Polarization Controllers

Phoenix Photonics

Firebird™ **Product range information**

FIREBIRD

Phoenix Fiber Polarization Controllers

Customer information note

Overview

Phoenix polarization range of controllers is all-fiber offering the following benefits over other technology approaches;

- ✓ there are no mechanical parts that may fail giving long product lifetime
- ✓ there are no free-space, bulk, optical components requiring alignment, increasing losses and affecting high power operation,
- ✓ the approach is fully solid state using the same propagation medium as the input/output fiber tails.
- ✓ Very large optical operational bandwidth

Individual waveplates are formed using standard polarization maintaining, high birefringence, fibers and the principle is to modify the birefringence of the fiber over a 2π differential phase shift giving a full circle rotation of the Poincare sphere for each waveplate. Accurately splicing three waveplates together with propagation axes at 45deg. to each other (90deg. rotation of polarization state on the Poincare sphere) gives full coverage of the sphere, i.e. any polarization state can be achieved from any starting state.

The Phoenix Firebird™ range incorporates many years of research and development to optimize, highly accurately fiber axis alignment, precision control of the waveplate birefringence with zero crosstalk between waveplates, robust packaging and full microprocessor control.

Principle of Operation

Unlike competitive approaches, Phoenix polarization controllers provide a direct relationship between waveplate phase shift and applied voltage. This means that as there is no hysteresis therefore, the polarization transfer function can be accurately set for any input wavelength and ambient temperature and the polarization evolution directly tracks the voltage control. This provides repeatability and stability of the output state of polarization.

The standard component consists of three polarization maintaining fiber waveplates, each accurately aligned at 45 deg. and fusion spliced (figure 1). The differential phase shift between the light on each of the axes is dependent on the wavelength of the light and the temperature of the fiber for a fixed length. The Phoenix approach is to accurately control the temperature of each of the waveplates thereby independently varying the birefringence of each section.

Benefits:

- ✓ Direct voltage to phase relationship (no hysteresis)
- ✓ No moving parts (no squeezers or rotators)
- ✓ Modification of the propagation parameters within the fiber therefore no break in the propagation path.
- ✓ Any wavelength range can be accommodated for which commercial PM fibers are available.
- ✓ Simple, stable, repeatable polarization control in many system applications and measurement environments.
- ✓ Cost effective

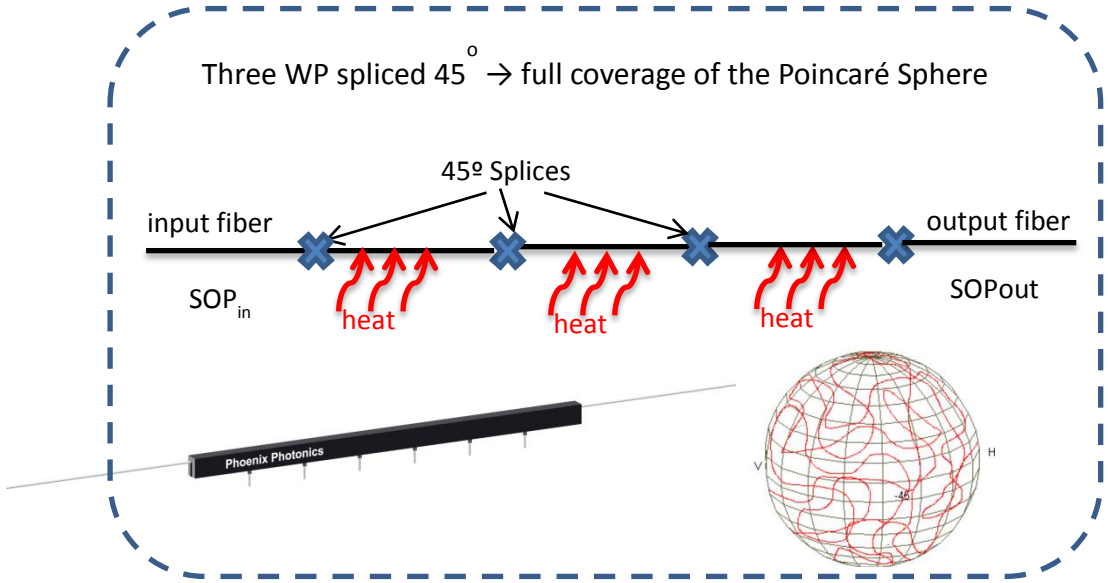

Figure 1 Principle of operation of the polarization controller. Three fiber sections are spliced to form individual controllable birefringence waveplates.

