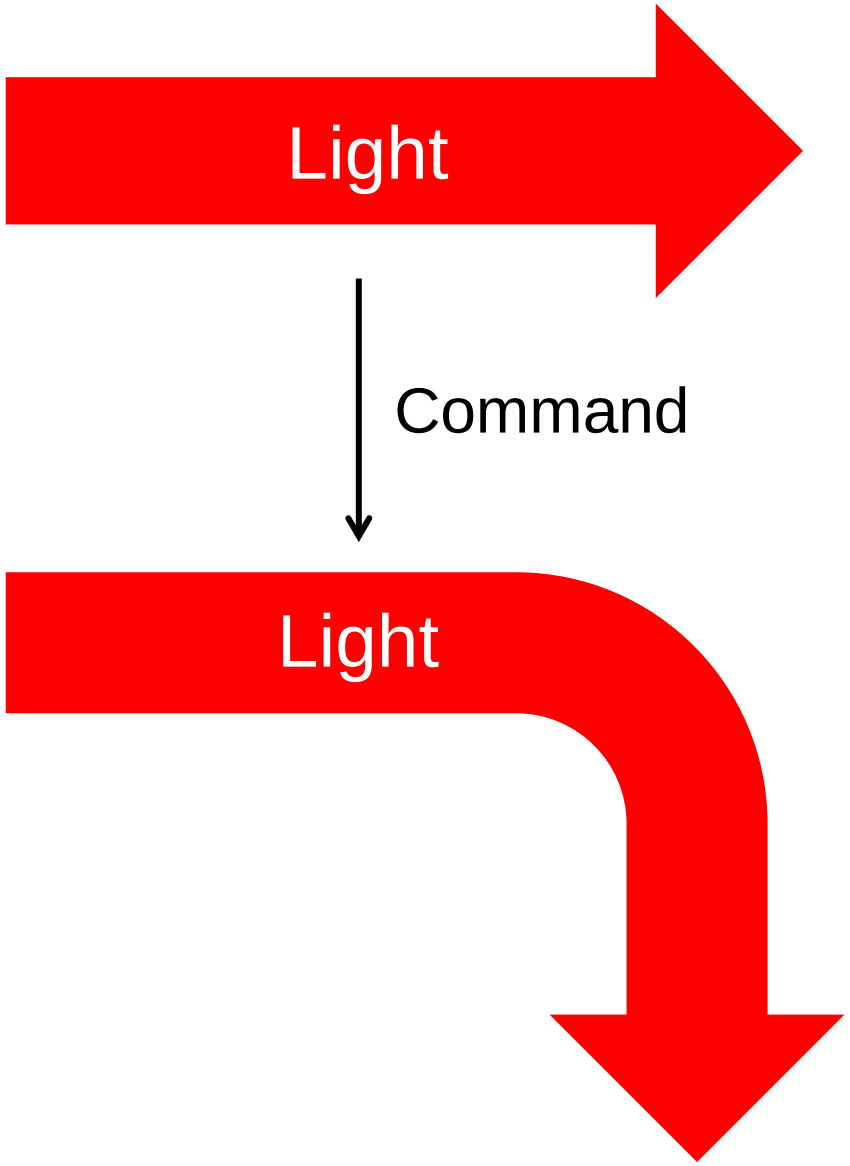
Optical Switches

Lecture 25, Fall 2012

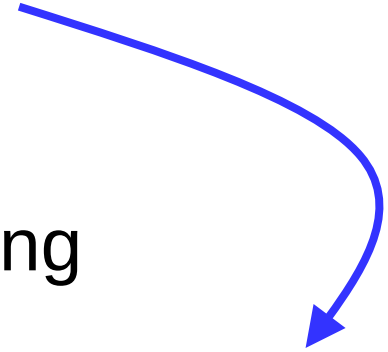
What is an optical switch?



Applications for Optical Switches

From Section 6.1.2 of the Vlachos chapter:

- Fast Provisioning
- Packet Switching
- Protection Switching



  - Optical Cross Connect (OXC)
    → switch everything in a fiber or wavelengths at network nodes as part of the routing process
  - Optical Add/Drop Multiplexer (OADM)
    → add and drop wavelengths at network aggregation points

What is the difference between a switch and a router?

A switch is used to direct the flow of traffic in order to connect nodes within a single network.
→ Ethernet switches

A router is used to direct the flow of data in order to connect nodes in two different networks
→ Key component for the Internet

Is all-optical switching faster than OEO switching?

