



## MBC-AN-LAB

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## Operating Manual

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Version 2.0



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## Legal Notice

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## About this Manual

### Purpose

The purpose of this instruction manual is to explain how to set up the MODBOX and to utilize the various features of the product.

### Audience

This manual is aimed at professionals with the necessary technical background and prerequisites needed to use fiber optics equipment, including lithium niobate modulators, and the related tests equipment and accessories.



## Prerequisites

Reader is assumed to be familiar with and fiber optics technology.

## Terms and Symbols in this Manual

The following terms and symbols may appear throughout this manual:

**WARNING:** Warning statement identifies conditions or practices that could result in injury or loss of life.

**CAUTION:** Caution statement identify conditions or practices that could result in damage to this product or other property

## Electrical safety

		<b><i>Operate under the proper environmental conditions</i></b>
	<b><i>WARNING</i></b>	The MBC-AN-Board is designed for indoor use. To avoid injuries, do not expose this instrument to water or excessive moisture. Do not operate the board in the presence of flammable gases or fumes.

## Contacting iXblue

For application oriented or service related requests, please contact iXblue customer service department:

[contact@ixblue.com](mailto:contact@ixblue.com)



## General Information

### Product Overview

MBC-AN-Board is a bias controller specially designed to lock the operating point of a LiNbO<sub>3</sub> Mach-Zehnder modulator by monitoring the bias voltage applied on the DC electrodes of the device.

Unlike classical dither signal based bias controllers, MBC-AN-board does not superimpose any tone signal to the optical modulated signal. It is designed for application where such a tone signal is not desired and typically for analog applications where a high purity carrier is required.

### Principle of operation

The MBC-AN bias controller is based on the comparison of the optical power before and after the Mach-Zehnder modulator. It uses optical tap couplers and photodiodes with a proportional integrator feedback loop to lock the operating point of the modulator at the Quad+ or Quad- position.

The MBC-AN-BT is operated with a user supplied PC. It comes with a Windows graphical user interface.

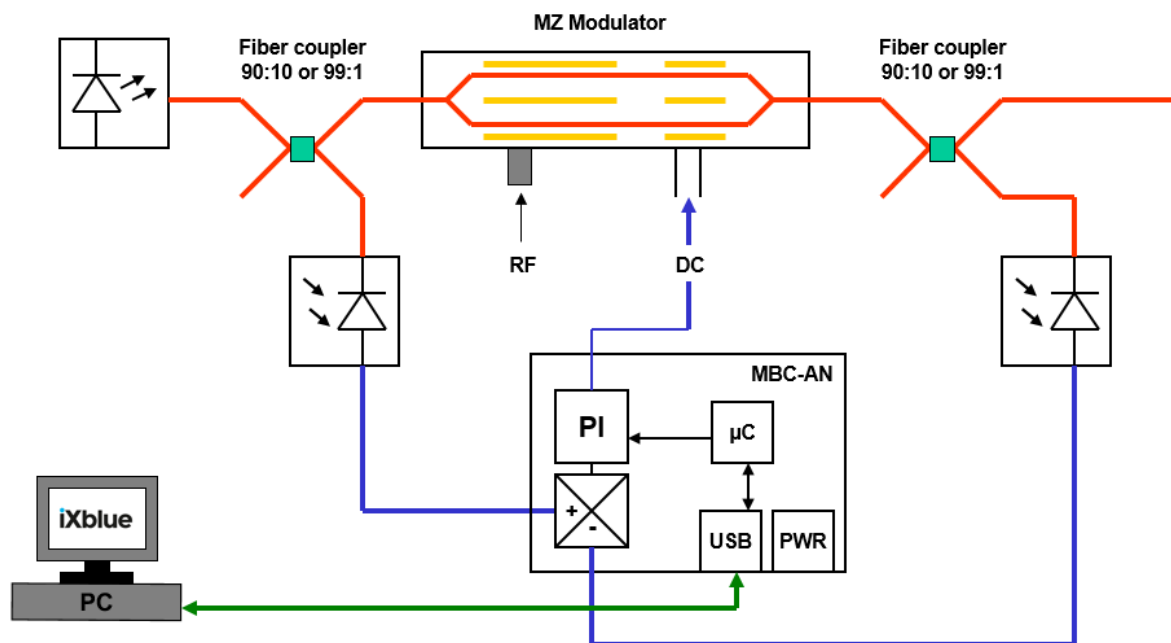


Figure 1: basic scheme of a modulation set-up including a modulator bias controller and 2 external monitoring photodiodes



A fiber coupler with a strong imbalance (10:90 or 1:99) is placed between the Mach-Zehnder modulator and the laser. At the output of the coupler a photodiode is used to monitor the average optical power emitted by the laser. The RF signal is applied to the RF electrodes. At the output of the MZ modulator, a fiber coupler with a strong imbalance (10:90 or 1:99) allows to detect a small portion of the transmitted light thanks to a monitoring photodiode. The signal from the photodiode is amplified and compared with the signal coming from the laser monitoring photodiode. The discrepancy between both signals are integrated and injected into the DC electrodes of the modulators in order to maintain the operating point at the desired position.

The principle of operation of the MBC-AN is based on a proportional integrator feedback loop. It has been design only for locking the operating point at Quad+ or Quad-.





