

ModBox VNA

User's Manual

Revision History

Table for the Software product:

Edition	Date	Release	Comments
A	02/2020	ModBox Interface Control v1.1	Creation
B	05/2020	ModBox Interface Control v1.4 Remote VNA GUI v1.3	Add support for DG MBC
C	07/2020	ModBox Interface Control v1.5.1 Remote VNA GUI v1.4	Fix minor issue (wrong single step value when changing a setting). Update Dither Amplitude's Step (MBC DG only) Update Dither Amplitude's Step (MBC DG only)
D	09/2020	ModBox Interface Control v1.6.4 Remote VNA GUI v1.5.1	Add support for new Laser Hardware.

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Manual Overview

This manual is the user guide for the ModBox VNA system manufactured by iXblue. It must be read and understood prior to using the product. The manufacturer shall in no case be held liable for any application or use that does not comply with the stipulations in this manual.

It is divided into several chapters:

- Part 1: Introduction

This part contains a general description of the ModBox and provides information about the theory of operation.

- Part 2: Installation

This part gives some recommendations about the ModBox installation. It also details the procedure to install the ModBox system.

- Part 3: Configuring the ModBox

This part describes how the user should configure his ModBox system for a certain application

- Part 4: Embedded User Interface Operation

This part provides the full description of ModBox operation using the embedded control interface on the front panel.

- Appendices

It contains the detailed drawings and diagrams.

The abbreviations and acronyms used in this manual are listed hereafter.

Abbreviations and Acronyms

NIR	Near Infra-Red
MZM	Mach Zehnder Modulator
ATR	Acceptance Test Report
MMI	Man Machine Interface
NA	Not Applicable
SNR	Signal to Noise Ratio

Text Usage

Bold	Bold text is used for items you must select or click in the software. It is also used for the field names used into the dialog box.
<i>Courier</i>	Text in this font denotes text or characters that you should enter from the keyboard, the proper names of disk Drives, paths, directories, programs, functions, filenames and extensions.
<i>Italic</i>	Italic text is the result of an action in the procedures. It is also used for referencing to other document titles.

Icons



The **Note** icon indicates that the following information is of particular interest and should be read with care.

Important

The **Important** mention indicates that the following information should be read to forbid or prevent a product dysfunction or a faulty operation of the equipment.



The **Caution** icon indicates that the following information should be read to forbid or prevent product damage.



The **Warning** icon indicates that possible personal injury or death could result from failure to follow the provided recommendation.



The **Advanced/Expert** icon indicates that the described procedure/action is reserved to advanced level of operation.

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1 Introduction

1.1 ModBox Overview

ModBox systems are advanced modulation format optical transmitters, laser systems, sensing instruments and application specific modulation units.

In the ModBox systems, we use innovative optoelectronics setups with premium components to provide world class modulation solutions to our customers.

The ModBox systems address a broad variety of applications including but not limited to analog modulation, all digital format optical communication, ultrafast laser pulse generation, laser pulse picking, spectral broadening, etc. We can also work towards custom systems to exceed some clients' specifications needs.

All modulation solutions come with the peace of mind of a bench top, plug & play equipment that can be remotely controlled using a pc.

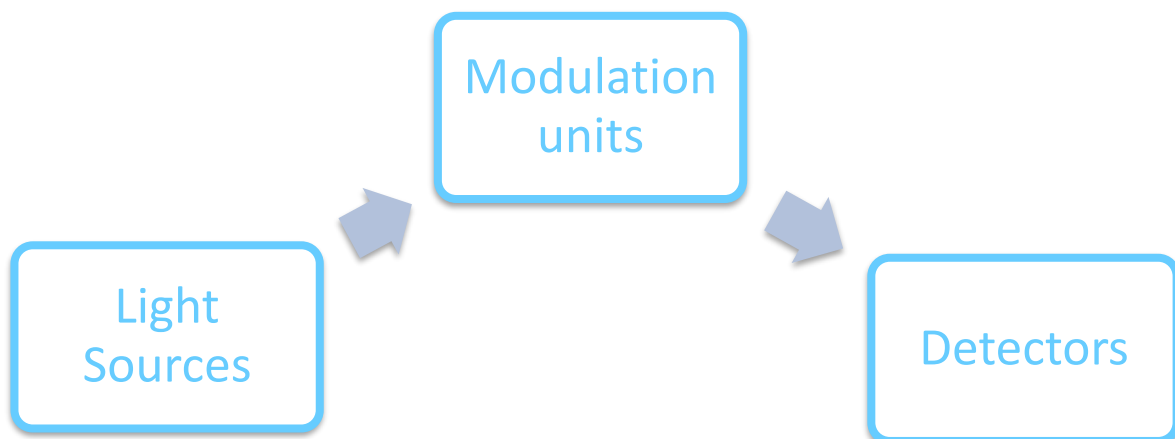


Figure 1 – Basic description of a ModBox system

1.2 Your ModBox system

1.2.1 INTRODUCTION

The ModBox-VNA is a bench top modulation unit intended at expanding vector network analysis features into the optical domain. The ModBox VNA can operate in the C-Band, O-Band, 850 nm and other optical bands with up to 70 GHz bandwidth (-6dB) following customer requests.