Conventional Optical Switching → Data remains in the optical domain, but we use electronics to control the switch.

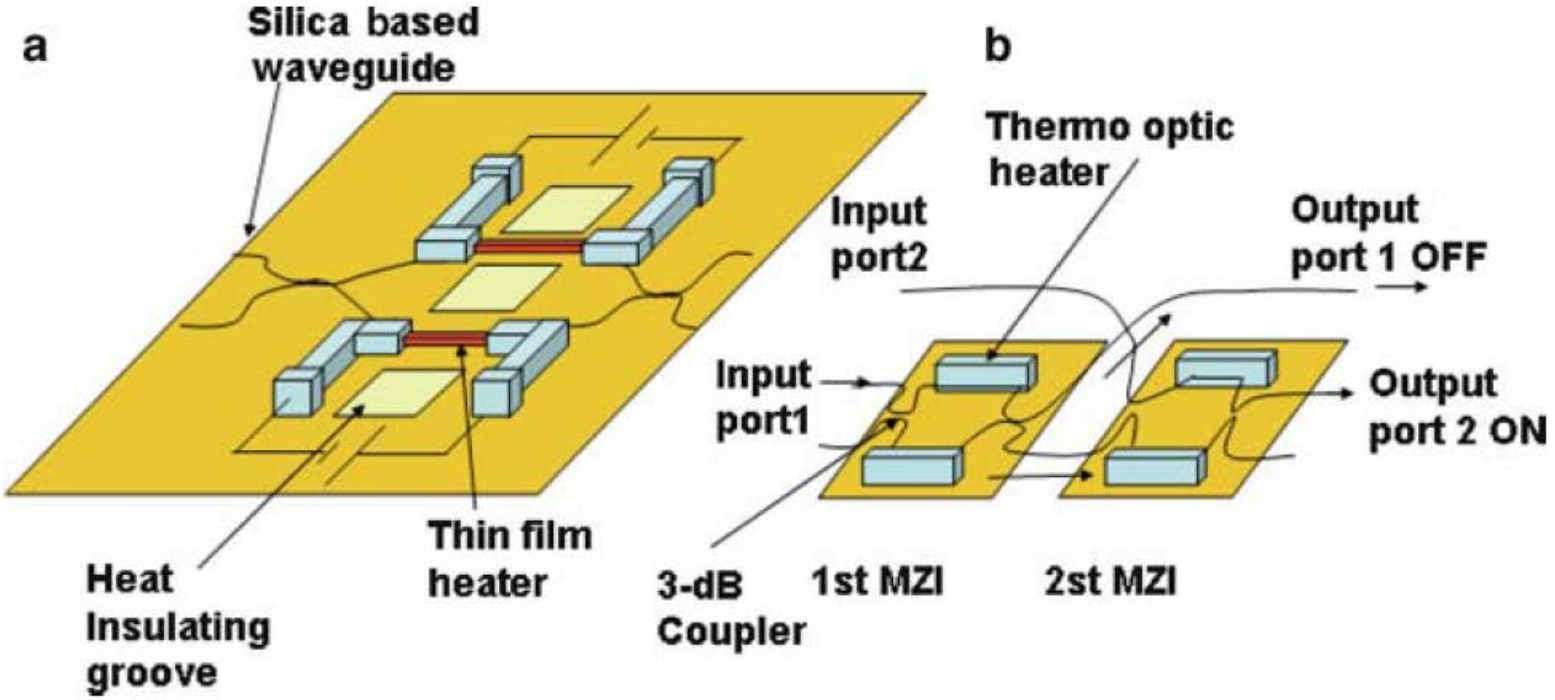


Fig. 6.19 Schematic of two thermo-optic Mach–Zehnder switches: **(a)** simple structure **(b)** double structure

Is all-optical switching faster than OEO switching?

Conventional optical switches are slower than electronic switches, which require OEO conversion.

Only electronic switches are fast enough to do packet switching, so we use them when we need to switch packets even though OEO conversion is expensive and consumes a lot of energy.

We can use optical switches for circuit switching, which avoids OEO and delays associated with packet switching.

Is all-optical switching faster than OEO switching?

All-Optical Switching → Data remains in the optical domain, and we use an optical signal to control the switch.

