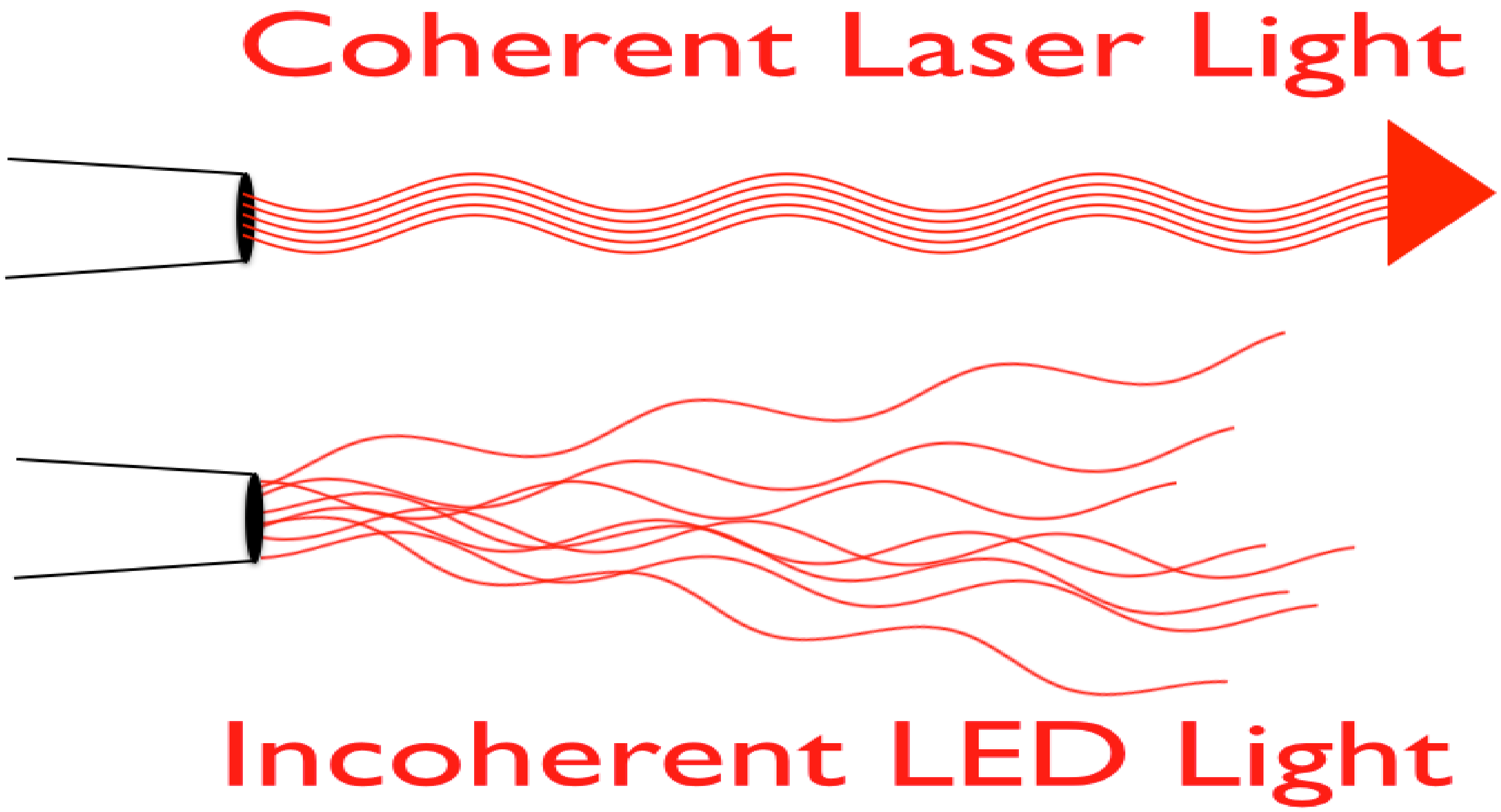


Module – 3
Optical Transmitters

Single Mode Lasers

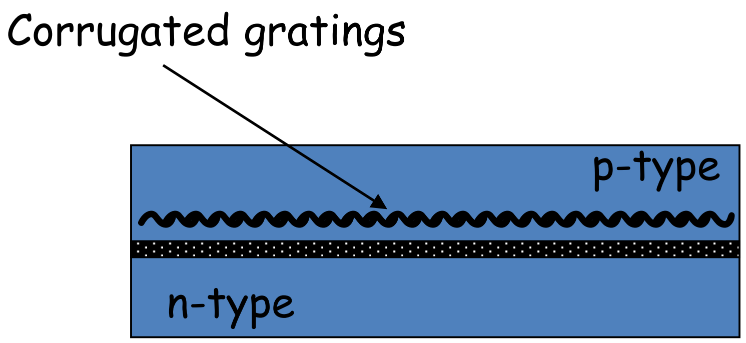
- SLM Lasers

- Single Mode Lasers
  - Single longitudinal mode & Single transverse mode
  - External Cavity Lasers
  - Quantum Well Lasers
  - DFB - Distributed FeedBack Lasers
    - Reflector function distributed over the AR
  - DBR – Distributed Bragg Reflectors
    - Signal Current, Control Current
  - VCSEL – Vertical Cavity Surface Emitting Lasers

DFB - Distributed FeedBack Lasers

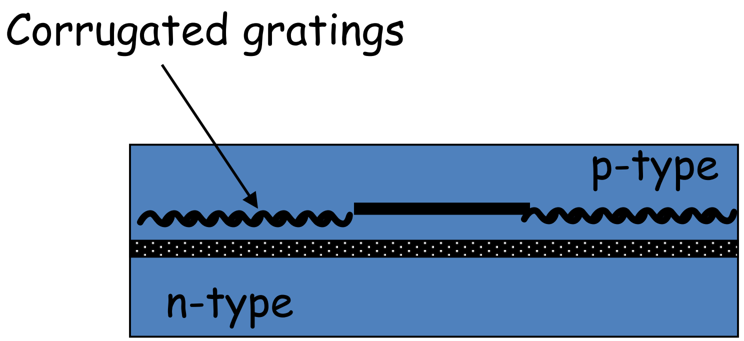
- Reflector function distributed over the AR
- Distributed Bragg Diffraction Grating etched on a passive cladding layer above AR
- Grating period $\Lambda = m \lambda_B / 2 n_e$; $m \sim 1$

