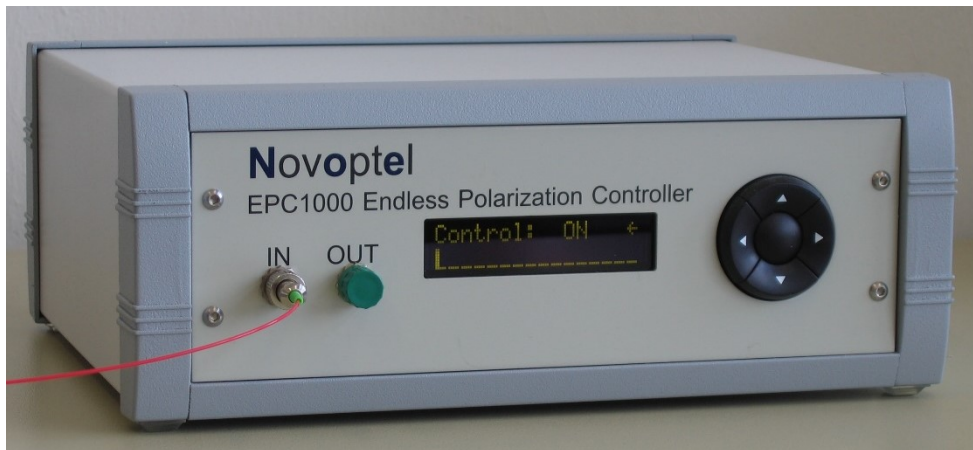


User Guide

# Novoptel

EPC1000 Endless Polarization Controller



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## Revision history

Version	Date	Remarks	Author
0.1.1	28.01.2012	Draft version	B. Koch
0.1.2	07.12.2012	Definition of averaging time exponent (ATE)	B. Koch
0.1.3	28.02.2013	Description of Detector Mode selection, new section "External Error Signals"	B. Koch
0.1.4	20.12.2013	Support of ATE>11	B. Koch
0.1.5	12.03.2014	Harmonics (Bessel line) detection	B. Koch
0.1.6	10.02.2017	Add description of optional LAN interface	B. Koch
0.1.7	07.12.2020	Control of APD/attenuator voltages, correction of external error signal range	B.Koch

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## Operation of the instrument using the front control panel

Power the instrument with the provided power supply and switch it on. The controller firmware provides a cyclic menu, which is shown on the LCD display. The menu structure is

Welcome Screen
Control ON/OFF
Show Feedback Signal
Select Detection Mode (optional)
Select Control Mode
Set Dither Amplitude
Set Control Gain
Set Feedback Delay
Set Averaging Time Exponent (ATE)
Swap Channels
Save Settings
Load Settings
Restore Default Settings
LAN Configuration

The control buttons *UP* and *DOWN* let you to navigate through the menu. The control buttons *LEFT* and *RIGHT* changes a selected setting.

The menu point *LAN Configuration* is missing if the unit is not equipped with a LAN interface

### **Detection Mode**

For the EPC units that provide different detection modes, two detector switches allow to select a specific feedback signal, e.g. optical input detection or electrical input detection.

### **Control Mode**

This menu point lets you temporarily maximize the feedback signal. This is required to determine the feedback signal range and calculate the optimum control gain. Polarization tracking using signal maximization is not recommended.

### **Dither Amplitude**

Small dither is recommended if error signal is of good quality. Large dither is needed if error signal is noisy. Register determines percentage of nominal dither amplitude. Default value is 0004h = 100%.

0000h = 50%	0001h = 62%	0002h = 75%	0003h = 87%
0004h = 100%	0005h = 112%	0006h = 125%	0007h = 150%

## Control Gain

Optimum control gain depends on detector type, dither amplitude and feedback signal range. Too low control gain reduces tracking speed, whereas a too high gain increases tracking errors even at low polarization changing speeds.

For an interference detector which provides two minima, the optimum control gain can be calculated by

$$\text{Gain} = 100 / \text{dither}^2 / \text{signal\_range},$$

where *dither* is the dither amplitude factor and *signal\_range* is the difference between maximum and minimum feedback signal divided by the full ADC range. For example, at 100% dithering and a feedback signal, which uses half of the ADC range, the optimum control gain is  $100 / 1 / 0.5 = 200$ .

## Feedback Delay

Error signal delay (deadtime, risetime), given as multiples of 20 ns. Default value corresponds to optimum value for given error signal detector. Only external feedback signals might require increasing the default value.