## Standard Specifications

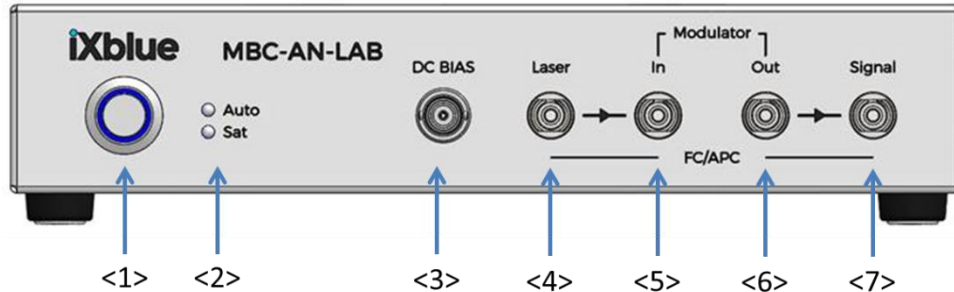
Input Signals Specifications	Units	Min	Typ	Max
Electrical				
Modulator Bias voltage	V	-12		+12
Photodiode Bias Voltage	V		-5	
Bias voltage step (in manual mode)	V	0.002	0.01	
Locking point (Transfert level)	QUAD-(-50%), QUAD+(+50%)			
Environmental				
Operating temperature	°C	+10		+45
Storage Temperature	°C	-40		+75
Power supply				
Positive bias voltage	V	0	+12	+15
Negative bias voltage	V	-15	-12	0
90-250V, 50/60Hz AC power supply	Provided			
Interfaces				
Photodiode Input /coupler input	FC/APC connector			
Bias Output	BNC Female connector			
Communication	USB Connector			
Environmental				
Operating temperature	°C	+10		+45
Dimensions				
LAB	220 x 220 x 52mm <sup>3</sup>			
Software (GUI)				
Minimum computer requirements	Windows XP SP3 One USB port			
Recommended computer configuration	Windows XP SP3 One USB port			





## Panel features

### Front panel



<1> Power button

<2> Control LED

- Auto: MBC is in Auto Mode
- Sat: MBC bias control voltage is saturating

<3> Bias Modulator connector (BNC)

<4>: Laser optical input

- Input, fiber from laser output (coupler option)
- Input, part of laser power (no coupler option)

<5>: Modulator optical input (optional)

Output of the first integrated coupler, to the input optical fiber modulator

<6>: Modulator optical output

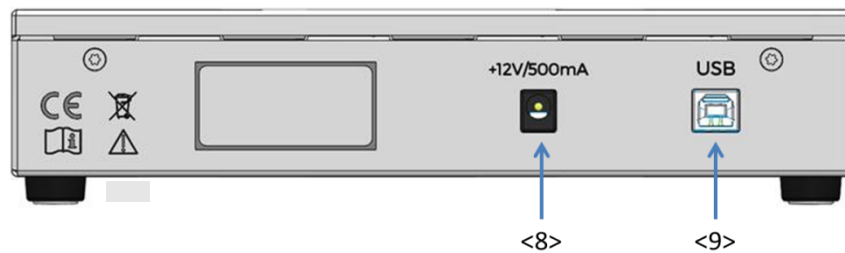
- Input, fiber from modulator output (coupler option)
- Input, part of modulator output power (no coupler option)

<7>: Signal (optional)

Output of the second integrated coupler, working signal.



## Back panel



<8> Power supply connector (Jack 3.5mm, 12V 500mA)

<9> USB connector

## Getting started

### Standard Accessories

User Manual  
Interface User Manual  
Cord Kit  
USB Cord  
AC-DC Power Supply

## Installation and set up

To set-up the MBC-AN-Board for your application you have to install the MBC-AN control software.

### Preliminary: **MBC Interface software installation**

Minimum computer requirements:

- Windows XP/Vista/7
- USB port



Installation: Install the USB driver (PhotlineUSBinstaller.exe), and then launch the setup.exe present on the CD.

The MBC interface software is now installed and ready to be used.