$\lambda_B \rightarrow$ Bragg wavelength



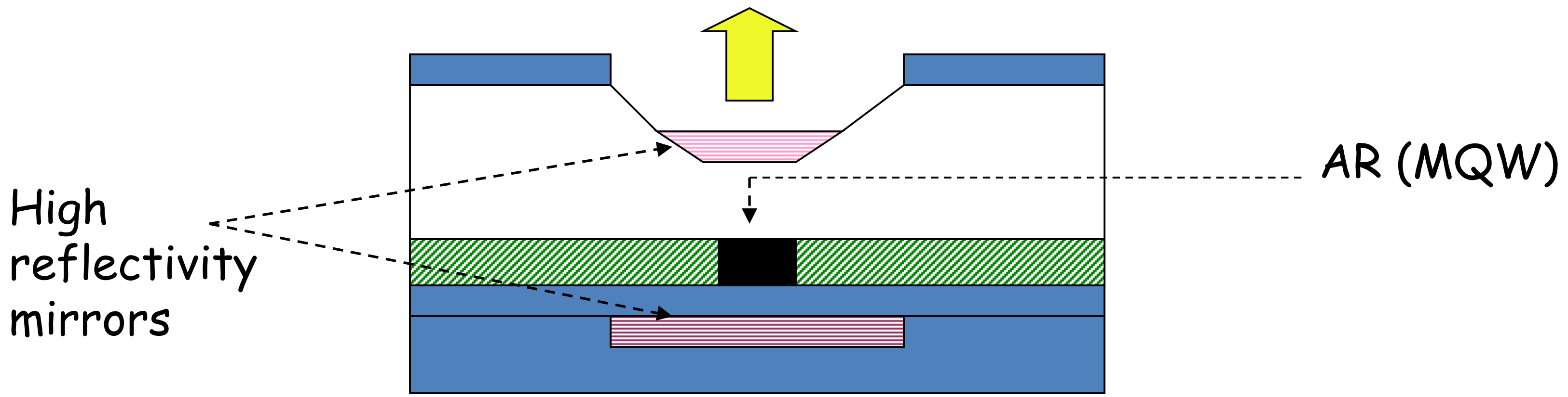
DBR - Distributed Bragg Reflector Laser

- Reflector function distributed but separated from the AR (pumped region)
- High efficiency & high output capability