## Averaging Time Exponent

Noisy or slow feedback signals may require averaging. The averaging time can be set by increasing the averaging time exponent (ATE). Averaging time influences the control time constant and hence the tracking speed:

Averaging Time Exponent	Averaging Time	Control Time Constant	Exemplary Tracking Speed (rad/s)
0	0.08 $\mu\text{s}$	1.1 $\mu\text{s}$	40,000
1	0.16 $\mu\text{s}$	1.6 $\mu\text{s}$	27,692
2	0.32 $\mu\text{s}$	2.5 $\mu\text{s}$	17,143
3	0.64 $\mu\text{s}$	4.4 $\mu\text{s}$	9,730
4	1.28 $\mu\text{s}$	8.3 $\mu\text{s}$	5,217
5	2.56 $\mu\text{s}$	16 $\mu\text{s}$	2,707
6	5.12 $\mu\text{s}$	31 $\mu\text{s}$	1,379
7	10.24 $\mu\text{s}$	62 $\mu\text{s}$	696.3
8	20.48 $\mu\text{s}$	123 $\mu\text{s}$	349.9
9	40.96 $\mu\text{s}$	246 $\mu\text{s}$	175.3
10	81.92 $\mu\text{s}$	492 $\mu\text{s}$	87.78
11	163.84 $\mu\text{s}$	984 $\mu\text{s}$	43.92
12	327.68 $\mu\text{s}$	1,967 $\mu\text{s}$	21.97
13	655.36 $\mu\text{s}$	3,933 $\mu\text{s}$	10.99
14	1,310.72 $\mu\text{s}$	7,865 $\mu\text{s}$	5.49
15	2,621.44 $\mu\text{s}$	15,729 $\mu\text{s}$	2.75
16	5,242.88 $\mu\text{s}$	31,458 $\mu\text{s}$	1.37
17	10,485.76 $\mu\text{s}$	62,915 $\mu\text{s}$	0.69

Default value is ATE=0. This value is needed to achieve the specified endless polarization tracking speed. The value ATE=11 will increase averaging time by a factor of 2048 and the control time constant by a factor of ~900. Note that ATE values > 11 are only supported by EPC firmware > 1.0.4.1.

## ***Swap Channels***

Use the *LEFT* or *RIGHT* button to switch to the orthogonal polarization channel. Only applicable with interference detectors.

## ***Load/Save/Restore Settings***

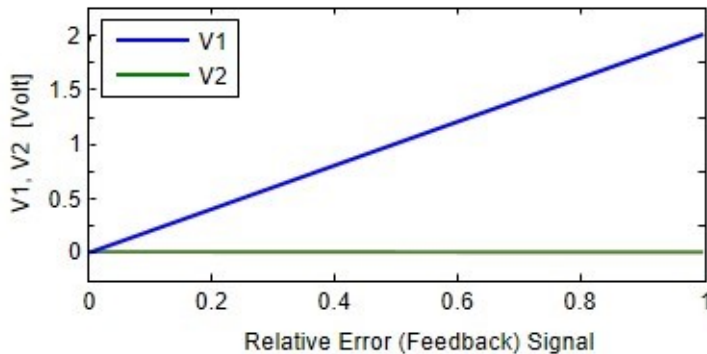
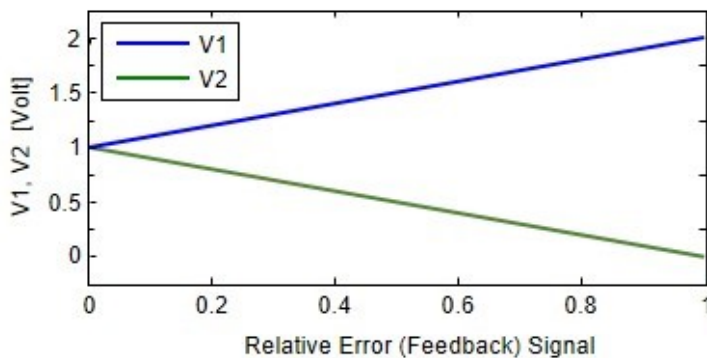
Settings can be saved in and loaded from a non-volatile RAM. *Restore* will apply the factory settings.

## External Error Signals

Depending on configuration, the EPC supports external error signals. In case of supported electrical external error signal, the unit will provide two SMA connectors at the backside of the desktop case, labeled  $V_1$ ,  $V_2$ . These are the inputs of a fully differential amplifier with offset.  $V_1$ ,  $V_2$  should be chosen in the range  $-0.5 \dots +3.3$  V. We typically work with a common mode voltage of  $V_{CM}=1$  V. Relative error (feedback) signal ranges from 0 to 1 for  $V_1-V_2$  ranging from 0 V to +2 V (or rather something like  $-0.05$  V to  $+1.95$  V, because we choose the offset such that 0 V is within the linear range).