This unit will transfer any analog signal from the electrical to the optical domain with the least amount of signal distortion. This electrical signal may be generated by a vector network analyzer. The optical signal obtained at the ModBox output can then be converted back into the electrical

domain using an optional reference embedded photodiode. This allows users to characterize high speed optoelectronics components.

The system incorporates a modulation stage based on a large bandwidth custom designed LiNbO₃ Mach-Zehnder analog modulator coupled with high performance control electronics to enhance the linearity stability of the system.

Customers can select lasers sources and photodiodes references depending their wavelength and bandwidth requirements.

The ModBox-VNA provides state of the art modulation performance with the peace of mind of a turn-key instrument to R&D and production engineers. This system can be set as a reference in optical telecommunication labs or in tests and production lines.

1.2.2 SYSTEM STRUCTURE

The ModBox VNA is a 19" 2U rackable modulation unit integrating:

- A modulation block :
 - One high bandwidth, chirp-free LiNbO₃ Mach-Zehnder analog modulator
 - A high-performance automatic bias controller to stabilize the modulator hence ensuring a highly stable output operation
- Control electronics to operate the ModBox system either through the front panel controls or through the Ethernet port on the rear panel
 - Optionally the system may embed:
- A laser block integrating an extra low linewidth laser (single line or tunable) with its high precision driver and with output power and wavelength real-time control

2 Installation

2.1 Checking the ModBox Pack Contents

You have just received your equipment in protective boxes. Before starting the installation, **we recommend checking the contents of the pack and the equipment immediately on receipt of your ModBox System**. Specifically, you should check that all items are present on delivery and that none has sustained damage.

For that, you will find in the shipping case a packing-list detailing all the shipped items. This packing list had been completed and checked for by iXblue shortly before shipment.



On receipt of the equipment, its overall condition should be checked and iXblue informed of any damage suffered during the loading operations.

It is highly recommended to contact the insurance company in case damage is found.

Check that the shock label of every parcel is still white.

2.2 Transport

The ModBox System should always be transported in the package it came in.

2.3 Panel Features

2.3.1 FRONT PANEL

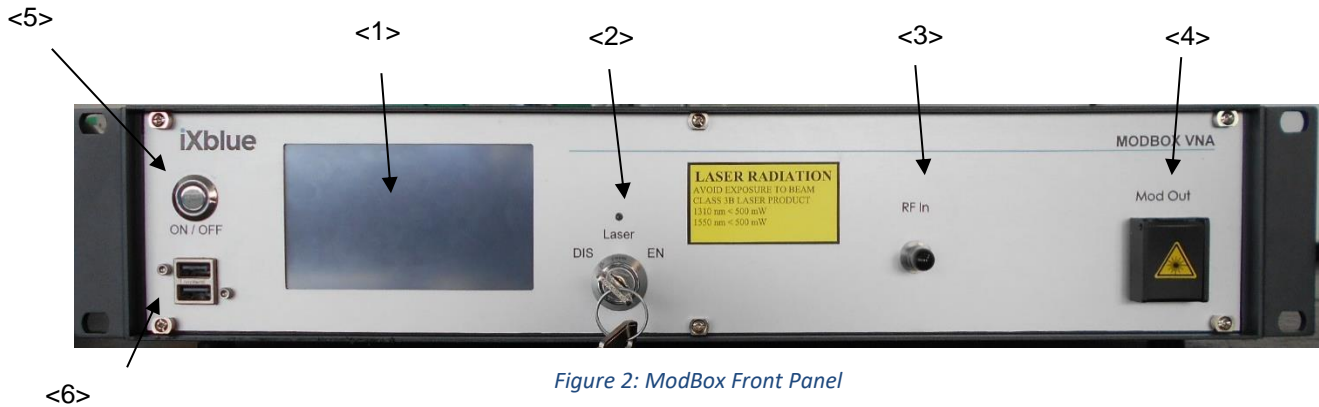


Figure 2: ModBox Front Panel

<1> LCD touch screen display:

Allows front panel system control and displays all necessary information to run the system

<2> Laser Key switch & Led:

Enables/disables laser channel(s).

<3> RF In:

RF input :2.92 mm RF connector or 1.85 mm RF connector

<4> Mod Out:

Modulation Optical Out

<5> ON/OFF Button:

Turn ON or OFF the embedded control system and its touch screen display.

<6> USB Ports

These USB ports may be used to attach a mouse, a keyboard or a USB memory stick. Keyboard and mouse may be used to interact with the ModBox's embedded User Interface, though it was made to be used entirely with the touchscreen. The USB stick may be used to export or import settings, update the firmware, or save recorded MBC data.

2.3.2 REAR PANEL



Figure 3: ModBox Rear Panel

<1> Internal ground port:

This port connects to the internal ground.

<2> Mains power supply socket and general mains switch:

Fuse socket accepts 5*20 mm sized fuse (2A, quick action)

<3> Fans:

This ensures excess heat removal

<4> RJ45 ethernet port

Allows network connection to the ModBox for Remote Control purposes.

