Optical Networks

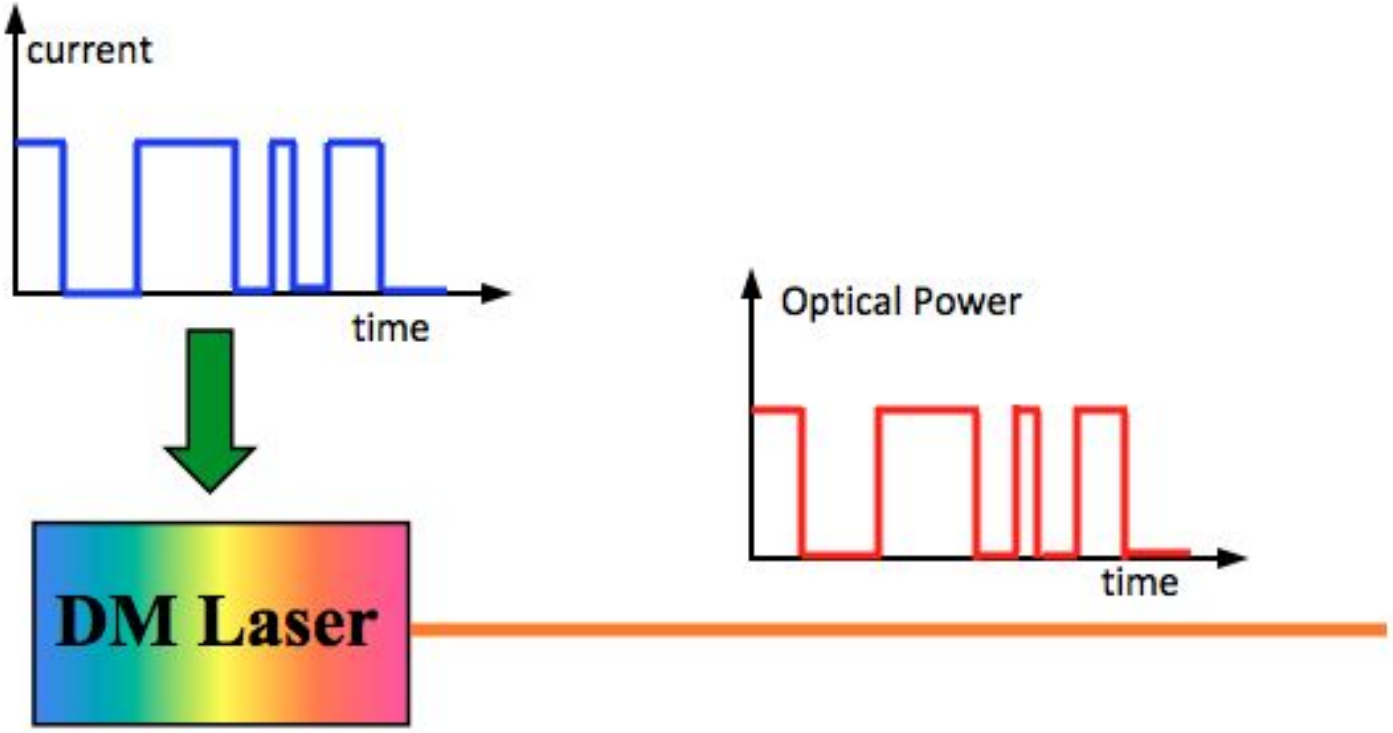
School of Information Systems Engineering