***Firebird* polarization control product family**

The concept for the product range is to provide solutions for different levels of application. The basic polarization control component (PSC) is primarily utilized in OEM applications for Test & Measurement and sensing instrumentation. The next level provided by the EPC gives the full functionality of conventional mechanical 3-loop controllers with the added benefit of electronic control targeted primarily at R&D laboratory applications where reliable, easy to use control modules are required. The full test & measurement instrument (MCPC) offers multi-channel control for production and R&D applications in PDL, PMD measurement and control. In addition the technology is ideal for selecting specific polarization states and switching between pre-selected options. These are based on referencing to the Phoenix all-fiber high extinction ratio polarizers The Polarization switch (PSW) component is targeted at OEM applications where switching between two orthogonal polarization states is required. The six-state polarization selector instrument is programmable to switch between key polarization states.

The variable waveplate technology leads to a series of easy to use, PCB compatible components including the PSC and with the addition of an integrated polarizer the PSW. The controller (PSC) branch provides, optical bench based modules and instrumentation. The PSW branch provides products for deterministic polarization selection (figure 2).

Although primarily targeted for application in telecommunication wavelength ranges, the technology is capable of fabricating products at many different wavelengths: 630nm, 780nm, 850nm. 980nm, 1060nm, 1310nm, C-band, L-band, 2000nm.

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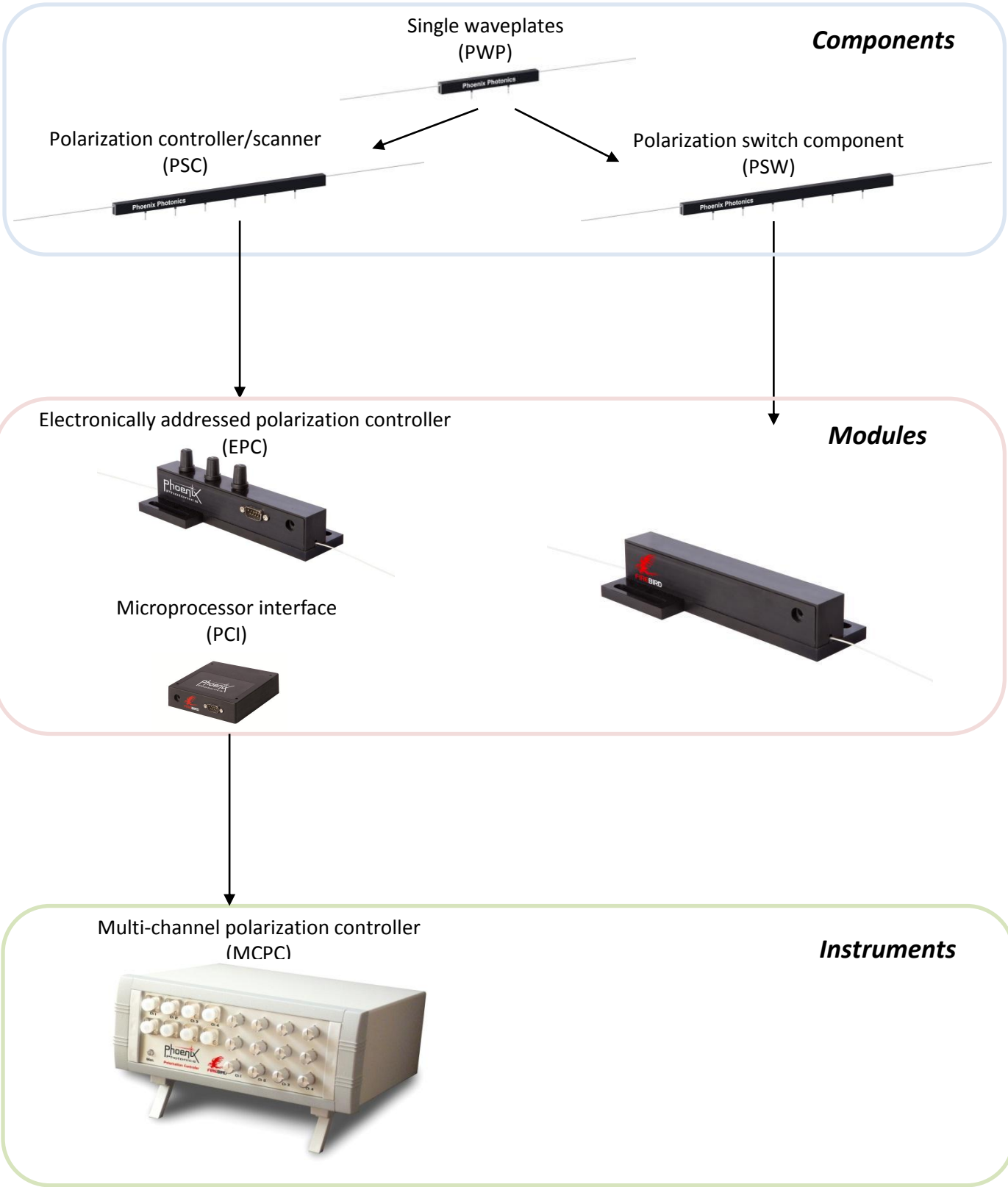