2.4 General Recommendations



Make sure that the optical patch cords connected to the Mod out and Ctrl optical ports are cleaned. Failure to do so may induce optical losses and possible damage to the optical fiber end tips.



Make sure there is enough clearance below and behind the unit to ensure proper excessive heat removal by ventilation.

The ModBox is intended to operate from a power source that does not apply more than 265 V RMS between the supply conductors or between any supply conductor and the ground.



The ModBox chassis is connected to earth via the power supply cable. A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation. A dedicated ground plug is available on the rear panel. In order to avoid potential injuries, insert the power cable only into a socket outlet provided with a protective earth contact. Before switching on the instrument, check that the electrical installation complies with the local safety requirements.

Only use specified power cord and connector for your product. This power cord should always remain in good condition.



To avoid personal injuries, do not operate this instrument without the protective cover of the chassis. Do not make any attempt to service or maintain the ModBox system. Should you need any help, contact iXblue staff to get customer service support.



The ModBox is designed for indoor use. To avoid personal injuries do not expose the instrument to water or excessive moisture. Do not operate the instrument in the presence of inflammable gases or fumes.

2.5 Installation Procedure

During the installation process you may need the following document and devices:

- User's Manual
- ATR
- Country specific power cord
- iXblue ModBox USB flash drive
- Ethernet cable

Step	Action
------	--------

I.	Make sure the general mains switch is in OFF position (<10>, rear panel)
----	--

2.	Set the instrument on top of flat stable surface
----	--

3.	Make sure the air is allowed to circulate freely around the instrument to ensure proper cooling and to avoid dust accumulation (especially on the back of the system).
----	--

Caution

Failure to ensure proper cooling may affect ModBox performances and may induce damages to the system.

4.	Use the proper cord for your location
----	---------------------------------------

5.	Connect the end of the power supply cord to the ModBox rear panel power socket and plug the other end to the proper voltage mains supply point. The ModBox is equipped with self-regulating power supply that adapts automatically to AC 110V/ 60Hz and 220 V/50 Hz.
----	--

6.	For ModBox remote control, connect your control PC to the RJ45 ethernet socket located on the back panel, <13>.
----	---

2.6 Connecting the Components

Here we will describe how to connect the ModBox system to your application.

Step	Action
1.	You should prepare at least 2 optical fiber patch cords (with FC or SC connectors depending purchased option) to use the ModBox system with the embedded reference photo receiver (if you purchased this option). Make sure that the fiber connector end facets are clean before using them with the ModBox.
2.	You should also prepare an electrical PRBS data signal to be fed in the system, you will need a 2.92 mm or 1.85 mm RF connector cable to connect with the ModBox RF input.
3.	Connect one of the laser optical output fiber connectors to a power meter using an optical fiber patch cord (delivered with the ModBox).

3 Configuring the ModBox

3.1 Software installation

Users can operate the ModBox system using the touchscreen interface on the front panel. Once the system is started, the ModBox interface application is launched, and the system is now ready for operation.

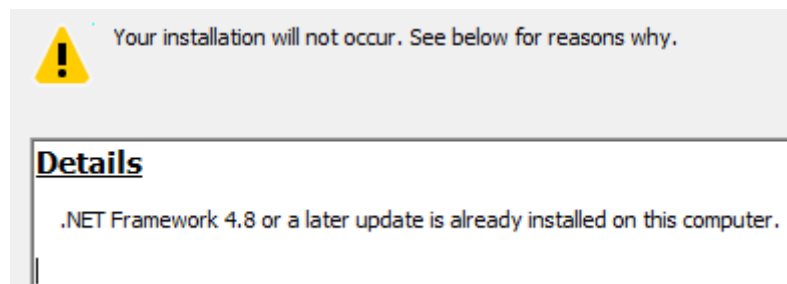
A remote-control Graphical User Interface (GUI) can be found on the USB flash drive delivered with the ModBox. The executable file is called **RemoteVNA.exe**.

This software requires the .NET Framework to be installed. If your system is running **Windows 10**, you do **not** need to do anything before **double clicking the file**.

If you are running a previous version of Windows, you may need to install the .NET Framework, but chances are that it may already be installed on your system.

If it is not installed yet, or if you do not know if it is, run the setup called **dotNet Framework Setup (v4.8).exe** (this requires administrator privileges).

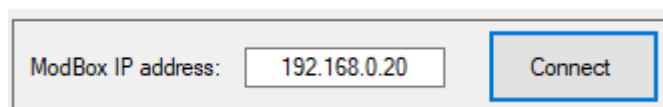
If the Framework was already installed, you will encounter the following kind of error message:



If that is the case, close the error window and run the remote control software.

You are free to copy and place the **RemoteVNA.exe** file wherever you want. There is no additional setup procedure and you can run the software on any Windows machine as long as the .NET Framework is installed.

To remotely connect to the ModBox using the **RemoteVNA** software, you will require the ModBox's IP address and enter it in the text box at the top of the window:



If you need help retrieving the ModBox's IP address, please report to the [Network Configuration section](#) (p. 27) of this document.