- Loss slightly increased
- Useful for tuning purpose ; temp. tuned / current tuned
- (0.1 nm / ^{o}C , 0.8 x 10^{-2} to 4.0 x 10^{-2} nm / mA)



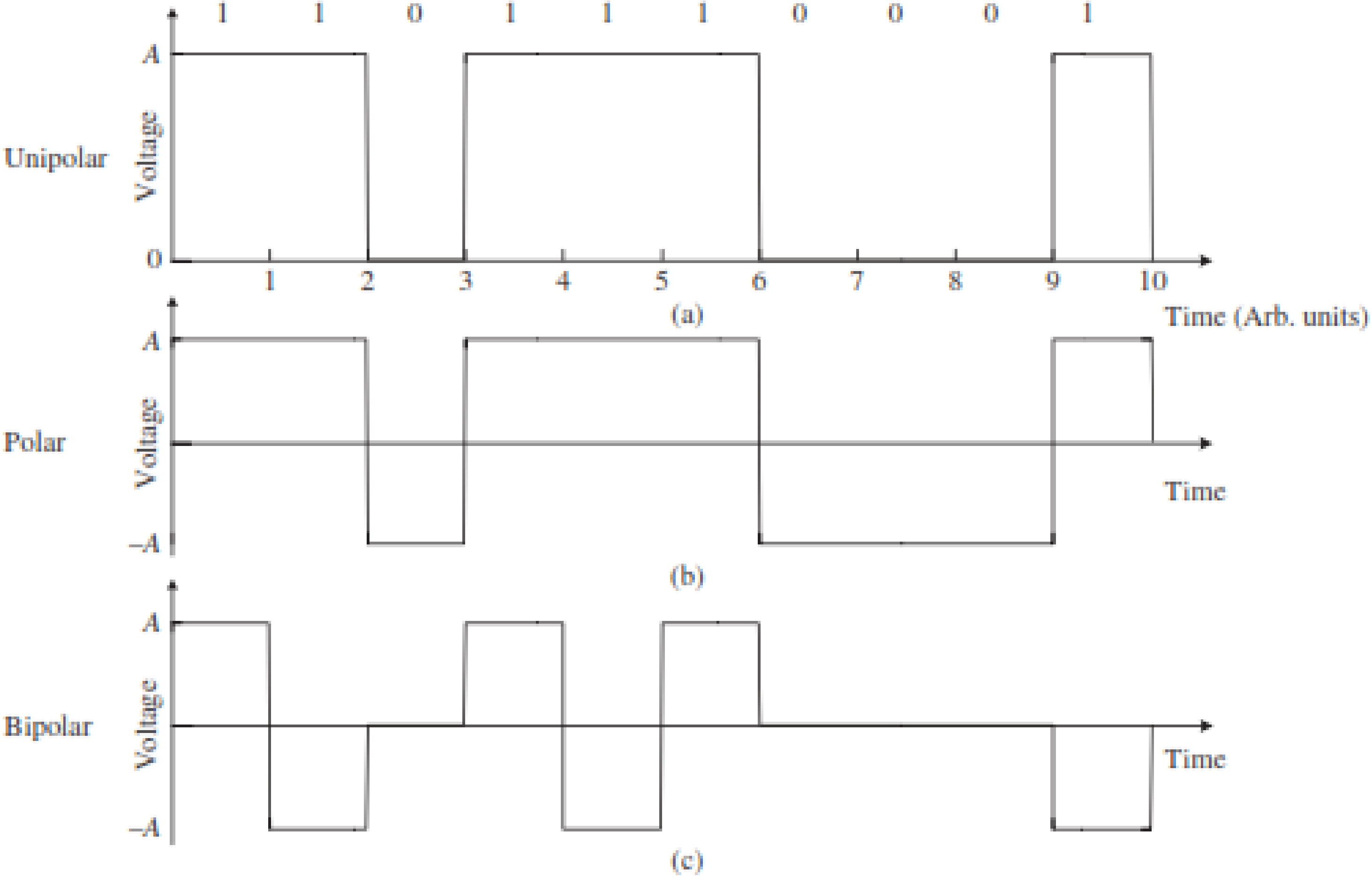
VCSEL – Vertical Cavity Surface Emitting Lasers

