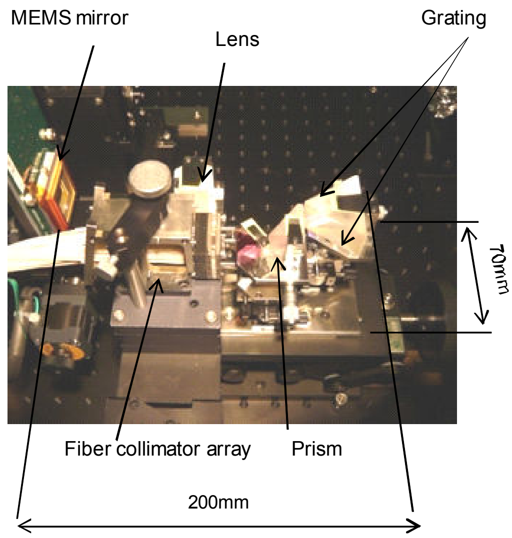

Fig. 2: Photograph of the prototype WSS.

mounted two transmissive gratings with low polarization dependence over the whole C-band at the Littrow configuration. No polarization diversity optics is required. Because the light path of the centre wavelength turns 180 degrees, no folding mirror is used.

In the prototype, we designed the port array of 4rows (X-direction) and 11 columns (Y-direction) to construct a 1x43 WSS. The 43 “colorless” service ports can add/drop all 40 wavelengths from/to individual ports. In addition, another three ports can be used for the interconnection with three other WSSs to build a 4-degree ROADM.

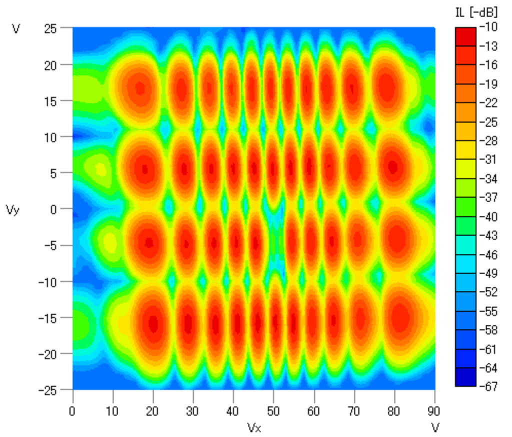

Fig. 3: Insertion loss and attenuation contour map for one MEMS mirror. Horizontal and vertical axes indicate the voltages applied to the MEMS mirror to tilt about the X- and Y-axis, respectively. Forty-three contour maps were overlaid to visualize 1x43 switching capability. The peak at (Vx=50, Vy=-5) is missing because it was used as an input port.

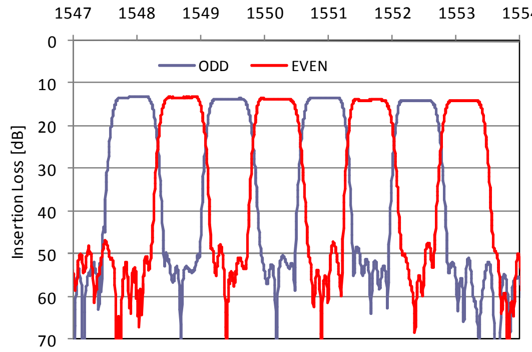

Fig. 4: Spectral traces of an eight-channel set operating as a two-port interleaver. The extinction ratio was measured to be 35 dB in this prototype.

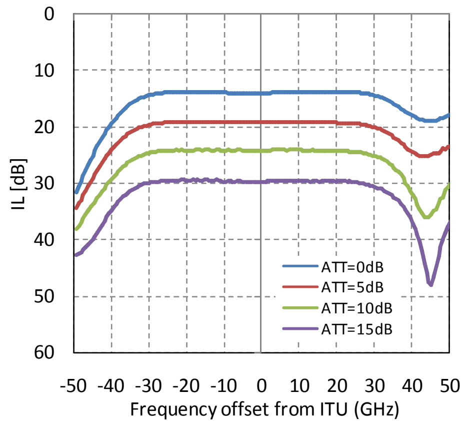

Fig. 5: Spectral traces of one particular wavelength channel with attenuation settings from 0 to 15 dB.

Results

The prototype WSS is shown in Fig. 2. Due to its simple and compact design, the prototype has a small footprint of 200x70 mm. The height of the optics is below 30 mm.

Fig. 3 shows the insertion loss and an attenuation contour map for one channel when the prototype was evaluated as a drop-type WSS. It plots as an overlay of 43 contour maps, which were received at the 43 different service ports. The Vx- and Vy-axis in Fig. 3 are the voltages applied to the MEMS mirror to tilt it on the X- and Y-axis, respectively. One can see 43 peaks that correspond to service ports arranged periodically within the designed scan angles. Due to the non-linearity of the V-θ characteristics, the port on the edge exhibits broader profiles. The insertion loss, recognized as the peak heights in Fig. 3, ranges from 12 to 15 dB among the 43 ports. Such high insertion loss is due to the grating, which accounts for a 7-dB excess loss. With an improved manufacturing process, we believe that less than 7-dB insertion loss is feasible.

Fig. 4 shows the measured spectrum when eight channels are switched to address a specific port. Flat passbands with a 0.5-dB bandwidth of ±30GHz were obtained. The extinction ratio was limited to 35 dB due to the high insertion loss of this early prototype.

It is certainly possible to attenuate optical power by offsetting the tilt angle of the MEMS mirror from the peak position. Fig. 5 shows the spectra with attenuation settings from 0 to 15 dB. Flat passbands were preserved without the appearance of unwanted spectral deformations, know as rabbit ears [5].

Conclusions

We have proposed and demonstrated a flat-passband 1x43 WSS. With the combination of anamorphic prism pairs and two-axis MEMS mirrors, the port-count can be scaled up while preserving the flat and wide passband characteristics. The prototype successfully demonstrated 1x43 switching with a transmission bandwidth of ±30 GHz. All 43-ports can handle any single wavelength or multiple wavelengths and can be used as colorless add/drop ports and WDM express ports to build a multi-degree ROADM.

References

1 L. Zong et al., Proc. OFC'06, NThC3, (2006).
2 D. M. Marom et al., Proc. OFC'02, FB7 (2002).
3 P. Wall et al., Proc. OFC'08, OWC1, (2008).
4 J.-C.Tsai et al., Photon. Technol. Lett., **18**, 1439 (2006).
5 D. Dahan et al., Proc. OFC/NFOEC'08, JThA108 (2008)