The use of a differential feedback signal is recommended. Or else, if the error signal is single-ended,  $V_2$  should be terminated to the ground, preferably to the ground of the signal source. This means, ground loop effects (due to EPC1000 and signal source possibly having slightly different ground potentials) are avoided.

Exemplary relations between  $V_1$ ,  $V_2$  and error signal are sketched here:



### Verifying control by internal optical detector

Desktop units of EPC with external electrical error signal also provide an optical feedback input connector in order to enable function verification of the EPC independent from the user supplied error signal. To do so, connect the optical controller output to the optical input at the backside of the unit using a single mode fiber patch cord. If the unit does not provide an internal PBS (Polarization Beam Splitter), a PBS or polarizer has to be included in the light path externally. Optical power at the optical feedback input should be  $<-10$  dBm to avoid error signal overflow unless otherwise specified.

***Adjustment of APD / attenuator voltages of internal optical detector***

Depending on configuration, the internal optical detector may be equipped with a photodiode of avalanche type (APD), or a variable optical attenuator (VOA) which is placed between optical input and photodiode. By modifying gain factor or attenuation, the error signal range of the detector can be adjusted to match the maximum power at the optical input within certain limits. This is done automatically by the controller if the control mode is set to maximize the error signal: The APD / attenuator voltages will then be modified until the maximized error signal reaches 28000/32767 of the ADC range. To make use of this function, the user should switch the control mode to error signal maximization after startup and then enable control. After a few seconds, the error signal shown in the GUI or on the front display should be near 28000 if the maximum input power is within the recommended range. Then the user can switch back to error signal minimization for normal operation. This step should be repeated if the error signal was highly unstable during maximization.



## Operation of the instrument using Novoptel Software

The instrument communicates by a USB I.C.FT232R from FTDI (Future Technology Devices International Limited, <http://www.ftdichip.com>).

The software is compiled on a Microsoft XP 32Bit system with .NET Framework 3.5 SP1 installed, but also tested with Windows 7 32 Bit and Windows 7 64 Bit.

### ***Installing the USB driver***

Execute the installation program of the provided USB driver (*CDM20814\_Setup.exe*). You will find more detailed information about the driver at <http://www.ftdichip.com/Support/Documents/InstallGuides.htm>.

### ***Connect the instrument***

After the driver is installed successfully, connect PC and instrument using the provided USB cable. Power the instrument with the provided power supply and switch it on. Wait until Windows has recognized the USB device and shown an acknowledgement message before proceeding.

### ***Installing the Novoptel Software***

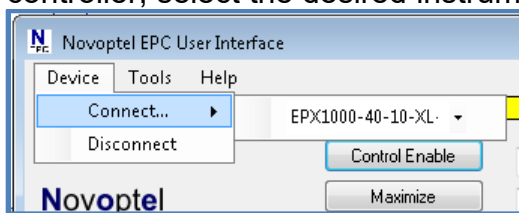
Execute *setup.exe* in the folder *EPC1000\_GUI*. Follow the instructions of the installation dialogue.

### ***First steps with the Novoptel Software***

The software launches automatically after installation. If you want to launch the software later manually, select *Programs\Novoptel\EPC1000* from the Windows Start Menu.

### **Select one of the attached instruments**

If you have attached only one Novoptel polarization controller, the software automatically selects this one. If you have attached more than one polarization controller, select the desired instrument from the drop-down menu.



If the software is not able to connect to an instrument, it may be blocked by a former program instance that has not been terminated correctly. In this case, terminate the former program instance by the Windows task manager.

Subsequently, you can launch further instances of the software and connect them to further instruments.

## Change Control Settings

Control value can be typed in the four fields shown below and applied by clicking 'X'. Current values are displayed beside the fields.

<input type="text" value="4"/>	4	<input type="button" value="X"/>	Dither Amplitude
<input type="text" value="100"/>	100	<input type="button" value="X"/>	Control Gain
<input type="text" value="24"/>	24	<input type="button" value="X"/>	Error Signal Delay
<input type="text" value="0"/>	0	<input type="button" value="X"/>	Averaging Time Exp.

For parameter information, refer to the previous chapter.