Week 9:
Optical Modulators

Week 9: Optical Modulators

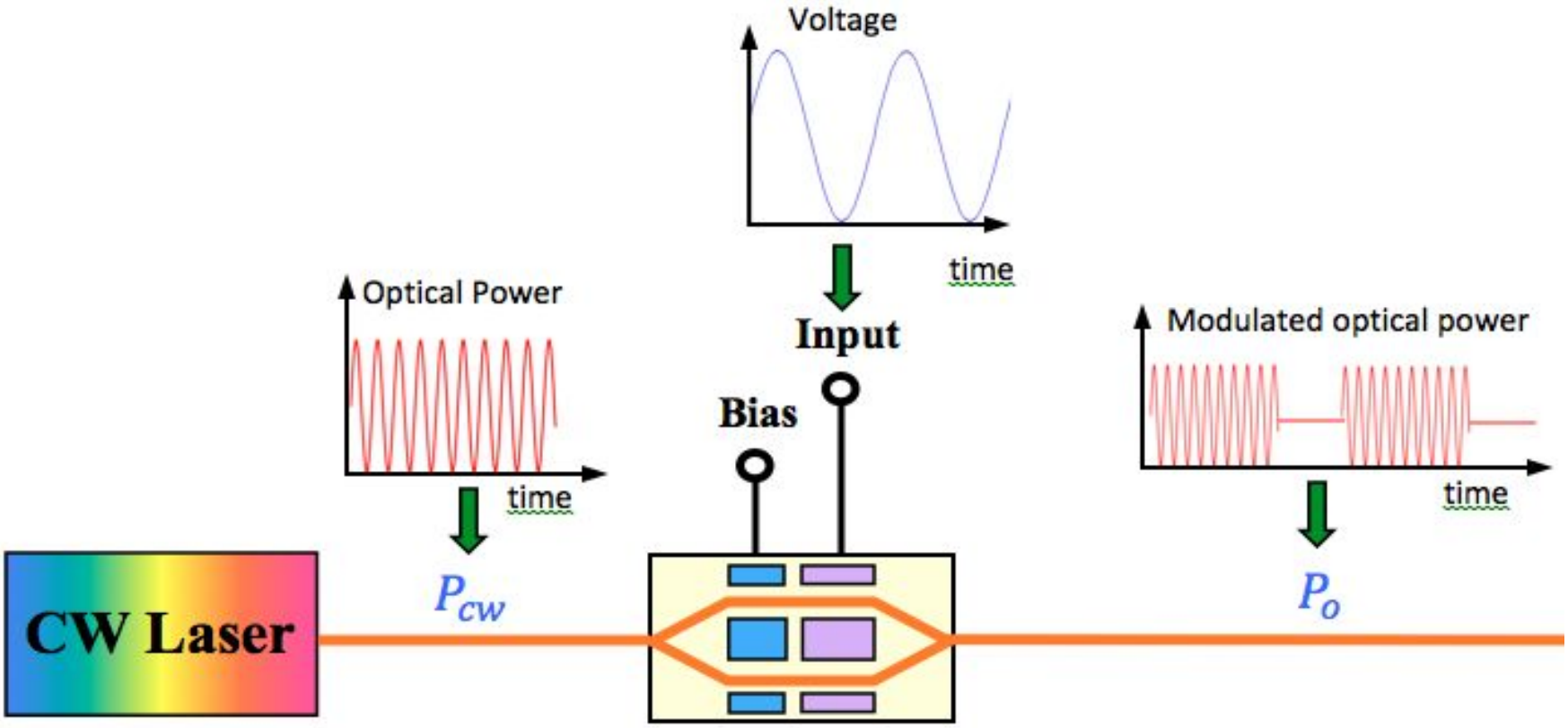
1. Advantage of external modulation over direct modulation.

Direct Modulation



Week 9: Optical Modulators

External Modulation



Week 9: Optical Modulators

1. Advantage of external modulation over direct modulation.

1) Broad Bandwidth
2) Large extinction ratio
3) Excellent spectral purity
4) High Power handling capability
5) Removes degrading effects of direct modulation such as chirping and laser line width stability

Week 9: Optical Modulators

2. Explain the principle of electro-optic phase modulator and electro-optic intensity modulator.

Electro-optic Phase Modulator

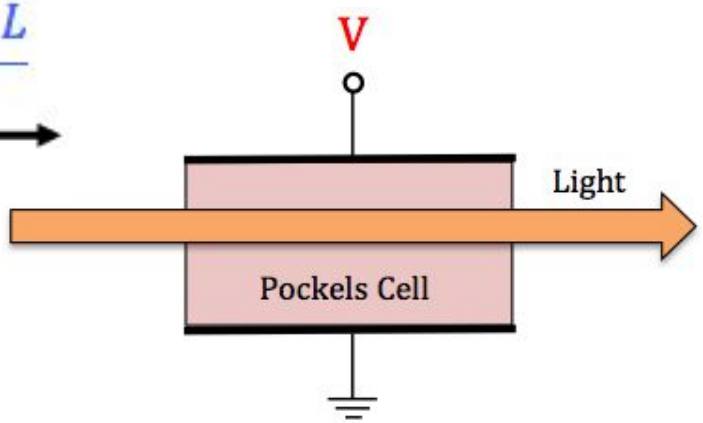
Pockels effect: A change in the refractive index of an optical medium induced by a constant or varying electric.