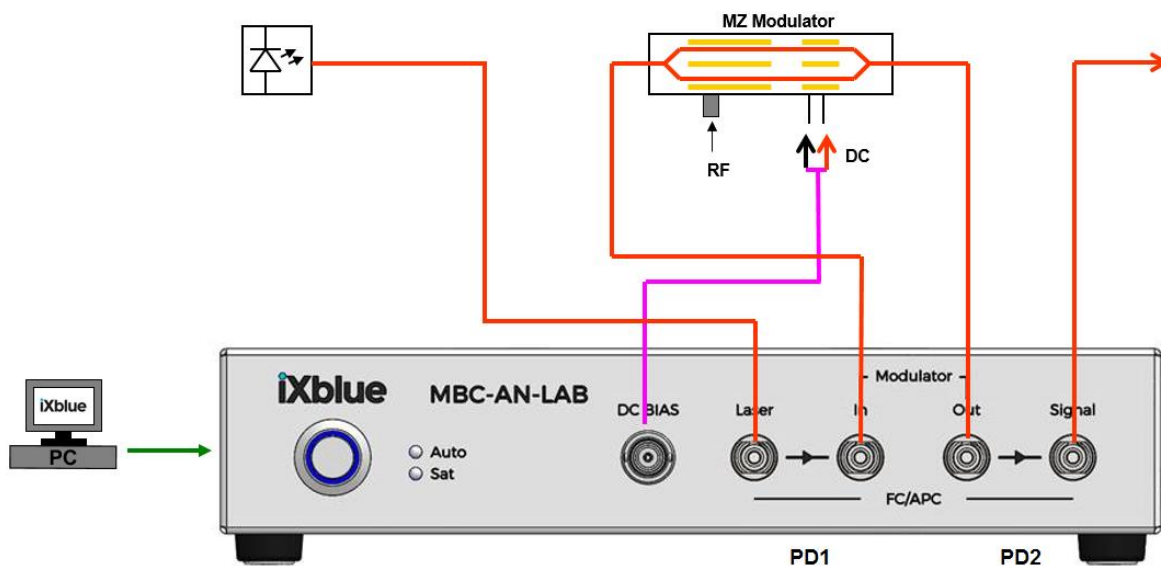
## Operation

### Quick start procedure

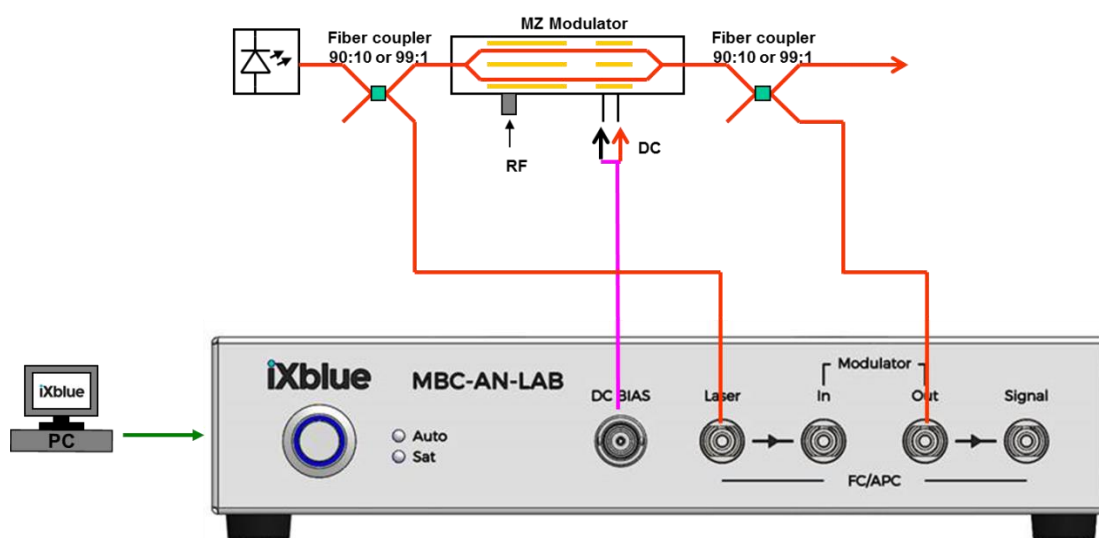
Your MBC-AN-Board has been carefully mounted so that you just need to set the correct adjustments with the windows interface to get going. You basically just need to plug the +12V/0/-12V supply (<3> or <4>) and connect the inputs (<1> and <2>) and the outputs (<9>). You will find a quick start procedure below:

1. Make sure you received all the ordered parts
2. Proceed to the MBC-AN-Board system installation
3. Connect the board to the power supply
4. Connect the PD2 output connector (Signal) to a power meter using an optical fiber. Then plug the modulator output connector to the PD2 input connector. Plug the modulator input connector to the PD1 output connector. And plug the laser connector to the PD1 input connector. Connect the Vbias connector to the modulator Vbias pin, and the ground connector to the modulator ground.

### Setup with an internal coupler (coupler option):



### Setup with an external coupler (no coupler option):



5. When you are done, start the laser
6. Start the MBC-AN windows control interface
7. Select the device
8. Select manual mode and adjust Vbias Mod (can go positive or negative) to get the maximum optical power at the input of your power meter