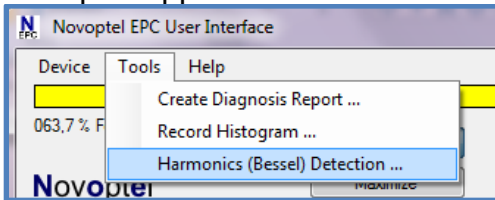
Detector Switch 1

Detector Switch 2

Depending on the ordered detector type, two switches allow for switching between different detector modes, e.g. interference detection, optical power detection and external electrical error signal.

## Detect Harmonics (Bessel Lines)

If supported by the connected EPC module, the software allows enabling the harmonics detection mode. In this mode, selected harmonics (Bessel lines) in the feedback signal will be analyzed and minimized instead of the feedback signal itself. For detailed information about harmonics detection please refer to Novoptel Application note 1: "Error signals for polarization control".



For this mode, a new form will be opened to observe and modify appropriate control parameters. It also shows the calculated error signal, e.g. the sum of the weighted power in the analyzed harmonics instead of the pure ADC signal.

Novoptel EPC Harmonics Detection...

000,3 % Harmonics Error Signal

Weight Constraint: none

New Weights: 0.216 0.338 0.446

Average Power: 0.453 0.407 0.139

The new form allows to enable a PWM signal, also described in Application note 1, at the BNC output. The average powers in the three detected harmonics are displayed. Detection of harmonics 1,2,3 or harmonics 2,3,4 can be selected. For each of the two sets, suitable weights are being proposed. To meet a specific transmitter configuration, the weights can be modified manually or via predefined weight constraints. The weight constraint (0 1) means that the weight for the lowest harmonic is zero. The weight constraint (0.25 0.75) means that the weight for the highest harmonic is 3 times the weight for the lowest harmonic, and so on.

Weight Constraint:	none	
New Weights:	0	1
	0.25	0.75
	0.5	0.5
Average Power:	0.75	0.25
	1	0
	none	

Set

Click on the button labeled “Set” to load the modified weights to the EPC.

## Operation of the instrument using Matlab®

The USB driver (CDM20814\_Setup.exe) has to be installed on your system and the polarization controller needs to be connected using a USB cable.

### Access the USB driver

Matlab needs a header file like *ftd2xx.h* from FTDI to access the driver. In the provided version *matftd2xx.h*, we have modified the data types to be compatible to Matlab.

You will find help about communicating to a driver at <http://www.mathworks.com/help/techdoc/ref/loadlibrary.html>

The different functions of the driver can be seen from the header file. Information about each function is provided at <http://www.ftdichip.com/Support/Knowledgebase/index.html>

### Transfer Protocol

The polarization controller is controlled by reading from and writing to USB registers. The register address line is 12 bits wide, while each register stores 16 bits. All communication is initiated by the USB host, e.g. the Matlab program.

Writing to a register uses a 9 byte data packet. Each byte represents an ASCII-coded character. The packet starts with the ASCII-character "W" and ends with the ASCII-code for *carriage return*.

Send *write data* packet

„W“	A(2)	A(1)	A(0)	D(3)	D(2)	D(1)	D(0)	^CR
-----	------	------	------	------	------	------	------	-----

The 12 bit register address A is sent using 3 bytes, each containing the ASCII-character of the hexadecimal numbers 0 to F which represents the 4 bit nibble. The character of the most significant nibble is sent first. The 16 bit data, which should be written into the register, is sent with 4 bytes using the same coding as the register address.

Reading data from a register requires the host to send a *request data* packet to the instrument. The packet starts with the ASCII-character "R", followed by the register address coded the same way as in *write data* packets.

Send *request data* packet

„R“	A(2)	A(1)	A(0)	„0“	„0“	„0“	„0“	^CR
-----	------	------	------	-----	-----	-----	-----	-----

After receiving the *request data* packet, the instrument sends the requested data packet to the host:

D(3)	D(2)	D(1)	D(0)	CR
------	------	------	------	----

## ***USB registers***

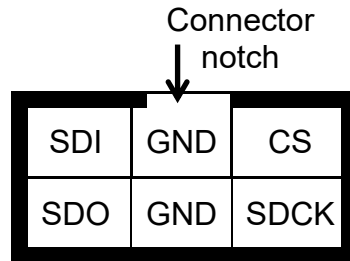
For register information, please refer to EPC1000 Data Sheet.

## Operation of the instrument using other programs

The USB vendor <http://www.ftdichip.com/Support/Knowledgebase/index.html> provides examples for USB access using other programs, for example LabVIEW®.

## Operation of the instrument using SPI

All control registers can also be accessed by SPI. The SPI interface allows much faster communication than USB. The SPI connector at the backside of the device provides the following connection:



For SPI timing, please refer to EPC1000 Data Sheet.