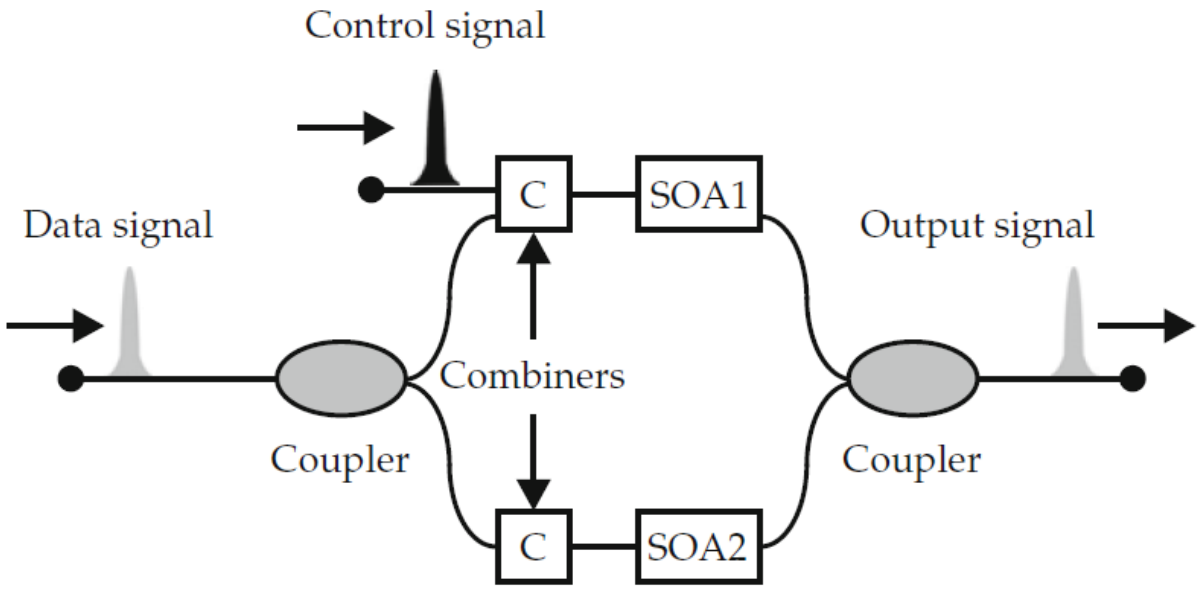


Fig. 6.23 SOA-based Mach–Zehnder interferometer switch

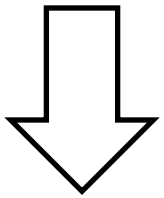
Is all-optical switching faster than OEO switching?

All-optical Switches can in principle be faster than electronic switchers and some ultra-fast all-optical switches have been demonstrated, but

- they are still in the research stage
- although ultra-fast they may have undesirable properties such as high-power consumption or instability
- the majority of optical switches that have been demonstrated are actually slower than switches

Are there other reasons to do OEO other than for packet switching?

The Three R's



We can re-amplify signals in the optical domain but we cannot reshape or re-time them.

Erbium-doped fiber optical amplifiers have very low noise and can simultaneously amplify 100's of signals at different wavelengths for WDM systems.

In optical switches, how is the modulation and deflection of light achieved?

Table 6.1 Summary of the main characteristics of some of the available technologies

Technology	Advantages	Disadvantages	Applications
Moving fiber	Low loss and low crosstalk	Long switching and stabilizing time, poor scalability	Protection, OADMs
MEMS	Small size	Low reliability due to moving parts	Large OXC
Bubble	Easy to integrate	Long switching time (down to 10 ms), limited reliability, high power consumption	Protection/restoration, OADM, medium OXC
Thermo-optic	Easy to integrate	Long switching times, high loss and crosstalk, high power consumption	Protection/restoration, OADM, medium OXC
Liquid crystal	Good reliability	Temperature-dependent slow switching time (ms)	Protection/restoration, small OXC and OADM
Electro-optic	Fast switching	Medium loss and high crosstalk Polarization-dependent and poor scalability	Protection/restoration, OADM, packet/burst
Acousto-optic	Flexible switching	Medium loss and complexity	Protection/restoration, small OXC and OADM
Electro holography	Highly flexible and (possible) built in wavelength demultiplexing	Medium loss and high power	Protection/restoration, Small OXC and OADM
SOA	Fast switching, gain amplification	Noise addition, actually moderately expensive	Protection/restoration, OADM, packet or bust switching

Switch Types

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How do MEMs switches work?