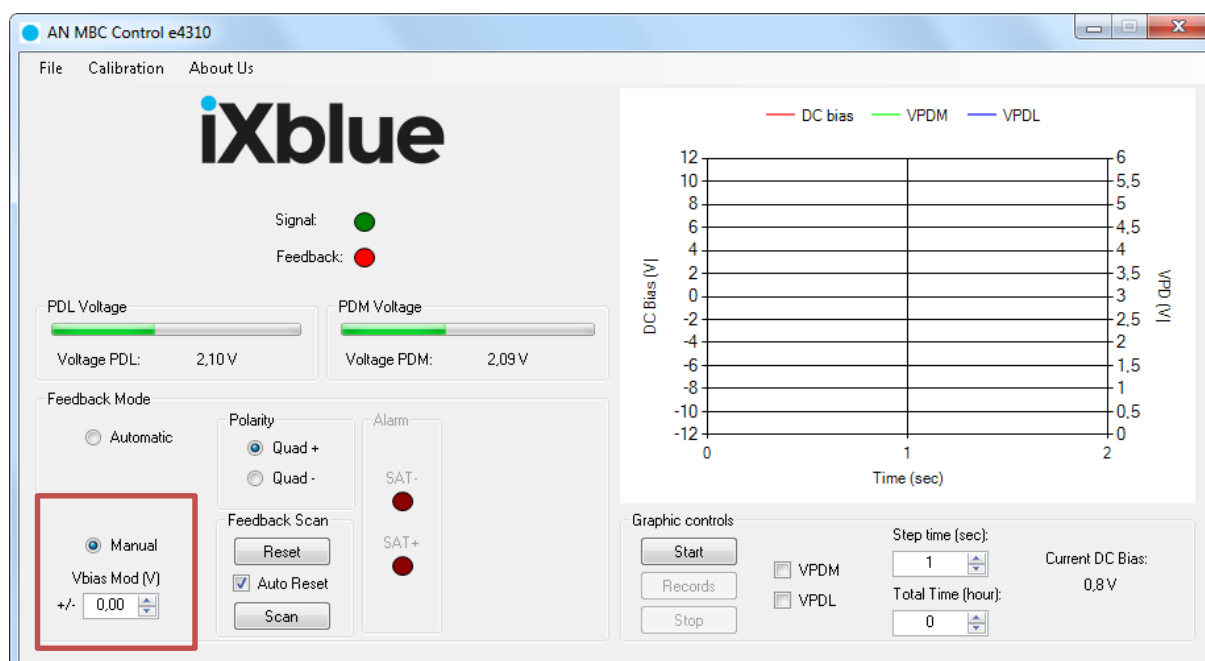


Figure 2: Manual mode selection

9. When done check Automatic



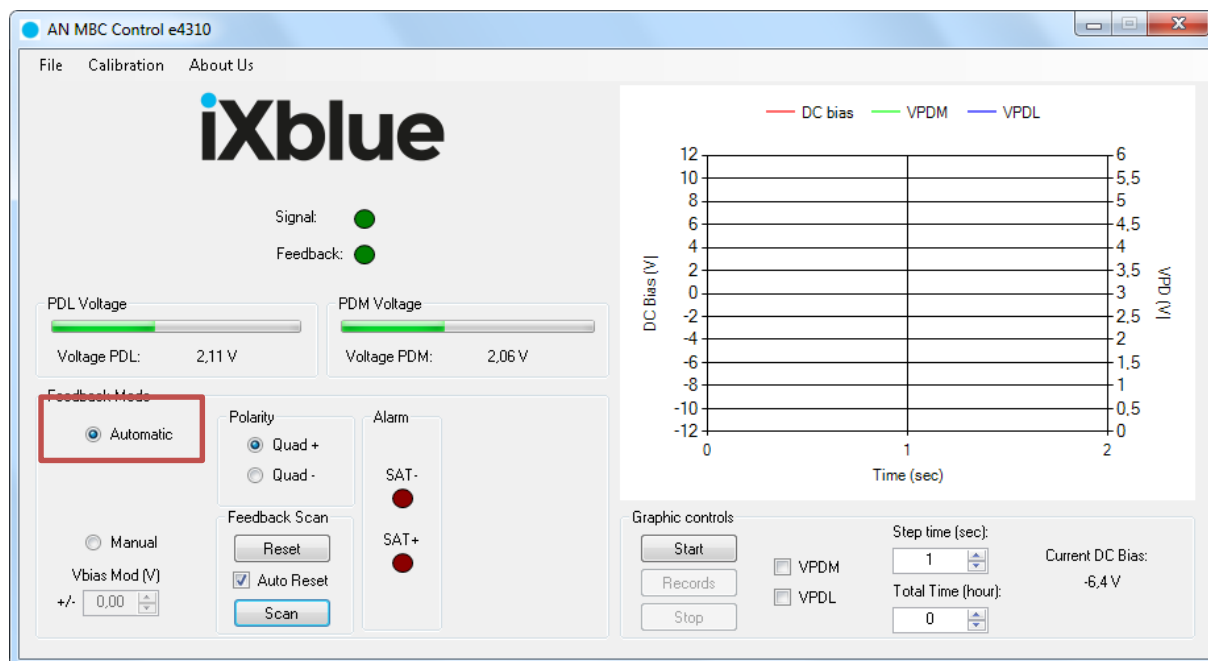


Figure 5: Automatic Mode selection

10. Check the Reset button to restart the integrator

11. The board should be in quad mode

## Remarks:

1. If needed the MBC-AN-BOARD can be used as a manual modulator bias source by selecting the manual mode.

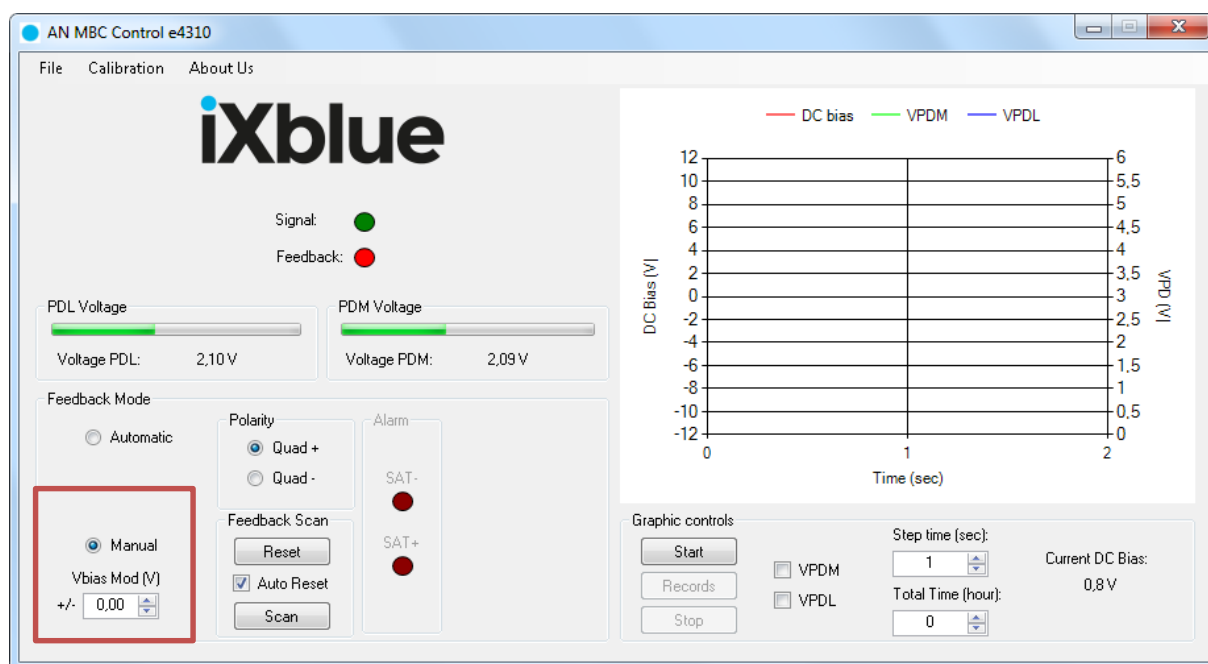


Figure 6: Manual mode selection



2. You can lock the MBC-AN next to the quad point with the “Scan” function.

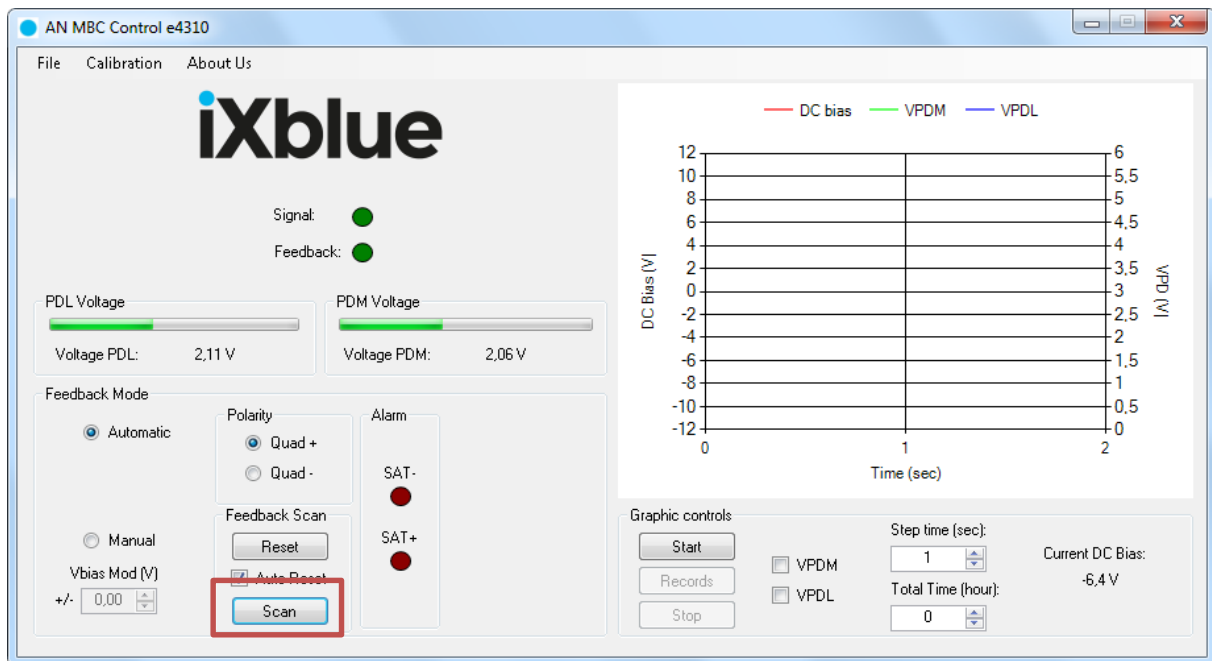


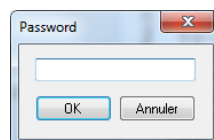