Once the software is connected to the ModBox, please report to the [Operation Procedure section](#) (p. 20) of this document for details about the ModBox's settings:

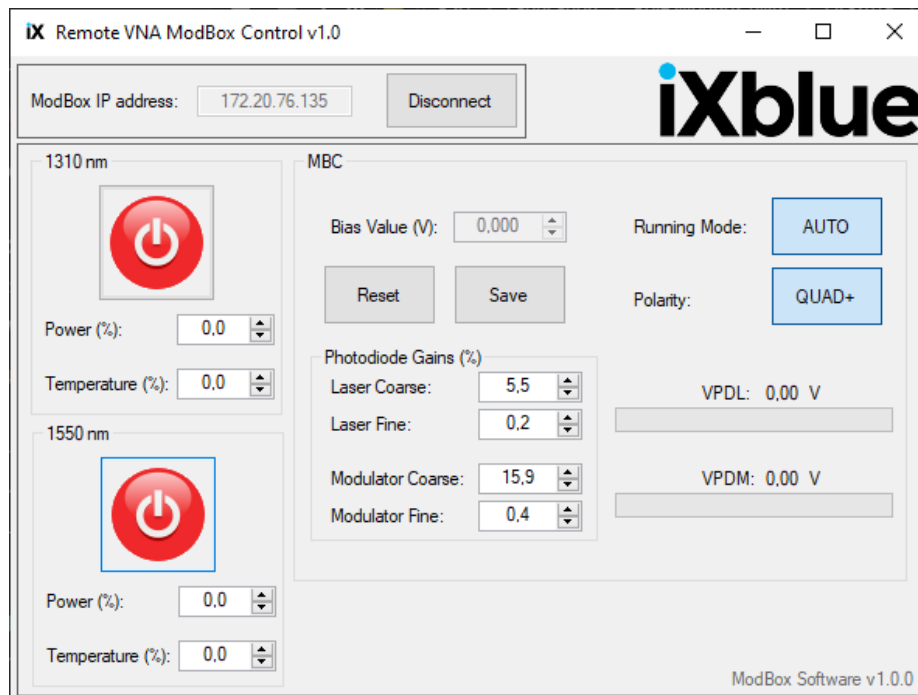


Figure 4: Remote Control GUI

(Every setting in this GUI can be found on the front panel's embedded system)

3.2 ModBox connections

The user may attach a mouse and/or a keyboard to the system for alternative browsing through the embedded control interface. Note that the system was made to be controlled using exclusively the touchscreen display.

The user may also connect a USB storage device to the system for file sharing using either one of the USB slots on the front panel.

The **“Mod Out”** fiber patch cord may be attached to a photodiode using proper inline attenuation so that the receiver is not overloaded (which may lead to permanent damages if crossing the absolute ratings bounds).

Finally, the system may be connected to a local network for remote control using the Ethernet slot on the back panel.

4 Embedded User Interface Operation

We consider here that the user has installed the hardware items related to the ModBox system. We also consider that the user is familiar with ModBox configurations and that the ModBox configuration is presently set.

4.1 Operation procedure

Step	Action
------	--------

- | | |
|----|---|
| I. | Turn on the ModBox general mains switch <10>. |
| 2. | The ModBox system will initialize and check critical components operation. The following screen will be displayed after the ModBox interface has controlled the hardware conditions and settings: |

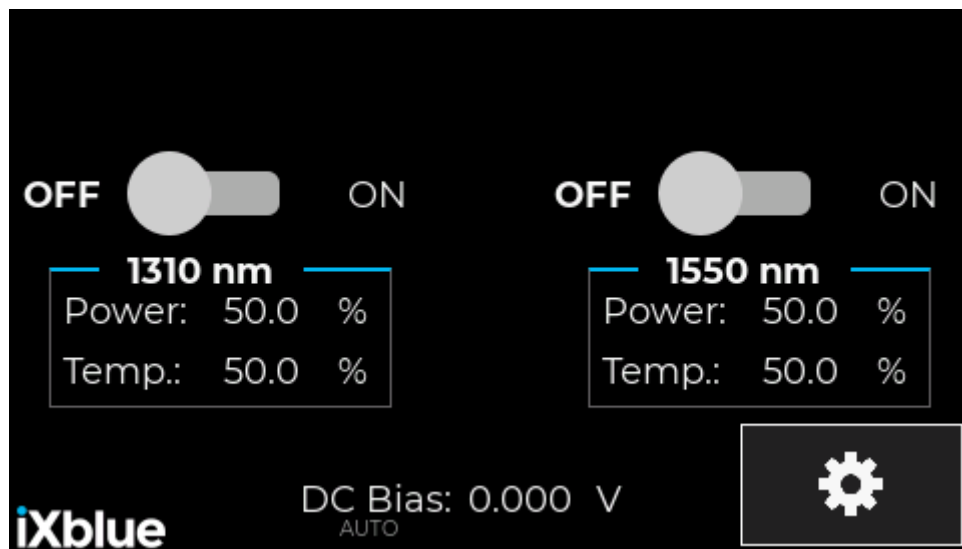


Figure 5: Main Tab

First, we need to start a laser:

To do that you have to switch the laser key (<2>, front panel) to the **EN** position, then turn on one of the lasers using the corresponding **ON/OFF** button.