- AR volume small , threshold currents < 100 μA
- Greater modulation bandwidths
- Integration of multiple lasers on a single chip ; 1D / 2D array

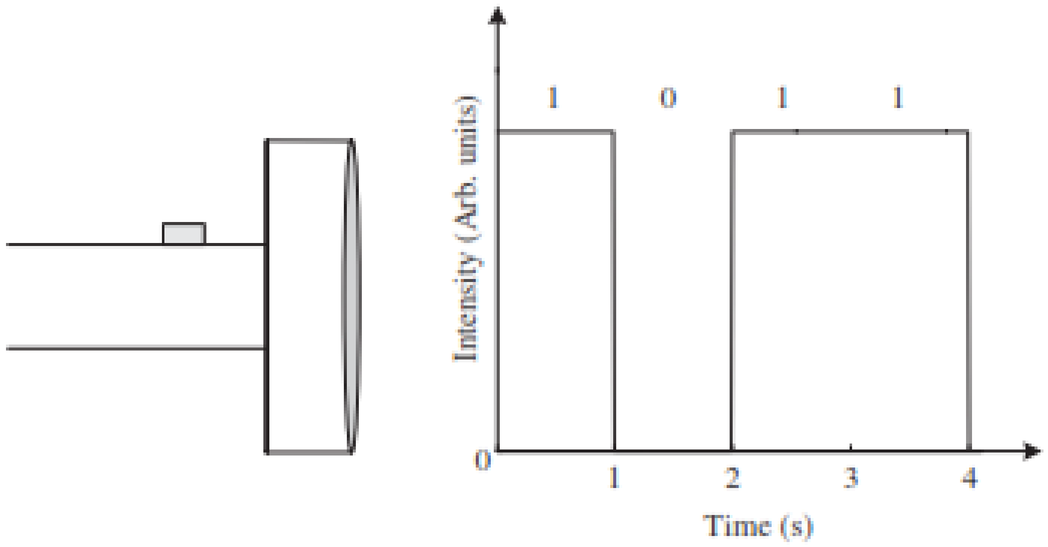


OPTICAL MODULATORS

Line coding schemes