Figure 7: Scan

3. In the case the MBC-AN-BOARD is not able to lock on the quad point, you have to calibrate your MBC-AN-BOARD by using the Calibration menu in the Control interface.

## Calibrating the board

The Calibration mode is used, when you need to set-up the board, for example when you change the modulator.

1. Select the Calibration Menu in the toolbar. Then enter the following password: *trepxe*





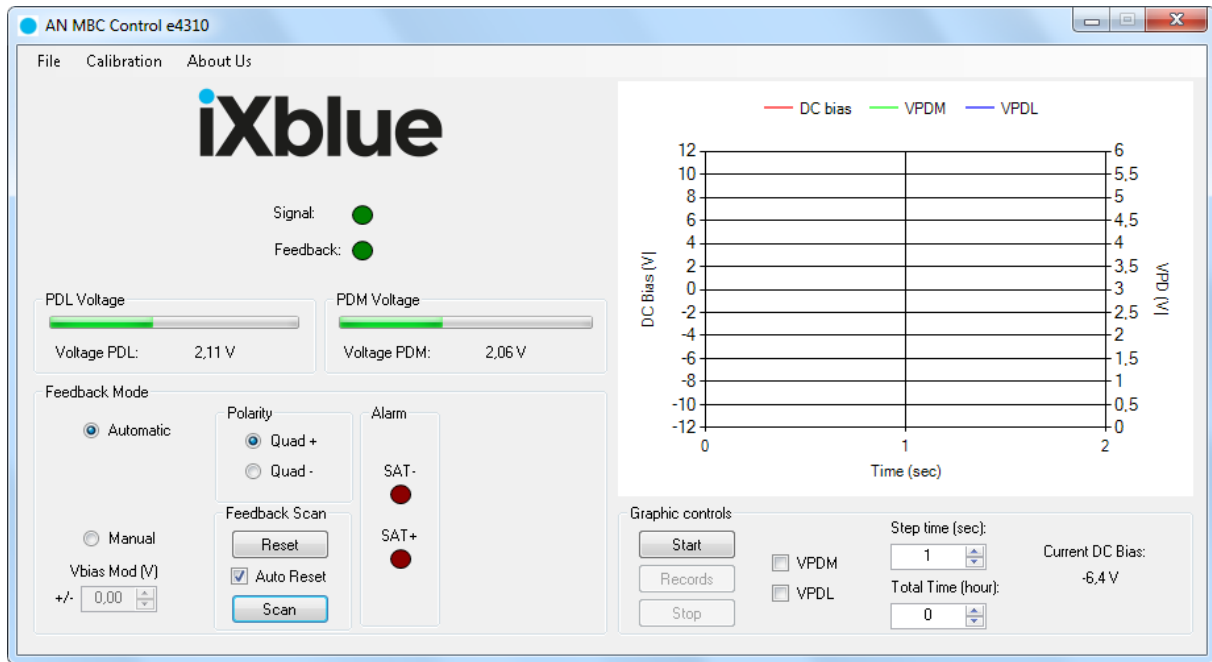


Figure 8: Calibration mode selection

2. Select manual mode and adjust Vbias Mod (can go positive or negative) to get the maximum optical power at the input of your power meter.