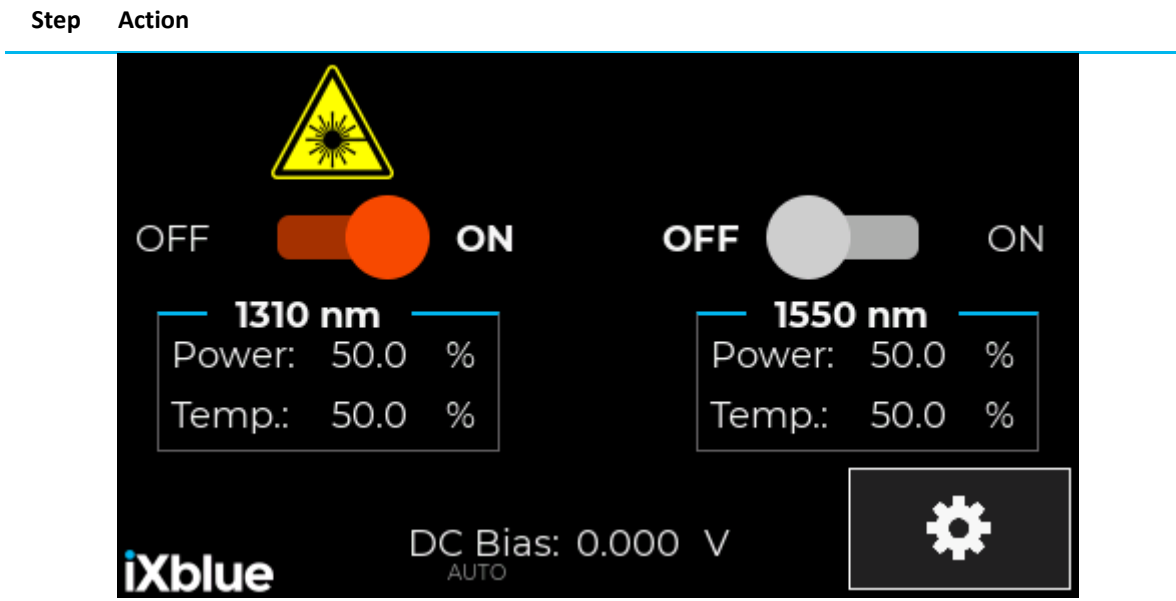


Figure 6: Main Tab Laser on

Wait few seconds and the MoxBox will be ready to use.

4.2 Settings description

When you click on the settings gear, you will be able to change some ModBox parameters:

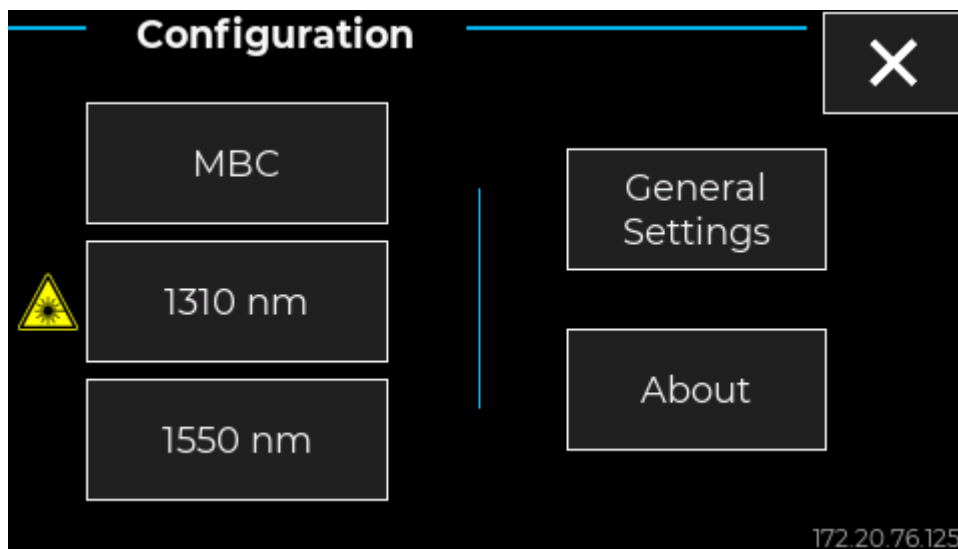


Figure 7: Setting Tab Laser on

Step	Action
I.	Press the MBC button:

Step Action

Depending on your order, the ModBox may include either a **Digital (DG)** or an **Analogic (AN)** MBC.

Ignore this step and step 2 if your ModBox includes a **Digital MBC** (see step 3).