Figure 2 Phoenix polarization control product family tree

Polarization controller/scanner component (PSC)

The PSC is the basic component forming the operational heart of ***Firebird***^{TM} instruments. The compact component has been designed to be compatible with PCB installation. This is a very popular device with test & measurement instrumentation manufacturers as a high performance, cost effective component for polarization based equipment.

Electronically driven polarization controller (EPC)

The EPC offers an electronic replacement for the conventional mechanical 3-loop fiber polarization controllers. The unit incorporates a PSC and driver board. The individual waveplates can be controlled manually by knobs on top of the module. This gives direct feedback 'feel' when adjusting polarization in the laboratory. It can also be controlled with three analog voltage inputs. These three buffered inputs require 0 to 10v to give >2π phase shift on each section. This enables the user to control from a variable voltage supply, or by computer via. a DAC. The packaging has been designed for use on optical benches.

Microprocessor interface (PCI)

The PCI, a microprocessor based controller designed for use with the EPC, provides a direct interface (figure 3) with a PC. Phoenix software enables full control of the EPC through a PC panel with the same functionality as the MCPC. The software will control up to 4 EPCs to set the state of polarization or provide continuous scanning/scrambling of polarization.

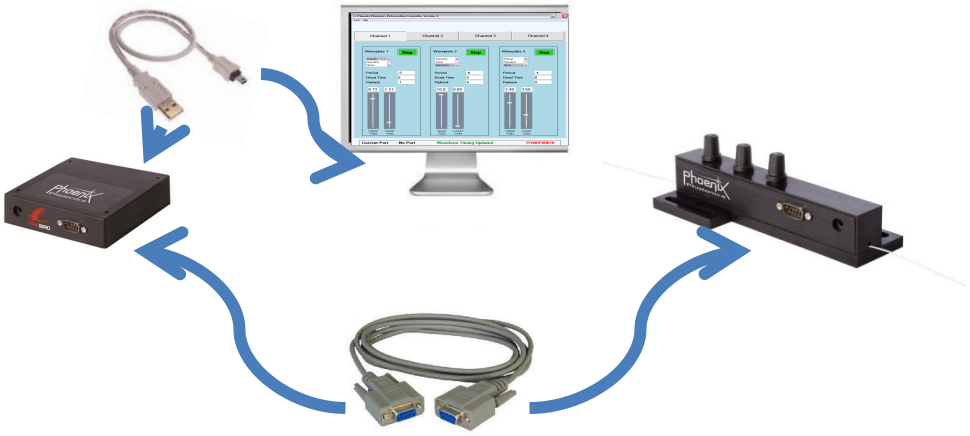

Figure 3 PCI interfaces EPC with PC for full control using Firebird software

Multi-channel polarization controller (MCPC)

