# Lithium Niobate Polarization Controller


The lithium niobate polarization controller is a device that can transform any arbitrary input polarization state to any arbitrary output polarization state when suitable control voltages are applied. The device consists of a cascade of integrated polarization transformer stages — each of which can be electro-optically adjusted at high speed to act as a variable thickness waveplate with adjustable orientation. Proper control of the cascade of stages allows for endless reset-free polarization control.

The device is based on Z-propagating lithium niobate[1] which has exceptionally high stability with variations in temperature.

A high-speed, low-loss polarization controller is the key component in a polarization mode dispersion (PMD) compensator. PMD causes pulse distortion that can severely limit transmission at data rates of 10 Gb/s and higher over long distances.

EOSPACE's polarization controller is based on our proprietary exceptionally high performance lithium niobate technology developed over the last 20 years for demanding aerospace applications.

[1] US Patent 4691984 by Suwat Thaniyavarn, President of EOSPACE

## Key Features

- Low insertion loss (< 3 dB max)
- Low polarization dependent loss (PDL)
- Low bias and control voltages
- Available with 3, 4, 6, or 8 integrated stages
- Response time < 100 ns
- Slim Package
- Designed for Telcordia GR-468
- C- and L-band operation (1.55 μm)

## Applications

- PMD compensation for 10 and 40 Gb/s systems
- High-speed endless reset-free polarization control
- Polarization scrambling
- High-speed polarization multiplexing

## Options

- Ultra-low insertion loss
- Custom number of stages
- Custom stage lengths
- 1.06 or 1.3 micron operation

## Operating Information

There are many possible control techniques for this device depending on the application[1,2,3]. For example, the required operating voltages to achieve a δ-wave plate with orientation angle α/2 using a single stage of the device are:

$$V_A = 2V_o \cdot \delta \cdot \sin(\alpha) - V_\pi \cdot \delta \cdot \cos(\alpha) + V_{A,Bias}$$
$$V_B = 0 \quad \text{(Ground)}$$
$$V_C = 2V_o \cdot \delta \cdot \sin(\alpha) + V_\pi \cdot \delta \cdot \cos(\alpha) + V_{C,Bias}$$

Where:

- $V_\pi$ is the voltage required to induce a 180 degree phase shift between the TE and TM modes for a single stage
- $V_o$ is the voltage required to rotate all power from the TE to the TM mode, or vice versa, for a single stage
- $V_{A,Bias}$ and $V_{C, Bias}$ are the bias voltages required to be applied to electrodes A and C, respectively, in order to achieve zero birefringence between the TE and TM modes. Typically, $V_{A,Bias} \cong -V_{C, Bias}$.
- δ is the desired waveplate retardation (in wavelengths). For example, to generate a 1/8-wave plate, set δ=1/8.
- α/2 is the orientation angle of the waveplate

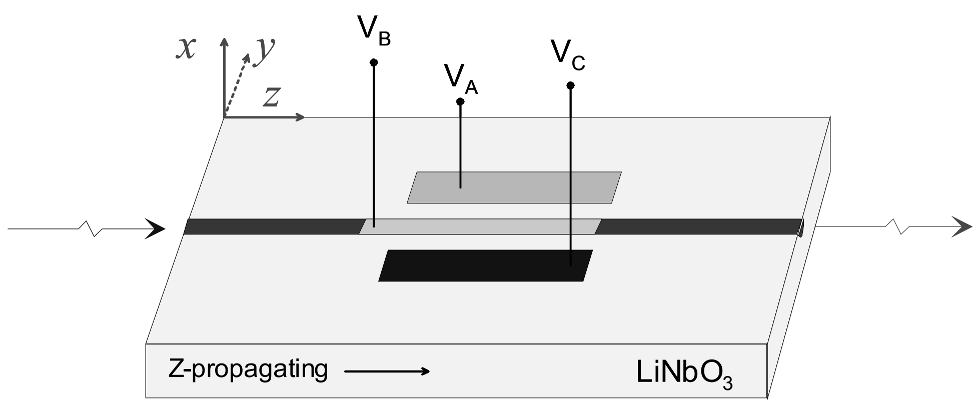



Figure 1 — Polarization Controller Waveguide & Electrode Configuration

[1] US Patent #4,691,984.
[2] Thaniyavarn, Suwat, "Wavelength-independent, optical-damage-immune LiNbO3 TE-TM mode converter," Optics Letters, Vol. 11, No. 1, January 1986, pp. 39-41.
[3] A.J.P. van Haasteren, et al., "Modeling and Characterization of an Electroooptic Polarization Controller on LiNbO3", JLT, Vol. 11, No. 7, July 1993.