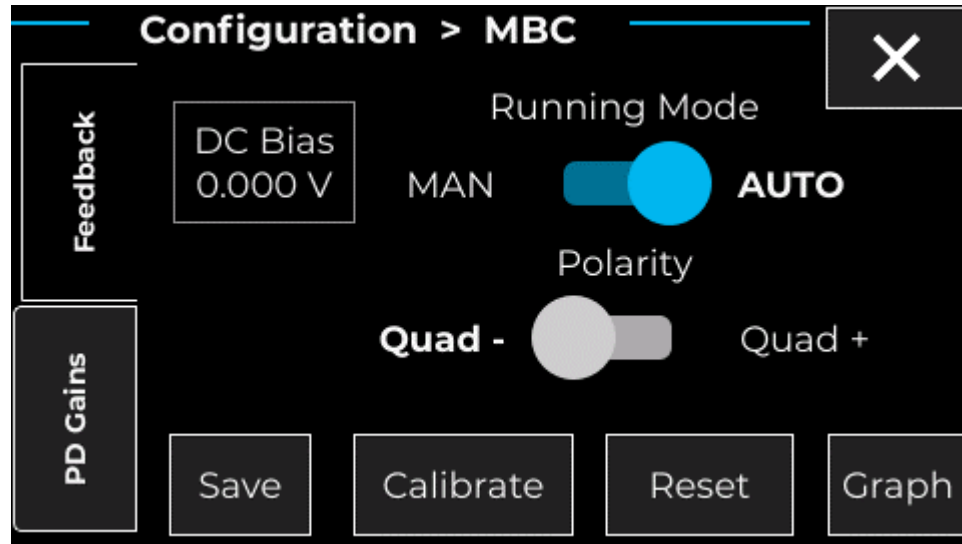


Figure 8: AN MBC Feedback tab

Running Mode/DC Bias: This parameter allows the user to switch between automatic and manual mode.

In manual mode, you can set the bias voltage manually using the following Bias Value parameter: you can set it between -10 V and 10 V.

In automatic mode, the system computes the bias voltage automatically: in that case the bias value may not be manually adjusted. However, you can initiate a rescan: the system will scan through the modulator’s bias voltage values and restart the loop control.

In the case you want the system to be ran automatically, select AUTO for the running mode.

- **Polarity:** select locking point Quad+ (positive slope) or Quad- (negative slope).
- **Save:** Save MBC parameters so that they can be restored the next time the ModBox is rebooted.
- **Calibrate:** Auto set MBC parameters.
- **Reset:** Reset feedback loop. Useful after a PG gains modification.
- **Graph:** Useful to save DC bias value over time for stability testing.