$$\Delta n = \frac{1}{2} r n^3 E \qquad \Delta n \propto E$$

Pockels effect occurs in crystals lattice such as lithium niobate

Phase modulator: When a beam of light traverses a pockels cell in which an electric field is applied, it undergoes a phase shift

A change in E $\xrightarrow[\text{causes}]{\Delta n = \frac{1}{2} r n^3 E}$ change in n $\xrightarrow[\text{causes}]{\Delta t = \frac{\Delta n . L}{c}}$ change in t $\xrightarrow[\text{causes}]{\Delta \varphi = \omega \Delta t}$ change in φ



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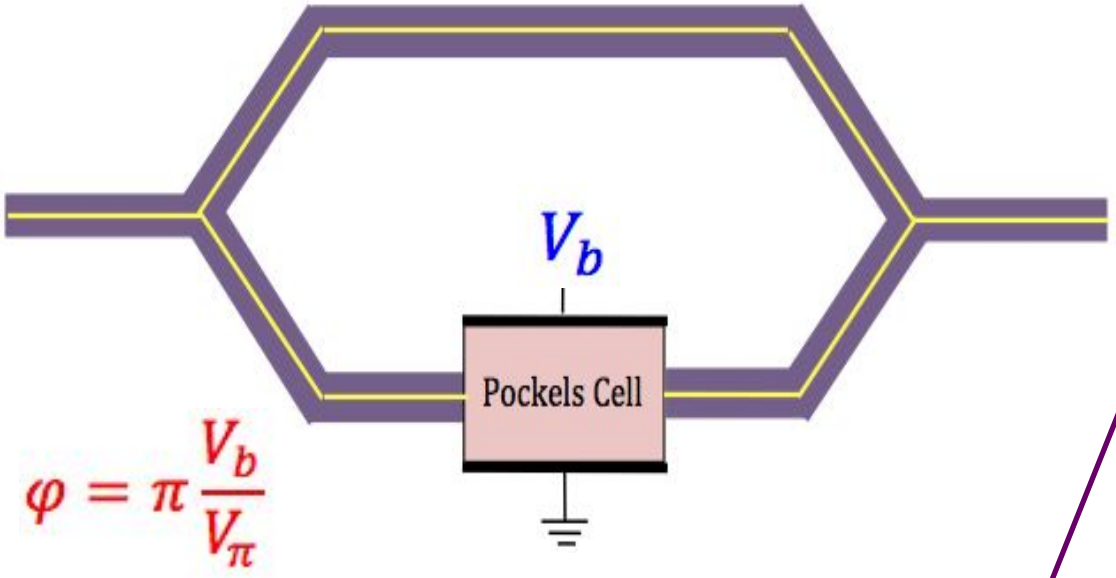
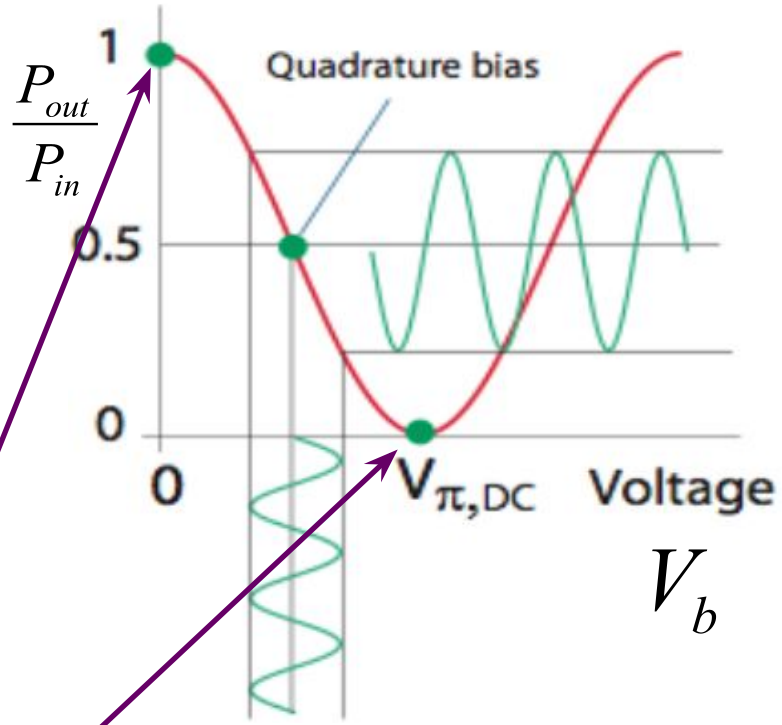
Electro-optic Intensity Modulator