The MCPC is the complete polarization control instrument. Available in compact instrument case format up to 4 channels and 19”rack format up to 8 channels. The instruments use PSCs and control each waveplate independently. The option of instrument front panel control through individual knobs has been retained, but full PC control is built into the instruments. There are several communication interface options and triggering facilities. The PC front panel control is shown in (figure 4). There is a control option to adjust the voltage (phase shift) of each waveplate through a slider or typing in a value or a scanning option is available. The scanning option has the facility to select parameters for each waveplate;

Scanning options: sine, triangle, square, random
Period: Repetition time
Flyback time: Vary triangle asymmetrically to saw-tooth
Deadtime: Time delay before next single cycle is triggered
Voltage limits: Maximum and minimum voltage range.

PC control and setting

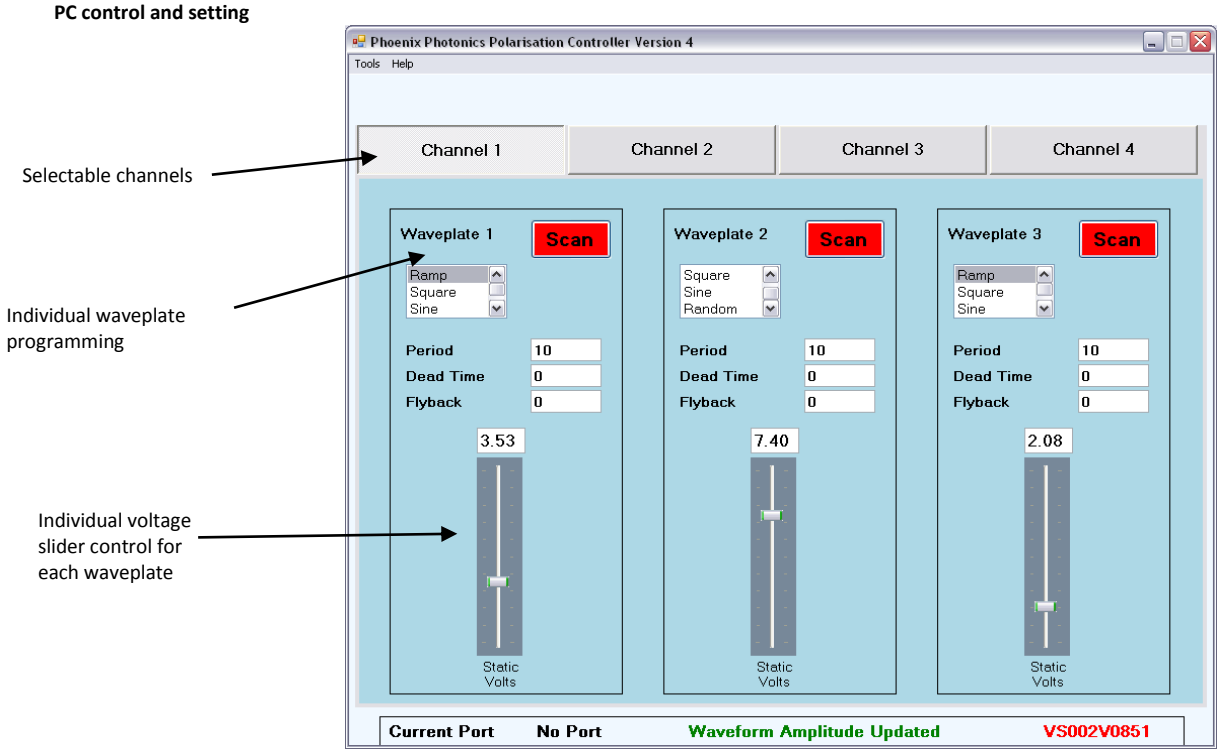

Figure 4a PC front panel control screen (manual control mode).