Step Action

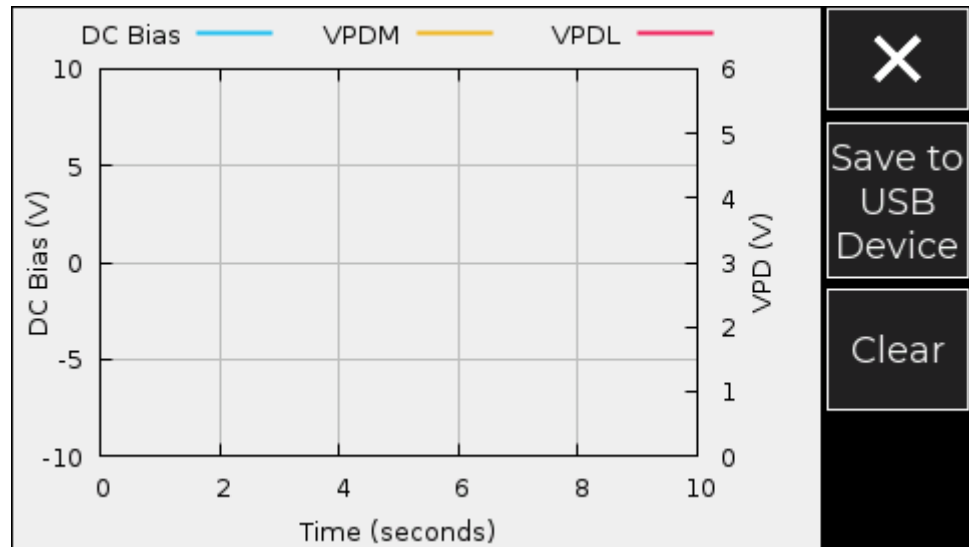


Figure 9: AN MBC Voltages tracking

2. Click on PD Gains:

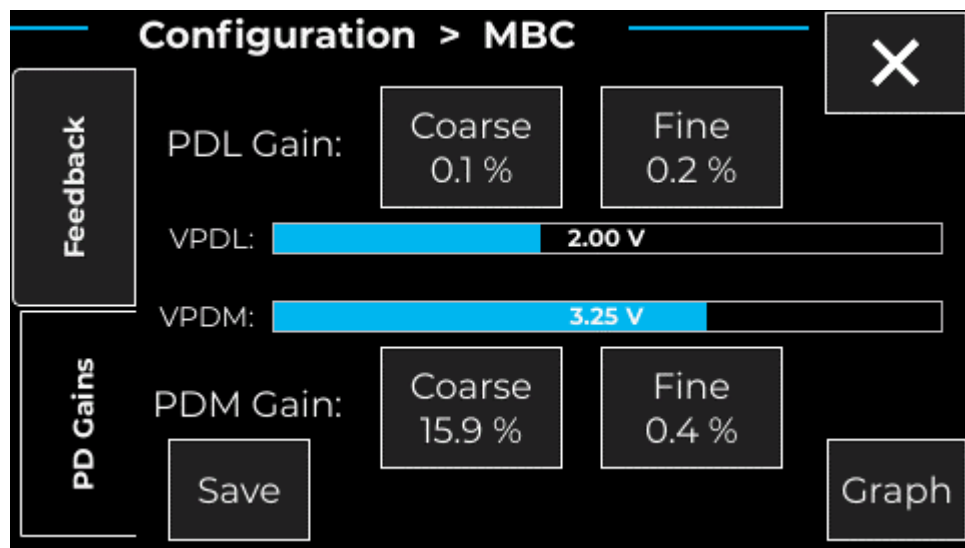


Figure 10: AN MBC PD Gains tab

- **Gain Coarse/Fine:** Used to calibrate the feedback. Adjust both to move feedback locking point to the value you want.
- **VPDL/VPDM:** Indicate feedback state. In auto mode, VPDM must be equal to VPDL at quad point.

3. Ignore this step if your ModBox includes an **Analogic MBC** (see step 1).

Step Action

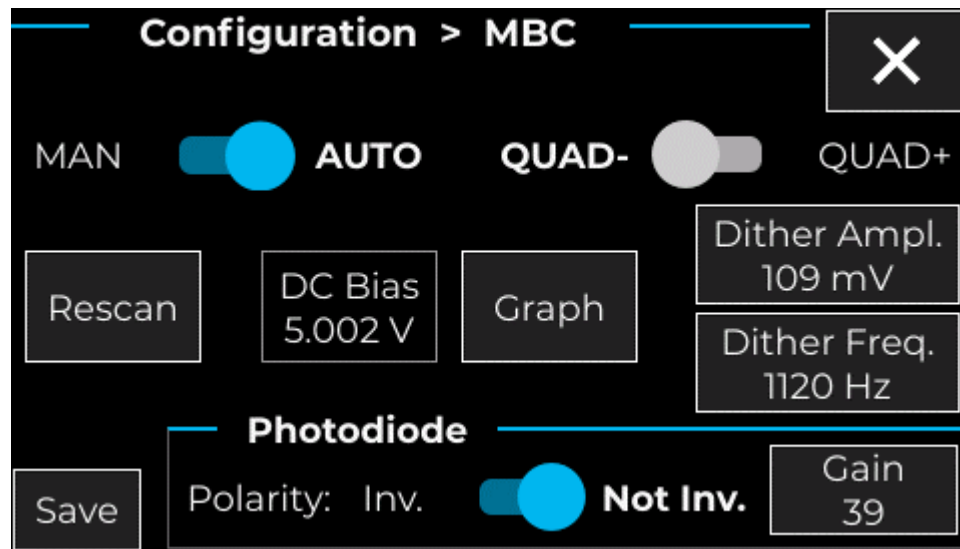


Figure 11: DG MBC Feedback tab

MAN/AUTO & DC Bias: This parameter allows the user to switch between automatic and manual mode.

In manual mode, you can set the bias voltage manually using the following DC Bias value parameter: you can set it between -10 V and 10 V.

In automatic mode, the system computes the bias voltage automatically: in that case the bias value may not be manually adjusted. However, you can initiate a rescan: the system will scan through the modulator's bias voltage values and restart the loop control.

In the case you want the system to be ran automatically, select AUTO for the running mode.

- **QUAD-/QUAD+:** select locking point Quad+ (positive slope) or Quad- (negative slope).
- **Save:** Save MBC parameters so that they can be restored the next time the ModBox is rebooted.
- **Rescan:** Force the MBC to restart searching for a working point. The MBC usually does this automatically after some operations.
- **Dither Amplitude:** This setting has been optimized to get the best modulator's performances. It should be equal to 3% of the modulator's V_{π} DC.
- **Dither Frequency:** This setting has been optimized to get the best modulator's performances.
- **Graph:** Useful to save DC bias value over time for stability testing (Figure 12).