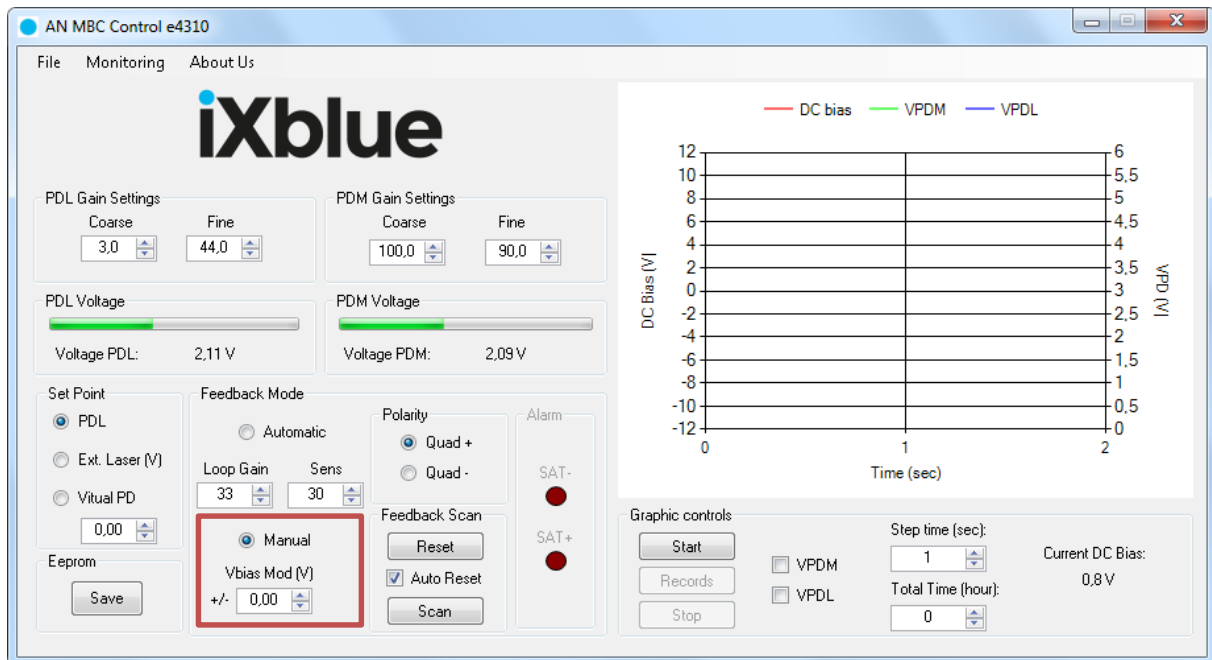


Figure 9: Manual mode selection





3. Change the coarse gain in the PDM (PhotoDiode Modulator) settings box to get a value around 3.5V in the PDM voltage box, and adjust with fine gain.

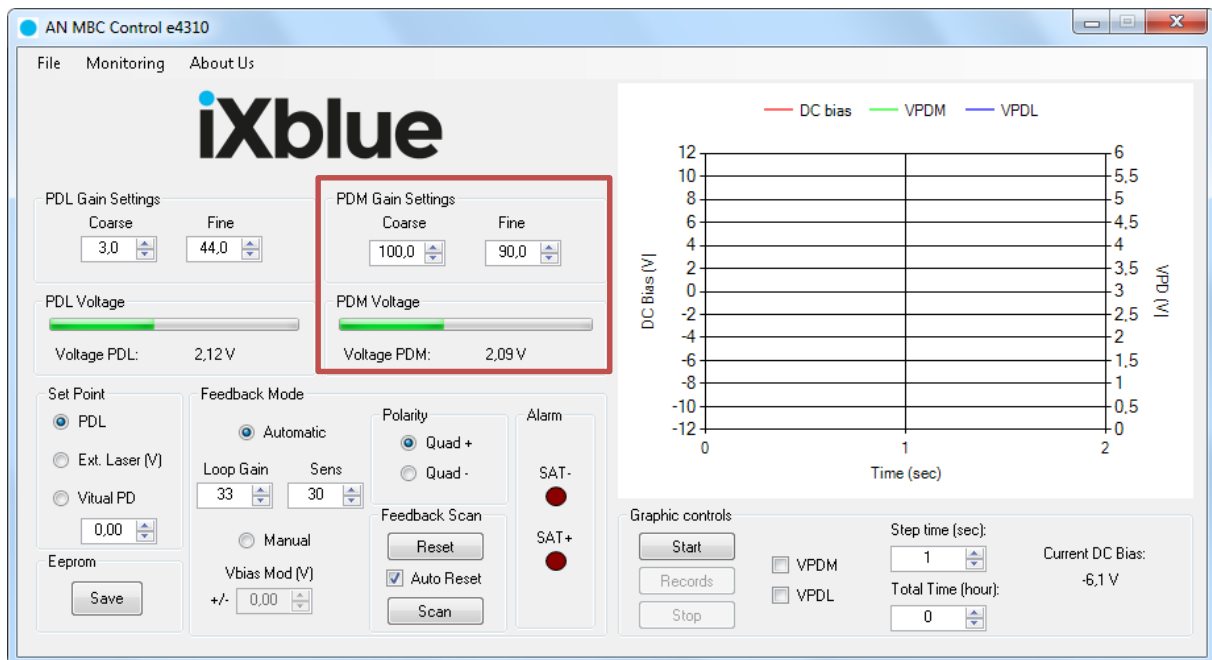


Figure 3: PDM adjustment

Change the coarse gain in the PDL (PhotoDiode Laser) settings box to get a value around 1.75V in the PDM voltage box, and adjust with fine gain. (PDL voltage = PDM voltage / 2)