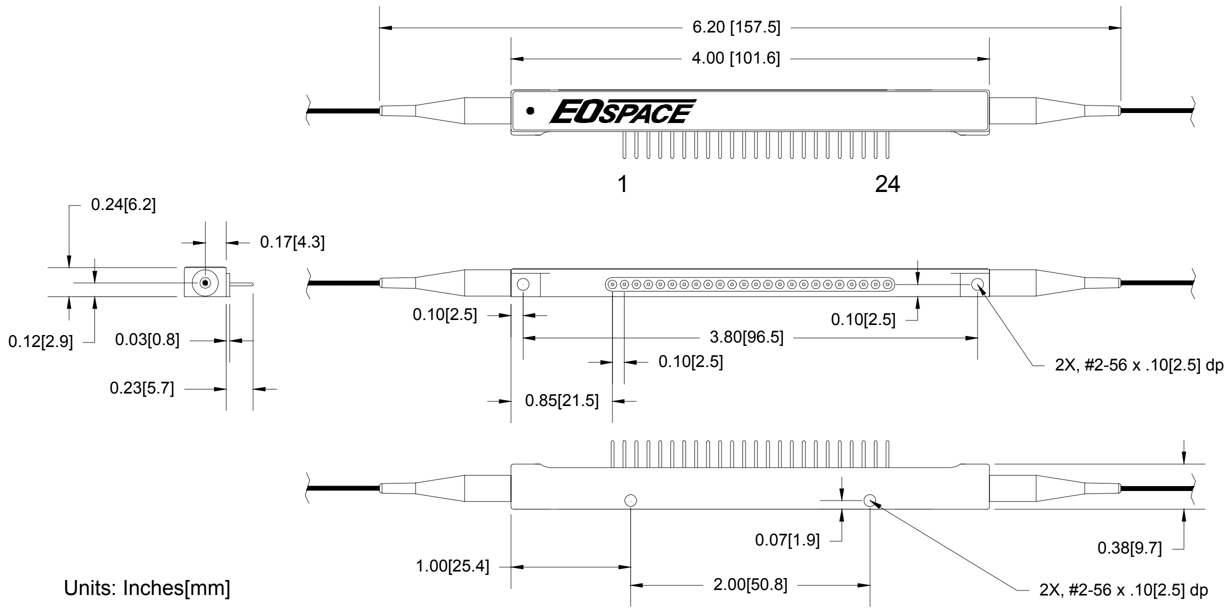
# Specifications

| Parameter | | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| **General** | | | | | |
| Material | | | $LiNbO_3$ | | |
| Crystal orientation | | | x-cut, z-propagating | | |
| **Electrical/Optical**[1] | | | | | |
| Operating wavelength | | 1525 | | 1620 | nm |
| N (number of integrated stages) | | | 3, 4, 6, or 8 | | |
| $2V_o/N$ (TE/TM rotation, each stage) | | | 10 | 14 | volts |
| $V_\pi/N$ (TE/TM phase shift, each stage) | | | 10 | 14 | volts |
| $V_{A,Bias}$, $V_{C,Bias}$ (zero birefringence bias) | A-version | -30 | | 30 | volts |
| | B-version | -12 | | 12 | volts |
| Response time | | | | 100 | ns |
| Optical insertion loss[2] | | | 2.5 | 3.0 | dB |
| Optical return loss | | 40 | | | dB |
| Polarization dependent loss (PDL) | | | | 0.2 | dB |
| **Mechanical** | | | | | |
| Input/output fiber pigtails | | | Single Mode or Polarization Maintaining | | |
| Fiber core/clad | | | 9/125 | | microns |
| Fiber jacket material | | | 900 µm Hytrel polyester loose tube | | |
| Fiber length | | | 100 | | cm |
| Fiber connector | | | FC/UPC standard, others available | | |
| Package | | | Designed to pass Telcordia GR-468 | | |
| **Absolute Max** | | | | | |
| Optical input power | | | 100 | | mW |
| Operating temperature | | 0 | | 70 | deg C |
| Storage temperature | | -40 | | 85 | deg C |
| Voltage on bias pins between adjacent pins within a stage, or from any pin to case | | | | 80 | volts |

Higher performance and/or custom specifications may be available upon request.

[1] All parameters specified at 1550 nm
[2] Includes FC/PC connector losses. Losses are lower when fusion spliced.

# Package Drawing




Units: Inches[mm]

# Pin Descriptions

| Pin | 3-Stage Device | 4-Stage Device | 6-Stage Device | 8-Stage Device |
|---|---|---|---|---|
| **1** | **1A** | **1A** | **1A** | **1A** |
| **2** | **1B** | **1B** | **1B** | **1B** |
| **3** | **1C** | **1C** | **1C** | **1C** |
| **4** | NC | NC | **2A** | **2A** |
| **5** | NC | NC | **2B** | **2B** |
| **6** | NC | NC | **2C** | **2C** |
| **7** | NC | **2A** | NC | **3A** |
| **8** | NC | **2B** | NC | **3B** |
| **9** | NC | **2C** | NC | **3C** |
| **10** | **2A** | NC | **3A** | **4A** |
| **11** | **2B** | NC | **3B** | **4B** |
| **12** | **2C** | NC | **3C** | **4C** |
| **13** | NC | **3A** | **4A** | **5A** |
| **14** | NC | **3B** | **4B** | **5B** |
| **15** | NC | **3C** | **4C** | **5C** |
| **16** | **3A** | NC | **5A** | **6A** |
| **17** | **3B** | NC | **5B** | **6B** |
| **18** | **3C** | NC | **5C** | **6C** |
| **19** | NC | **4A** | NC | **7A** |
| **20** | NC | **4B** | NC | **7B** |
| **21** | NC | **4C** | NC | **7C** |
| **22** | NC | NC | **6A** | **8A** |
| **23** | NC | NC | **6B** | **8B** |
| **24** | NC | NC | **6C** | **8C** |

NC = No Connection
All Pins Are Floating Relative to the Case

# Model Number Information

PC-□□-□□-□□□-□□□-□…□

| Bias Version | No. of Stages | Body Style | Input Fiber | Input Connector | Output Fiber | Output Connector | Special |
|---|---|---|---|---|---|---|---|
| A = +/-30 volt max | 3 | 00 = 4" 24-pin | S = SM | FU = FC/UPC | S = SM | FU = FC/UPC | see quote |
| B = +/-12 volt max | 4 | | P = PM | FA = Angled FC/PC | P = PM | FA = Angled FC/PC | |
| | 6 | | | SU = SC/PC | | SU = SC/PC | |
| | 8 | | | SA = Angled SC/PC | | SA = Angled SC/PC | |
| | | | | (omit) = None | | (omit) = None | |

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