Lecture 20

Photonic Signals and Systems

- An Introduction

- By

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- *Text Book Reference: N. A. Riza, Photonic Signals and Systems – An Introduction, McGraw Hill, New York, 2013.*

LC Switches and Time Delay Units

Topics:

- **Optical operation of a classic cube Polarization Beam Splitter (PBS)**. This includes how input light of the two orthogonal, i.e., Vertical and Horizontal direction polarizations flows through the two ports of the PBS given a certain optical power associated with each polarization and the PBS Fresnel Transmittance T and Reflective R Coefficients (for each linear polarization) including their typical values for a classic cube PBS indicating the two PBS ports are not symmetrical in polarization performance –Fig.8.6.

- System design and working principles (electronic control as well as light polarization and optical flow properties flow) of a **TN-NLC device-based freespace beams 1x2 optical switch** assuming perfect performance TN-NLC device and classic cube PBS device.

- System design and working principles (electronic control as well as light polarization and optical properties flow) of a <u>low noise</u> **TN-NLC device-based freespace beams 1x2 optical switch** assuming perfect performance TN-NLC and a classic cube PBS device.

- System design and working principles (electronic control as well as light polarization and optical flow and time delay properties) of **a <u>low noise</u> TN-NLC devices-based freespace beams 1-bit switchable optical Time Delay Unit (TDU) assuming non-perfect performance TN-NLC 90 degree polarization rotation on/off digital control devices and non-perfect performance cube PBS devices**.

Cube PBS Operations with Free-space Input Optical Beams *of p (horizontal) or s (vertical) polarizations*

INPUT Beam is 100 % P-polarized Of Power P_p watts

Ideally one OUTPUT Beam That is the 100 % P-polarized Straight Beam as **Ideally T_p=1 and R_p=0**

INPUT Beam is 100 % S-polarized of Power P_s watts

Ideally one OUTPUT Beam That is the 100 % S-polarized 90 deg Reflected Beam as **Ideally R_s=1 and T_p=0**

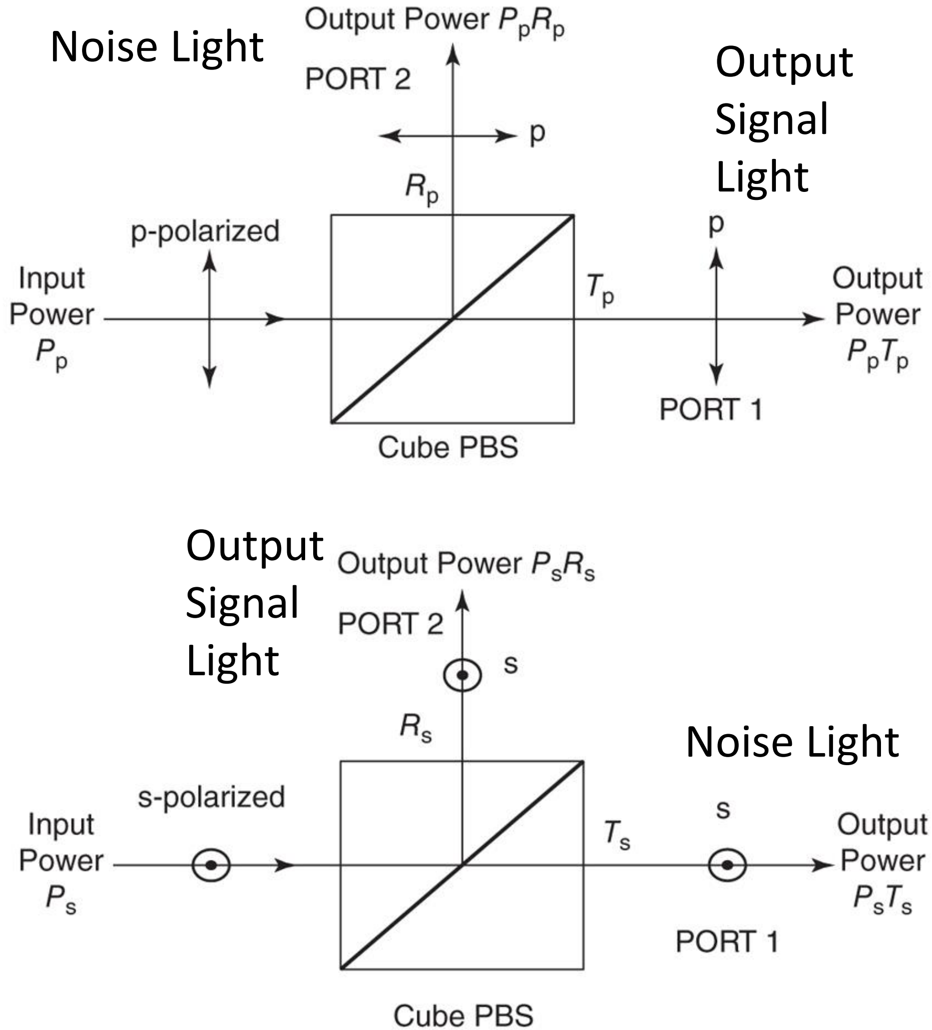

FIGURE 8.6 Operation of a classic cube polarization beam-splitter (PBS).