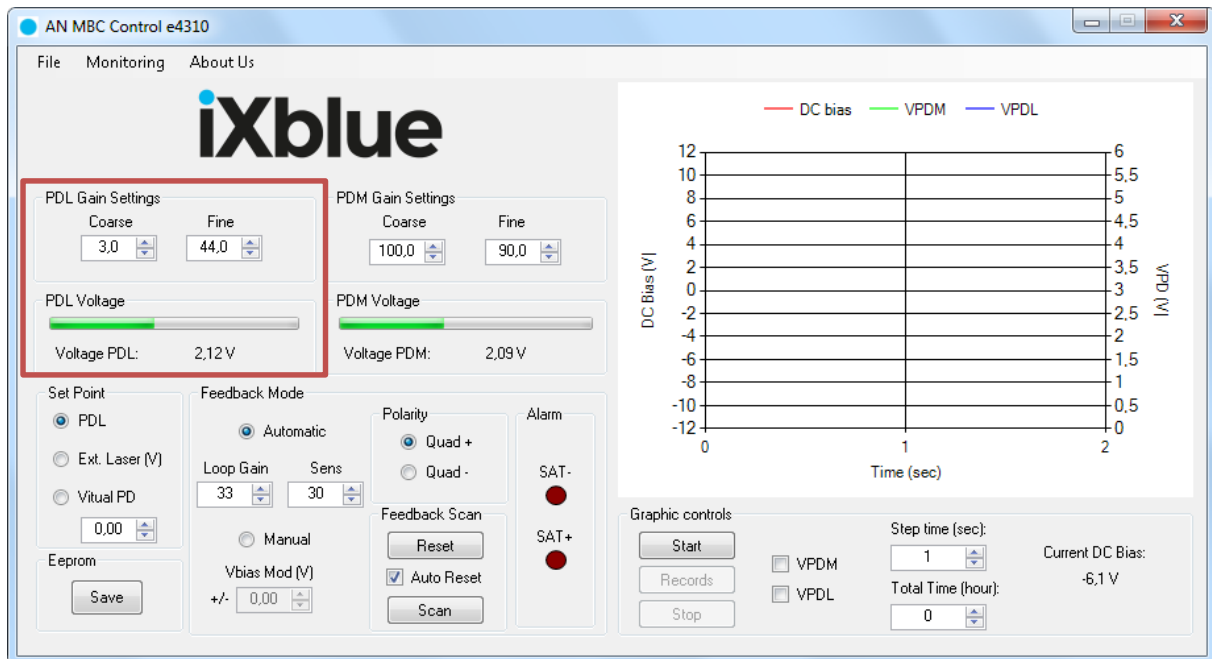


Figure 4: PDL adjustment



#### 4. When done check Automatic

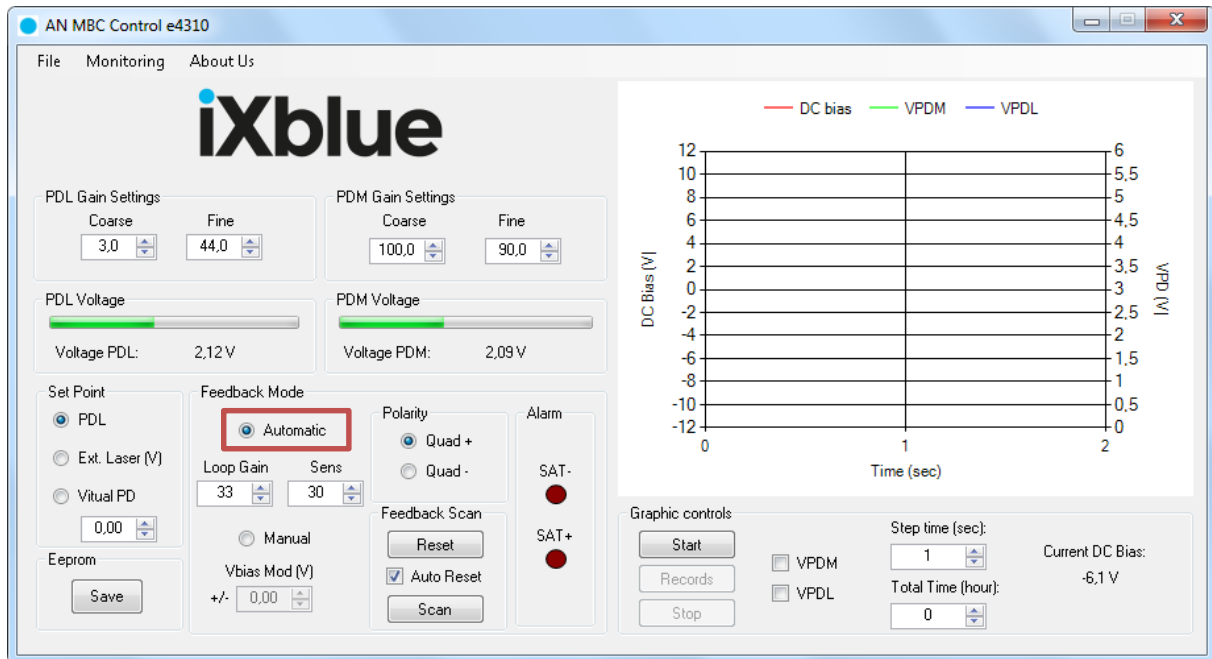


Figure 5: Mode selection

5. Check the Reset button to restart the integrator.
6. The board should be in quad mode. If the optical power measured at the output is different from  $P_{max} - 3\text{dB}$ , and that the LED  $\pm V_{bias}$  sat. are not ON, you can adjust the power by changing the value of the fine gain and coarse gain of PD1.



## Appendices

### A. Mach-Zehnder intensity modulators

Lithium Niobate ( $\text{LiNbO}_3$ ) Mach-Zehnder modulators (MZMs) are external modulators that have been widely used since the mid-nineties, mostly in long haul optical networks for their ability to modulate optical signal from 1300 nm and 1550 nm laser diodes with short transition times and without chirp compared to other techniques (direct laser diode current modulation for instance). Thanks to their broad wavelength performance, they currently also offer modulation solutions at 1064 nm, 850nm and other NIR laser wavelengths.