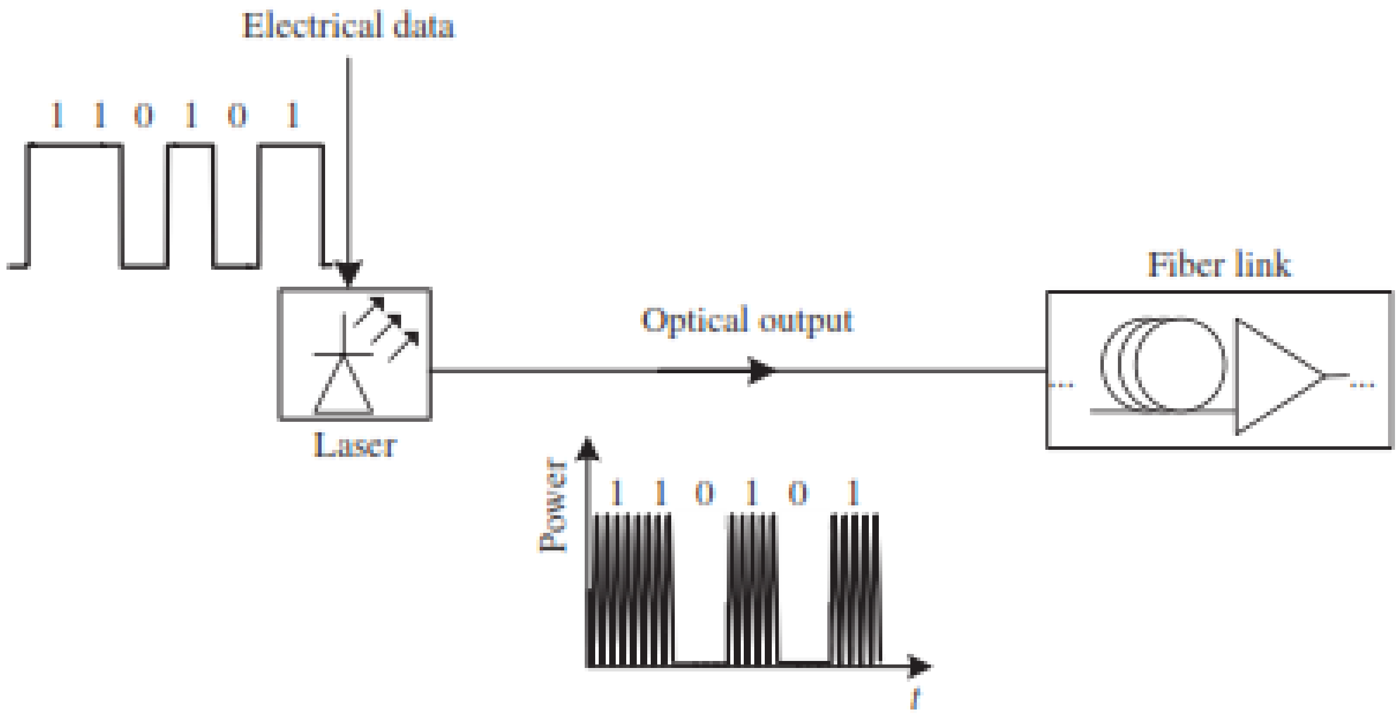
Flash light – Simplest modulator



Types of optical modulation

- Direct Modulation
- Indirect Modulation

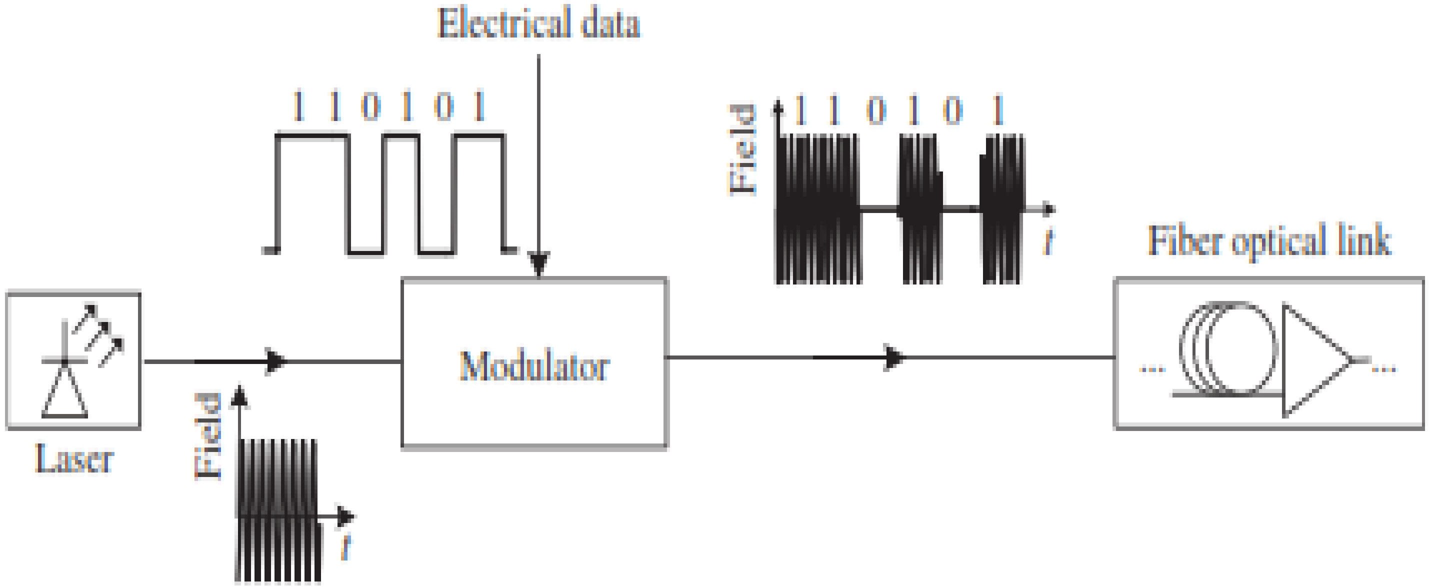
Direct Modulation (Internal)