- Phase modulation is converted into amplitude modulation with the help a Mach-Zehnder interferometer (MZI)





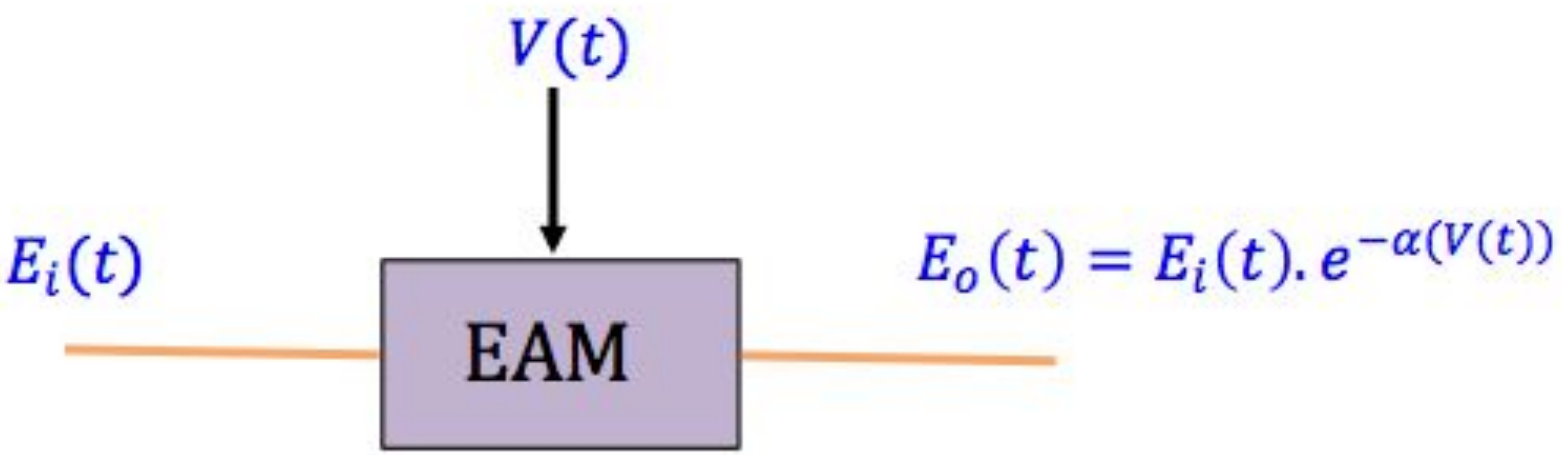
- When $V_b = 0$ ⟹ Constructive interference
- When $V_b = V\pi/2$ ⟹ Most linear point
- When $V_b = V\pi$ ⟹ Destructive interference

Week 9: Optical Modulators

3. Explain the concept of electro-absorption effect.

A change in the optical absorption coefficient caused by an applied electric field

