Karlsruhe Institute of Technology

Optical Communications Lab

Experiment 7

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1. Preparation

1.1 The Mach-Zehnder Modulator

In a Mach-Zehnder Modulator the light is split up in two branches. In each branch there is a non-linear medium, through which the Phase of the Light can be shifted. At the end the Light is brought together, so that it is interfering. This setup is shown in Figure 1.1. The Amplitude of the Field at the end of the Modulator can be expressed as:

$$E_{\text{out}} = \exp\left(j\frac{\vartheta_1 + \vartheta_2}{2} + j\frac{\vartheta_{\text{Bias}}}{2}\right) \cdot \cos\left(\frac{\vartheta_1 - \vartheta_2}{2} + \frac{\vartheta_{\text{Bias}}}{2}\right) \cdot E_{\text{in}}. \tag{1.1}$$

The phase shift of the Signal at the output of the modulator is described by the first term, the amplitude by the second term. For the phase Modulation $\vartheta_1 = \vartheta_2$ only the phase of the Signal is changed while the Amplitude stays constant. This operation mode is called "'push-push"' mode. For $\vartheta_1 = -\vartheta_2$ only the Amplitude of the Signal is modulated. This operation mode is called "'push-pull"' mode. **(Null-point vs. quadrature point)** [1] ToDo

1.2 Modulation Formats

1.2.1 Amplitude Shift Keying

In Amplitude Shift Keying (AFK) information is transmitted by the signal amplitude. The level of the signal amplitude defines a binary value. There is the case "On/Off keying" (OOK) where the binary symbol is "0" when there is no power transmitted. It's a "1" when there is power transmitted. Figure 1.3a) shows such an ASK signal.

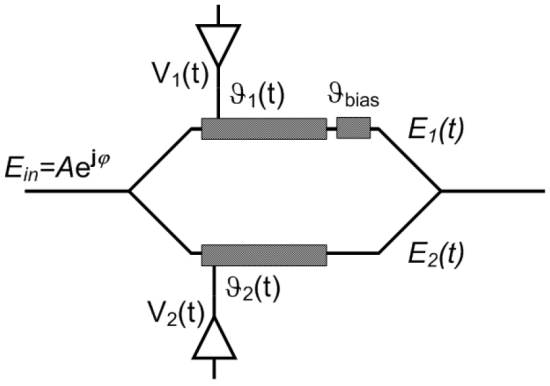

Figure 1.1

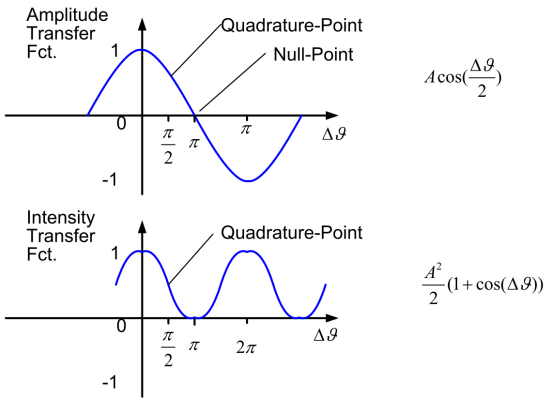

Figure 1.2

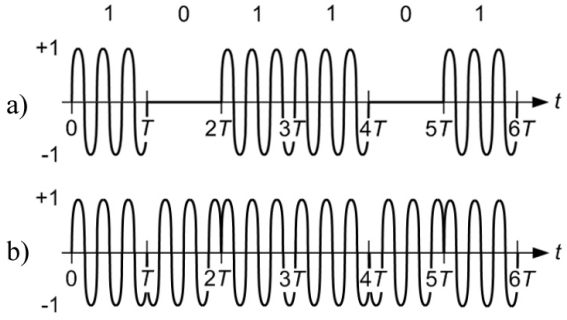

Figure 1.3 – **a)** Amplitude Shift Keying **b)** Phase Shift Keying

1.2.2 Phase Shift Keying

In Phase Shift Keying (PSK) information is transmitted by modulating the phase of a carrier wave. Because the amplitude and the freuency of a carrier wave is not changed, the intensity of the signal is constant and thus not influenced by non-linear effects. An example for a psk modulated signal is shown in Figure 1.3b)

1.2.3 Quadrature Amplitude Modulation

1.3 Signal Generation

1.4 RZ Signal Generation

Bibliography

[1] Leuthold, J. : *Optical Communication Systems.* WS 2010/2011