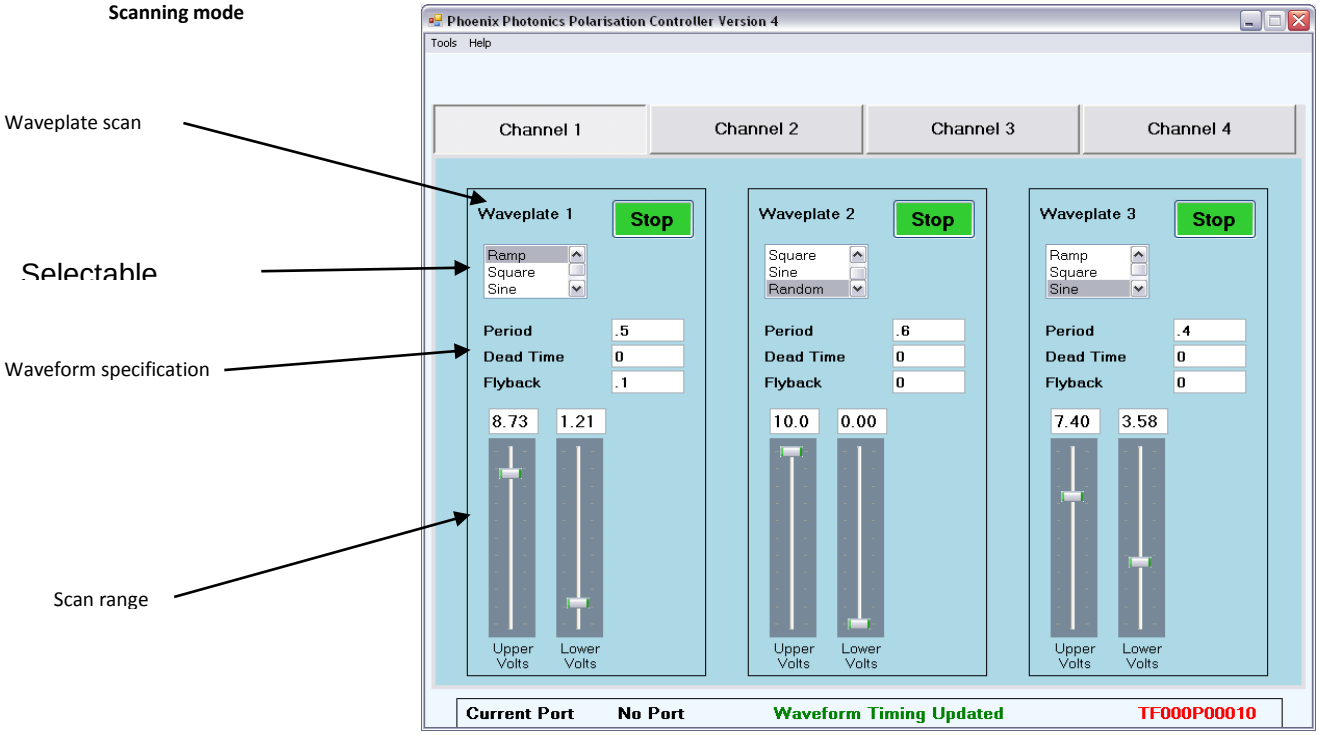

Figure 4b PC front panel control screen (auto control mode).

Principle for 6-state selector

Part of the Phoenix ***Firebird*** range of polarization control modules and instruments, the six-state polarization selector (or synthesizer) is a cost effective method to generate six pre-defined states.

The precision achievable from the voltage – phase relationship of each waveplate enables repeatable control of the output state of polarization when the input state is defined. Phoenix produces high extinction ratio linear state polarizers that have very high bandwidth and are very stable over large temperature ranges. The 6-state selector is an open loop system using a high performance Phoenix fiber polarizer to reference and maintain the input state of polarization. Adjusting the voltage of just two waveplates enables selection of six pre-defined states; Vertical, Horizontal, +45deg, -45deg, Right circular and Left circular. The calibration data for the selector is stored in the microprocessor for the full temperature range and operational wavelength range. The user inputs the wavelength and the selector will produce the requested state of polarization.