➡ Change the intensity of light



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Electro-optic modulator

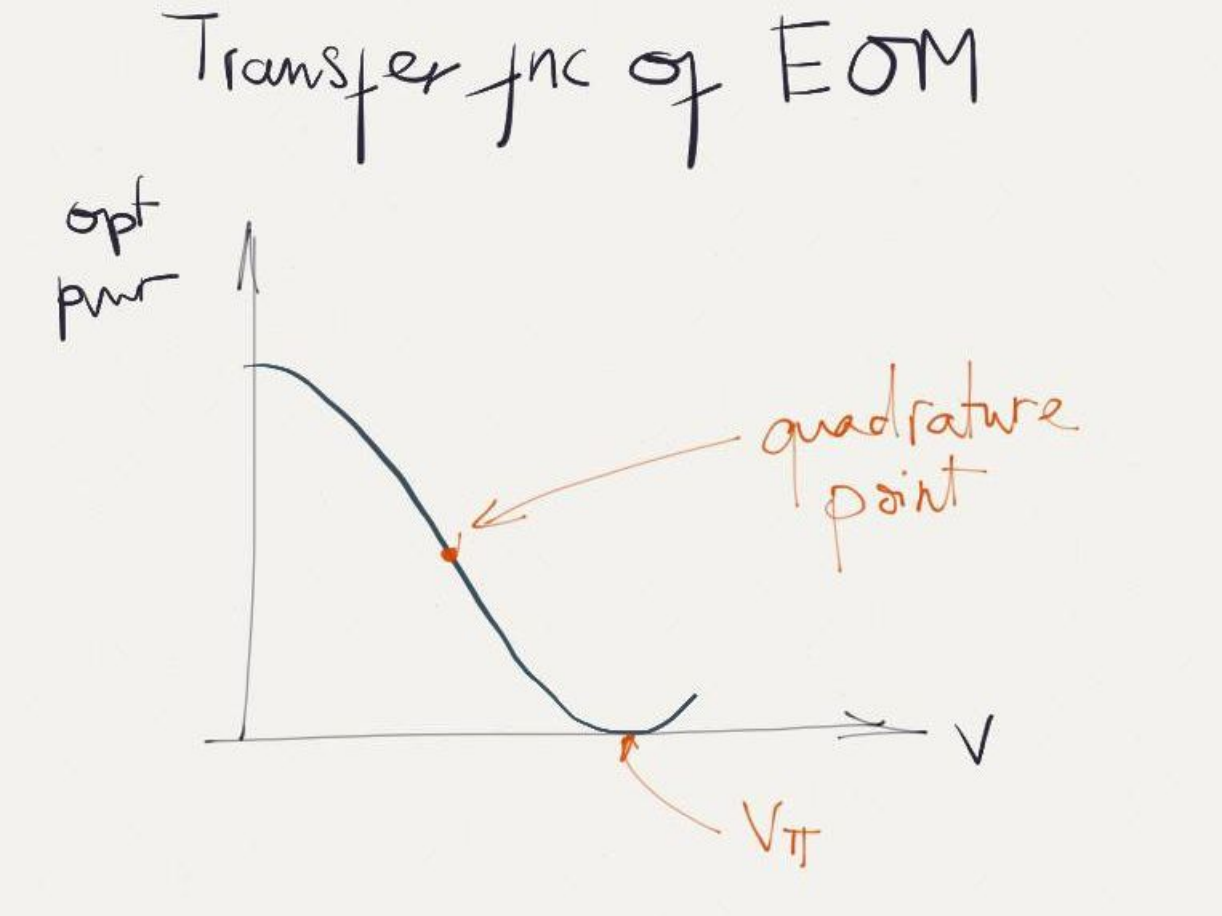
Change optical path length with applied electric field.

Electro-absorption modulator

Change amount of light absorbed with applied electric field.