The Classic Cube PBS

A classic cube polarization beam-splitter (PBS) operates on the principle of linearly polarized light generation by Fresnel reflections off a multilayer dielectric film stack on the diagonal interface face of two sandwiched TIR prisms. Input any state polarized light is split into two orthogonal linear polarizations called s- (vertical) and p- (horizontal) polarizations produced at two spatially independent output ports (Port 1 and Port 2) of the PBS.

The PBS Fresnel irradiance reflection coefficients for p and s polarized light is given by R_p and R_s notations, respectively. These R_p and R_s reflection coefficients indicate what fraction of the input p and s light irradiance (or power) is directed to the PBS reflection port called Port 2 in Figure 8.6.

In a similar way, the PBS Fresnel irradiance transmission coefficients for p and s polarized light is given by T_p and T_s notations, respectively. These T_p and T_s transmission coefficients indicate what fraction of the input p and s light irradiance (or power) is directed to the PBS transmission port called Port 1 in Figure 8.6.

In an **ideal cube PBS**, Port 2 has zero p-light and 100 percent s-light so ideally $R_p = 0$ and $R_s = 1$ and Port 1 has zero s-light and 100 percent p-light so ideally $T_s = 0$ and $T_p = 1$.

In practice, a typical cube PBS Fresnel irradiance coefficient numbers would be $R_p = 0.05$ (or a 5 percent reflection of input p-light) and $R_s = 0.999$ (or a 99.9 percent reflection for s-light), $T_s = 0.001$ (or 0.1 percent transmission of input s-light) and $T_p = 0.95$ (or 95 percent transmission of input p-light). Recall That $T_p + R_p = 1$ and $T_s + R_s = 1$.

Clearly such a **practical cube PBS has an asymmetric performance across the two output ports** and in many photonic system design cases, this aspect would be **detrimental to overall system performance**.