The selector includes a method to substantially reduce the wavelength and ambient temperature variations of the set state of polarization providing a very stable device.

The selector is calibrated in a specific plane and any birefringence in the path following the calibration plane will modify the state. However all states are affected in the same way and the relative relationship between states remains the same. If required in a specific plane along a length of fiber a polarization control can be used to restore the original setting.

Fluctuations of the input state of polarization will cause changes in throughput power, but the selected state remains constant, this is the same as experienced with linear polarizers and can be adjusted using an input polarization controller.

The compact unit consists of the fiber controller with high extinction ratio polarizer, heater control to drive the waveplates, temperature sensor to measure ambient (box) temperature, microprocessor and PC interface. The unit is powered from an external 12v supply and connected to the PC. The PC enables individual polarization selection or programming to step between selected states. Figure 5 shows the control panel.

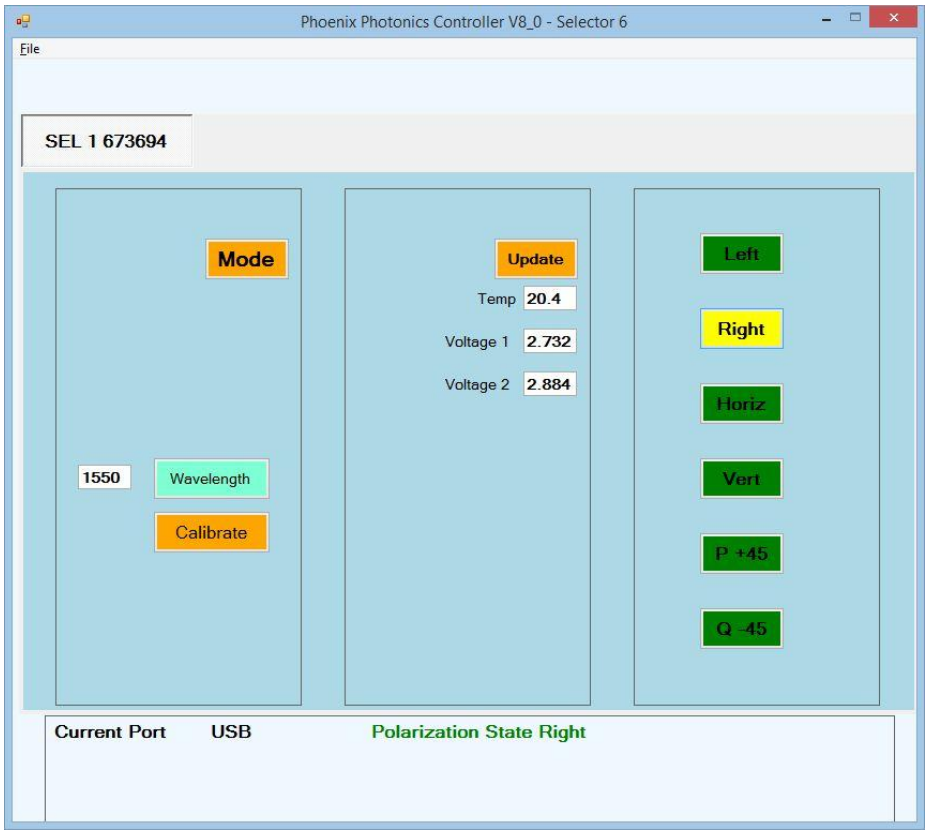

Figure 5 PC front panel for polarization selection

Polarization switch (PSW)

The 6-state selector can be used as a polarization switch. In some applications it is desirable to switch between two specific states, two orthogonal linear or two circular. Phoenix offers accost effective basic switch components in addition to the 6-state selector. In this case the user can design the switch into an instrument