Week 9: Optical Modulators

4. For EO Intensity modulators, why do we need to bias at quadrature point?



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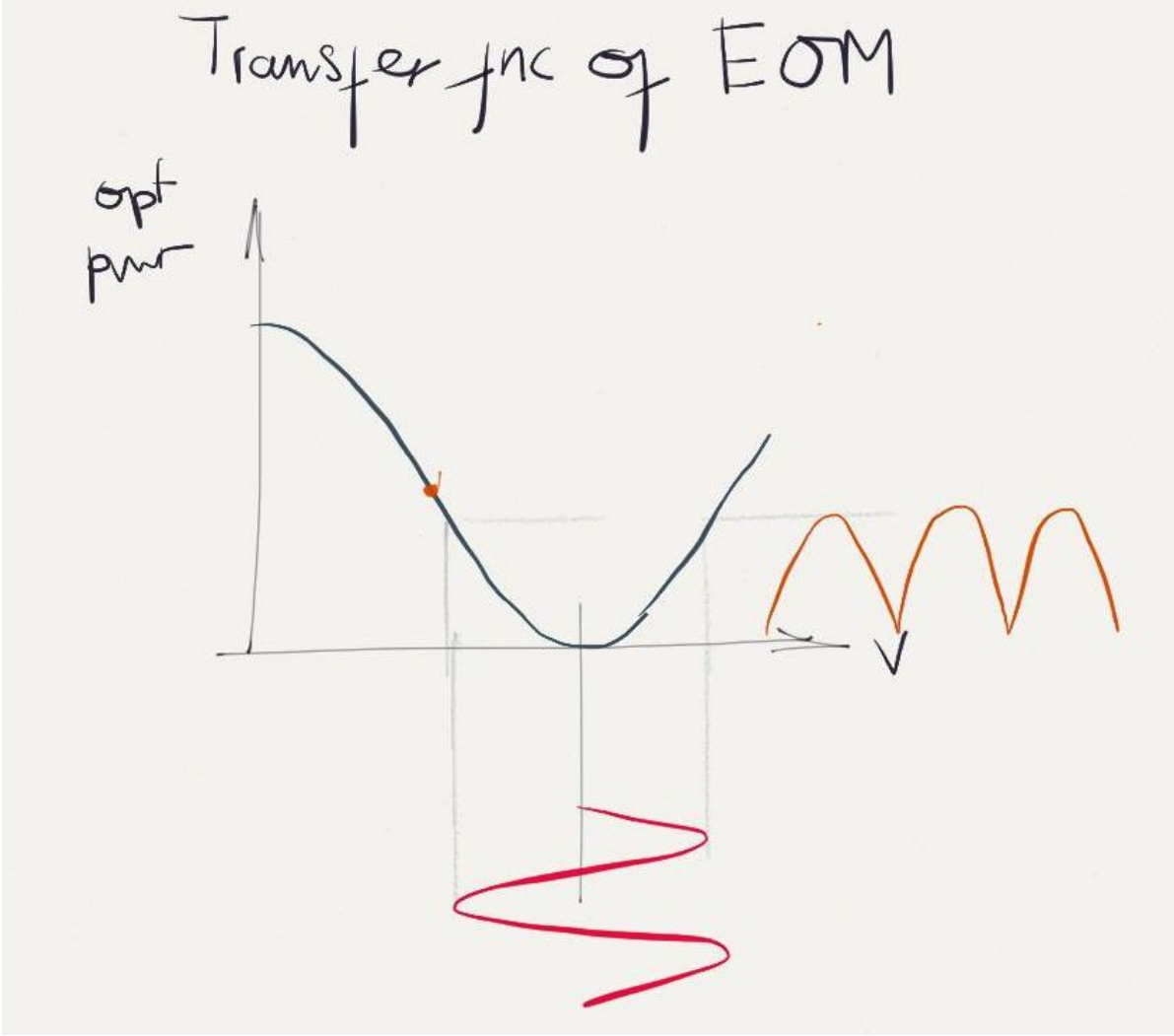

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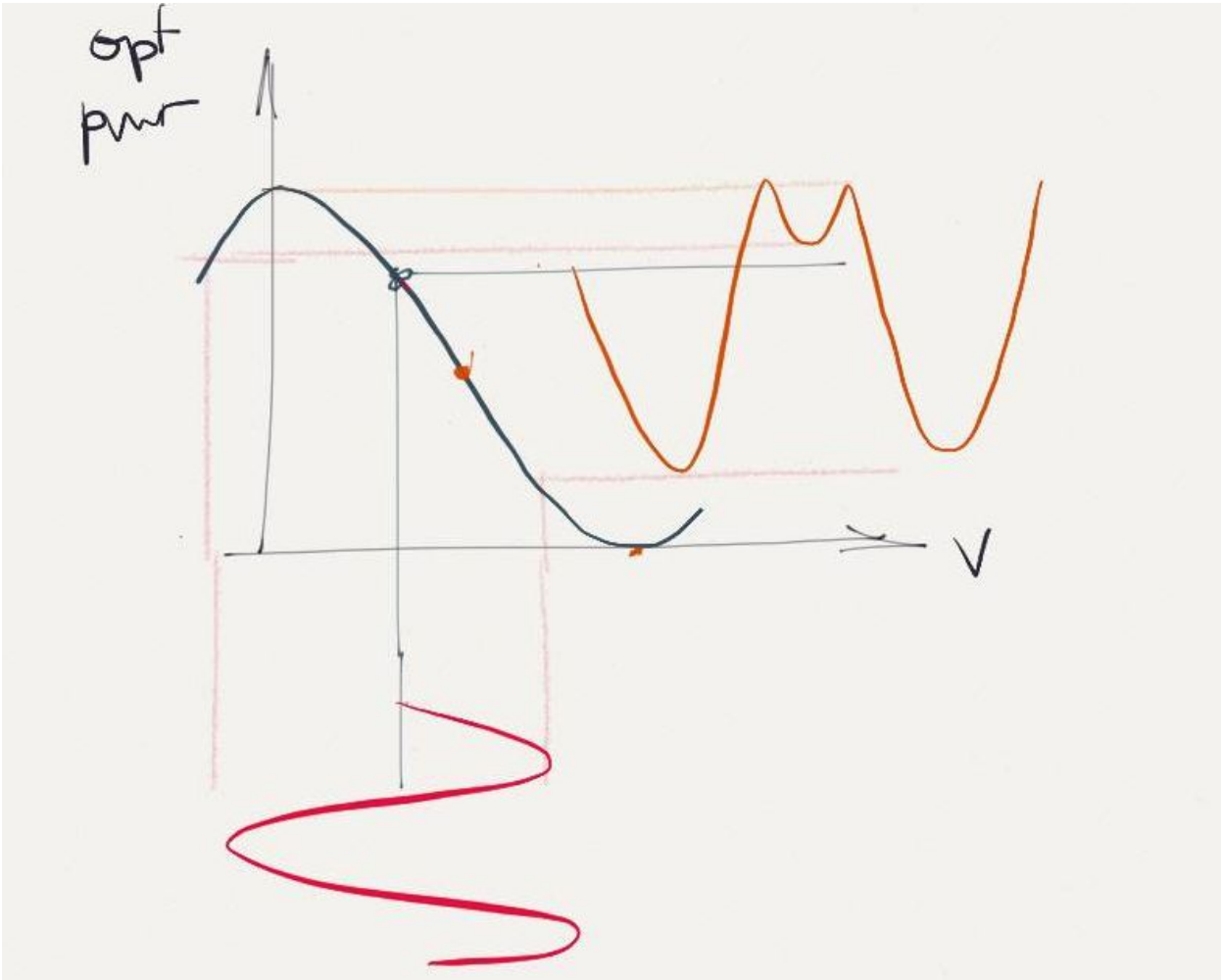