Low Noise LC Freespace Beam 1 × 2 Switch Using Cube PBS

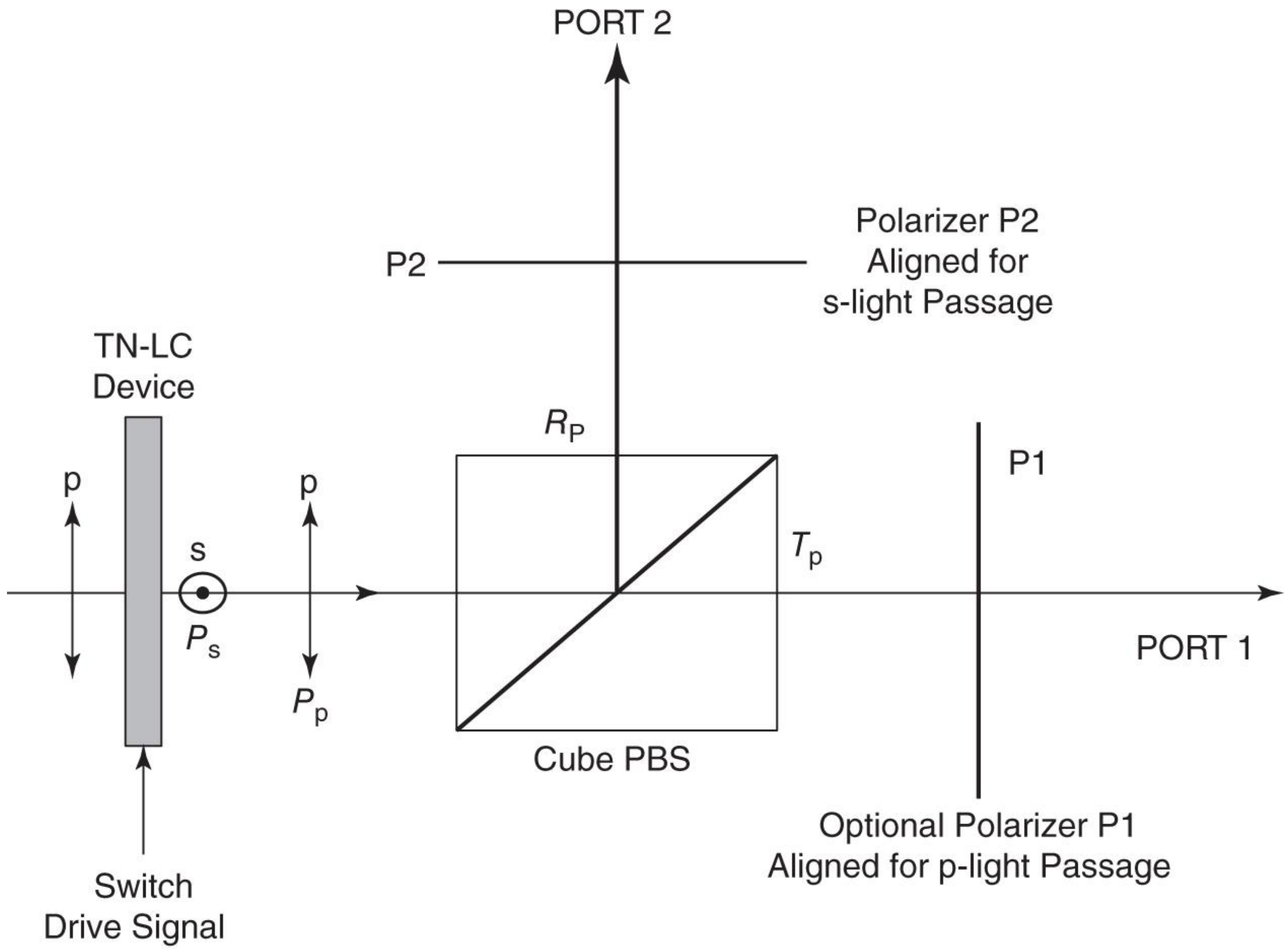

Figure 8.9 The desired higher-performance 1 × 2 switch.

Use of Polarizers at the PBS output ports block the polarization noise created by non-ideal cube PBSs.

Low-Noise LC 1-Bit (2 state) Freespace Time Delay Unit Using cube PBSs and TN-LC on/off Polarization Rotation Devices

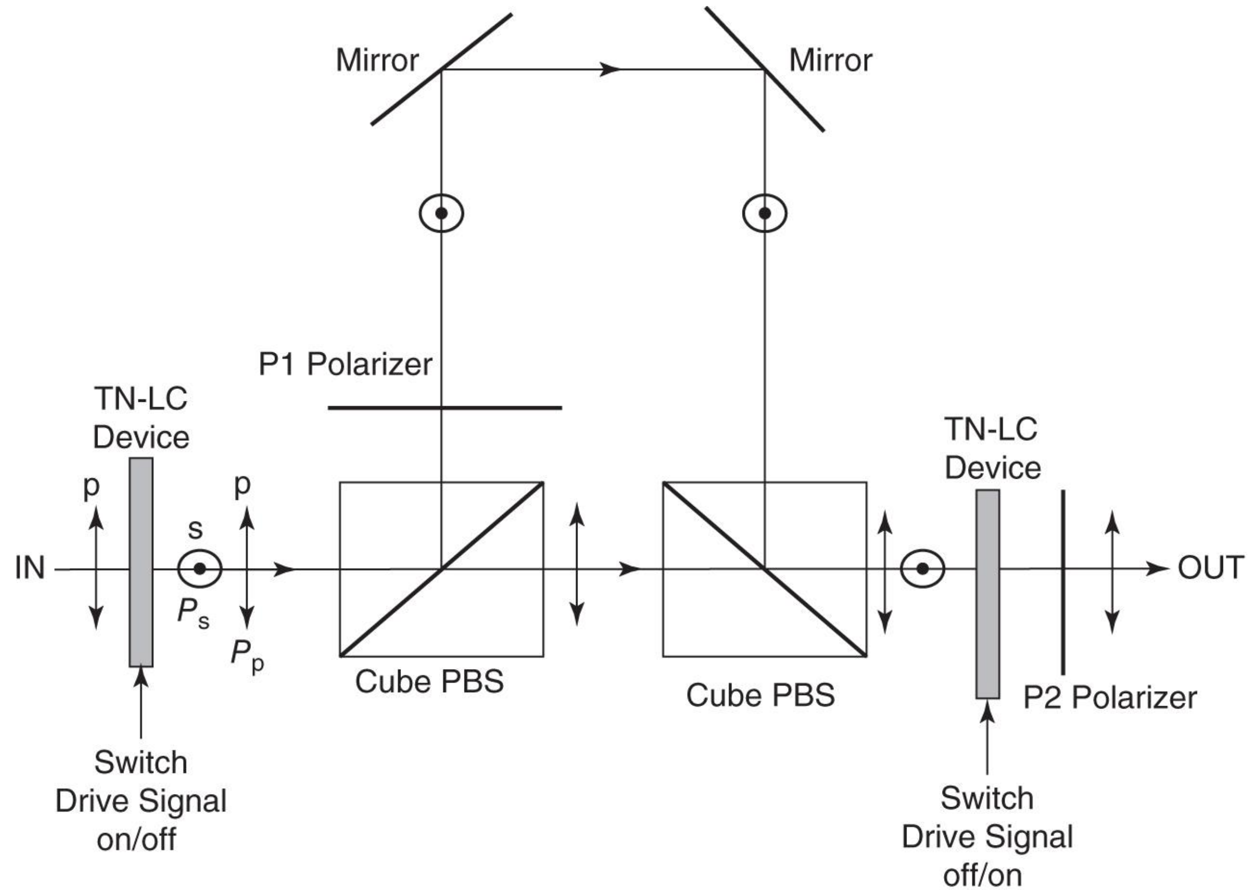

FIGURE 8.10 The desired low-noise performance 1-bit optical TDU.

An N-bit Digital Switching Variable Optical Delay is formed by cascading N such delay units, Each with its specific delay of T, 2T, 4T, 8T, etc. For example, a 2-bit delay line gives delays of 0, T,2T, and 3T or 4 different delays.