Mach-Zehnder modulators are 2-waves interferometer devices that exhibit a sine transfer function (Figure 6). Although MZMs are highly stable components, their operating point can suffer slow drifts due to variations of external conditions (like pressure and temperature for instance) and those drifts may induce key performances time fluctuations like the extinction ratio for example.

In order to adjust the operating point of  $\text{LiNbO}_3$  MZMs independently from the RF modulation signal applied, the design can be done with two sets of electrodes: the RF set (the RF Electrodes) is used to apply the RF signal (PRBS data stream, analog signal, short pulses...). The DC set (the DC Electrodes) is applied to set the MZM operating point using a fixed voltage. Figure 7 illustrates the typical electrode architecture of  $\text{LiNbO}_3$  MZMs.

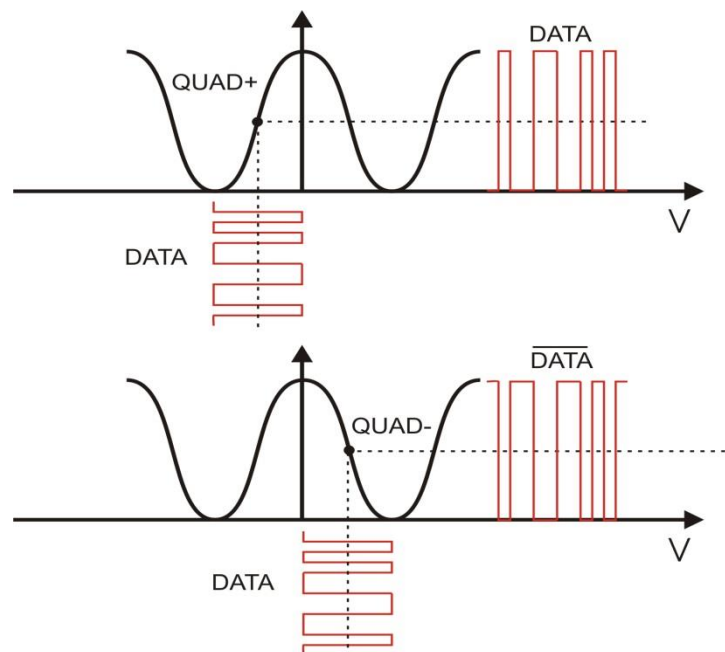


Figure 6 : Transfer function of a Mach-Zehnder modulator and data output vs. data input at QUAD+ and QUAD- operating point



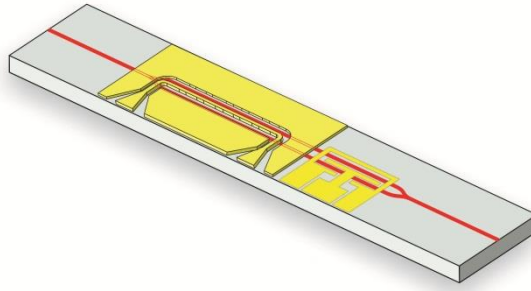


Figure 7: typical electrode and waveguide architecture of a Mach-Zehnder modulator

## B. Drift effects

**DC drift** is the optical output power variation under the constant DC bias voltage application. Figure 8 shows the output power of the modulator as a function of the applied voltage. The broken line shows the output power as a function of applied voltage when only AC voltage is applied (and no DC is applied, at  $t = 0$ ) and the solid line shows the same, after  $t = t_1$ , when DC voltage is also applied in addition to the previous AC signal voltage. The shift between these two curves,  $\Delta V$ , is the measure of the DC drift.

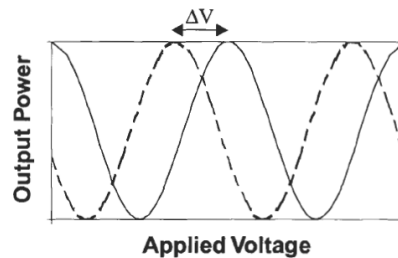


Figure 8: Output power of the modulator as the function of the driving voltage, with/without the DC applied voltage.

The DC drift physical mechanism and its causes are not yet well understood. But this can be attributed to the ions movement, including  $\text{OH}^-$  ions, inside the Lithium Niobate substrate and the buffer layer. It is influenced by the balance of the RC time constants, in both horizontal and vertical directions in the equivalent circuit model, as is displayed in Figure 9. It was also found that the DC drift is more affected by the buffer layer. In the circuit model of Figure 8, all layers, including the  $\text{LiNbO}_3$  substrate, the  $\text{Ti:LiNbO}_3$  optical waveguide and the buffer layer, are represented in terms of resistances  $R$  and capacitances  $C$ , in both vertical and horizontal directions of the crystal.



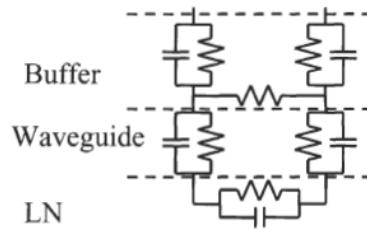


Figure 9:Equivalent RC circuit model of the MZM crystal electric structure, with vertical and horizontal components.

**Thermal and humidity drift** is the optical output power variations under temperature (respectively humidity) changes. Once the temperature changes, piezoelectric charges are induced on the surface of the LN substrate. This raises a surface charge distribution across the two arms of the interferometer, affecting the global electric field. This results into a shift in the switching curve, in the same way that operates the DC drift. Hence, to mitigate thermal effects, there is a need to distribute or dissipate the charges that are accumulating on the LiNbO<sub>3</sub> crystal surfaces and between the electrodes.