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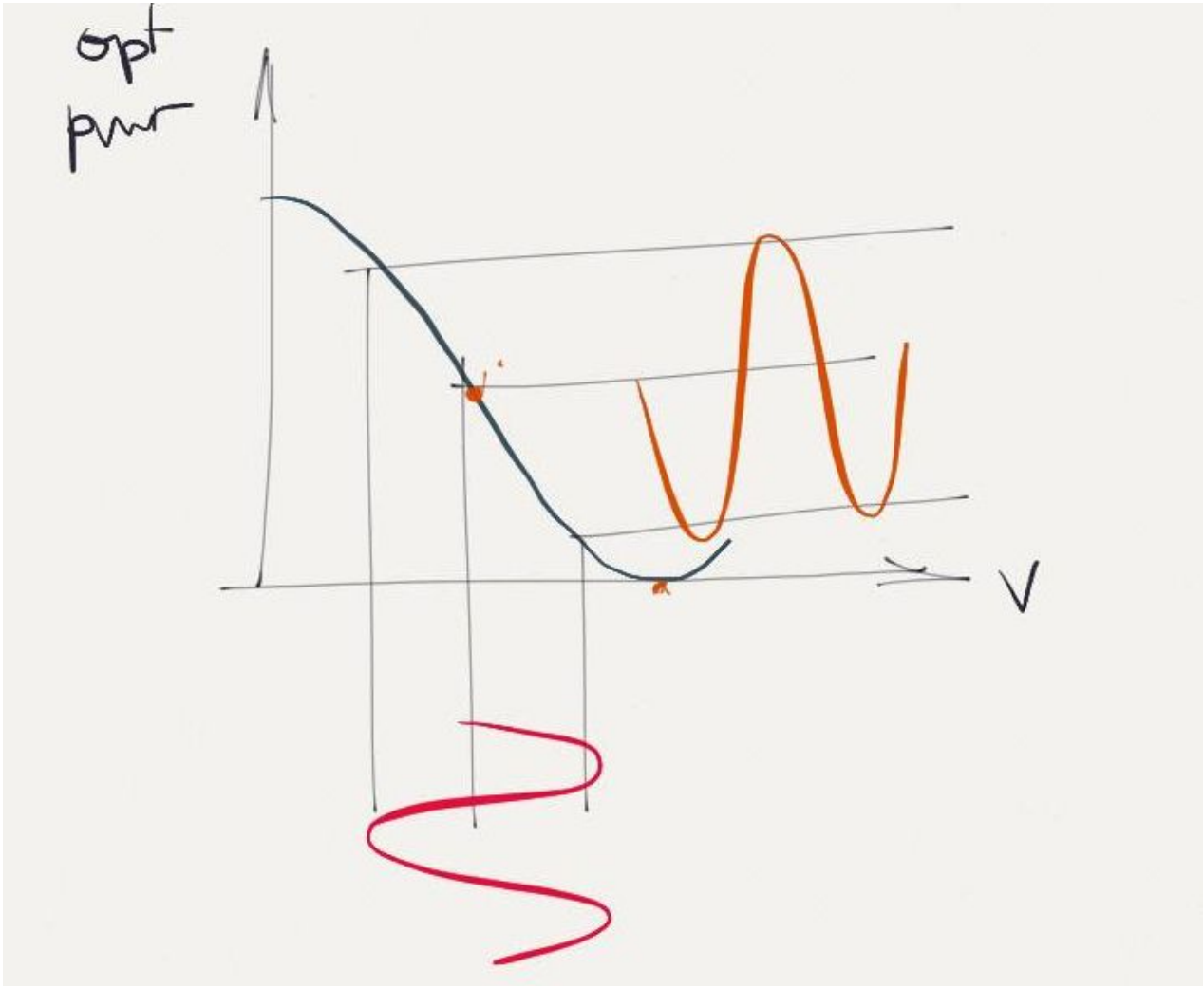