Direct Modulation

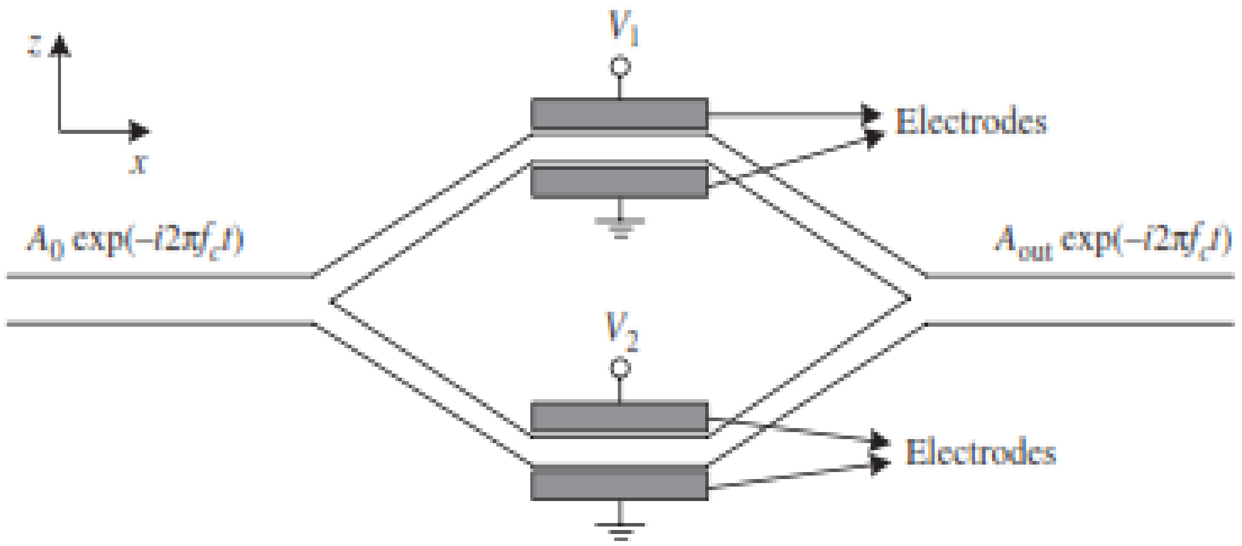
- Direct modulation on semiconductor lasers:
  - Output frequency drifts
    - carrier induced (chirp)
  - Limited modulation depth
  - Limited bit rate (<10 Gb/s) and distance (< 100 Km)

External Modulation



- Mach Zehnder (MZ) Modulator
- Electro Absorption (EA) Modulator

Mach Zehnder Modulator (MZM)



- Constructive interference (Output = on)
- Destructive interference (Output = off)