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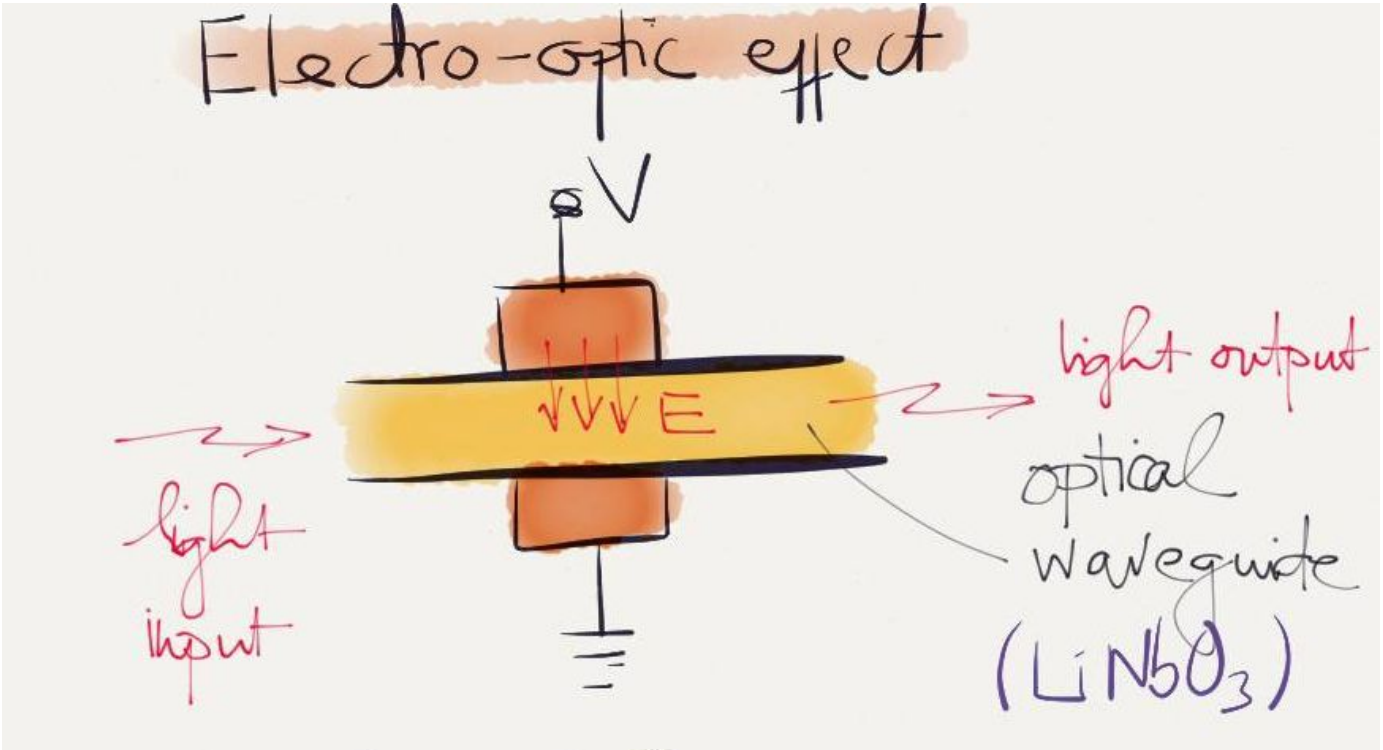
5. How to increase the EOM bandwidth?



n ↗ when V ↗

→ phase of light ↗

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