Mach Zehnder Modulator (MZM)

- MZM works on electro optic effect
- R.I changes with respect to applied voltage

$$\Delta n = -\frac{1}{2}\Gamma n^3 r_{33}(V/d_e) \Rightarrow \Delta\phi = \frac{2\pi}{\lambda}\Delta n L$$

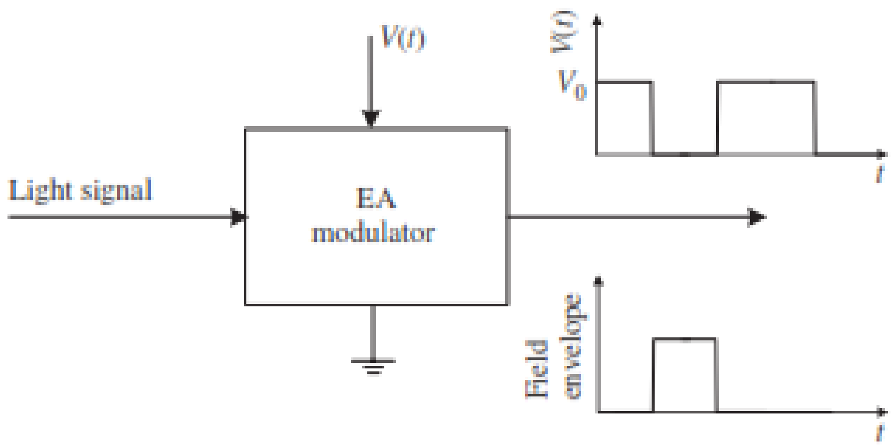
Δn – change in the R.I
$\Delta\Phi$ - phase change
r_{33} – electro optic coefficient of LiNbo3
d_e- separation of electrodes
L – length of electrodes

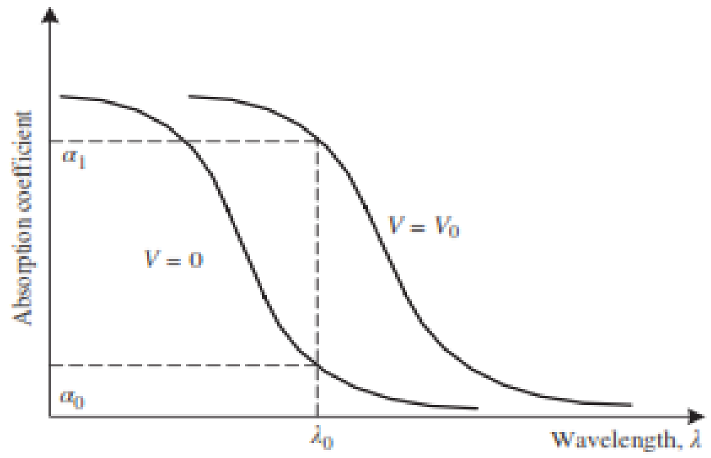
Mach Zehnder Modulator (MZM)

$$E_{\text{out}}(t) = \frac{1}{2}\left[\exp\left(j\frac{\pi}{V_\pi}V_1(t)\right) + \exp\left(j\frac{\pi}{V_\pi}V_2(t)\right)\right]E_{\text{in}}$$

v_π – differential drive voltage (V_1-V_2=V_π)

Electroabsorption Modulator (EAM)





Electroabsorption Modulator (EAM)

- The optical power exiting at the modulator is

$$P_{out} = \begin{cases} P_{max} = P_0 \exp(-\alpha_0 L) & \text{when } V(t) = 0 \\ P_{min} = P_0 \exp(-\alpha_1 L) & \text{when } V(t) = V_0 \end{cases}$$

L – Length of the modulator

P_0 – Input power

- The extinction ratio is

$$\delta = \frac{P_{max}}{P_{min}} = \frac{\exp(-\alpha_0 L)}{\exp(-\alpha_1 L)}.$$

Merits and demerits of EAM

- Easily integrated with laser diode

- Residual chirps
- Low extinction ratio