Step Action

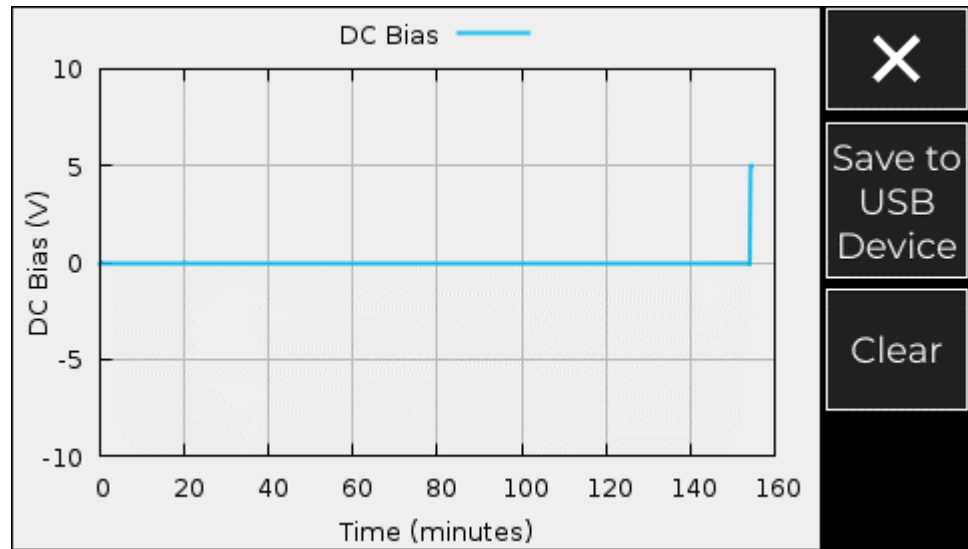


Figure 12: DG MBC DC Bias tracking

- Go back to the previous menu and click on a wavelength:

This Laser menu can have two slightly different versions, depending on the hardware inside the ModBox.

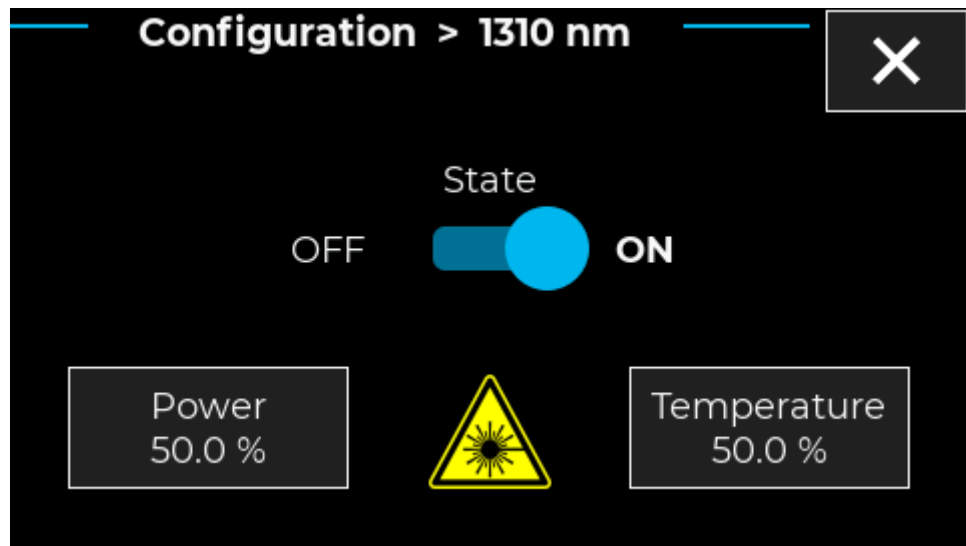


Figure 13: Laser tab (basic)

In both versions of the menu, the following settings can be found:

- ON/OFF:** Enable or disable laser output. Please check that the physical key switch on the front-panel is set to the EN position before trying to turn ON the Laser.
- Temperature:** Adjust laser temperature from 0 to 100%. Usually, it can change the laser wavelength up to 1nm.

Step Action

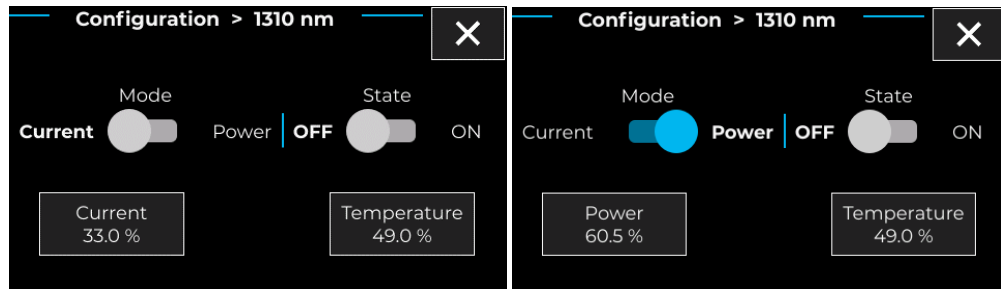


Figure 14: Laser tab (with regulation mode choice)

In the basic menu (Figure 13), there is only one additional setting:

- **Power:** Adjust laser power from 0 to 100%. Actual output power varies between lasers.

In the second type of menu (Figure 14), you can choose if the Laser output power should be regulated for either a constant **current** consumption or a constant output **power**:

- **Current/Power** switch: Change from one mode to the other. Please note that the laser must be turned OFF first.
- **Power:** Adjust laser power from 0 to 100%. Actual power output varies between lasers. (This setting only appears in **Power** regulation mode)
- **Current:** Adjust laser current from 0 to 100%. Actual power output varies between lasers. (This setting only appears in **Current** regulation mode)



5. If you wish to shut down the ModBox, **first press the ON/OFF button (<5>)** on the left of the front panel and **wait about 10 seconds** before cutting power to the ModBox. This ensures a **proper shutdown** of the embedded control system as well as the embedded devices inside the ModBox.

- The main ModBox settings have now been covered. The next section covers more secondary or advanced features.

Go back to the general Configuration menu and click on General Settings:

Remote & Network:

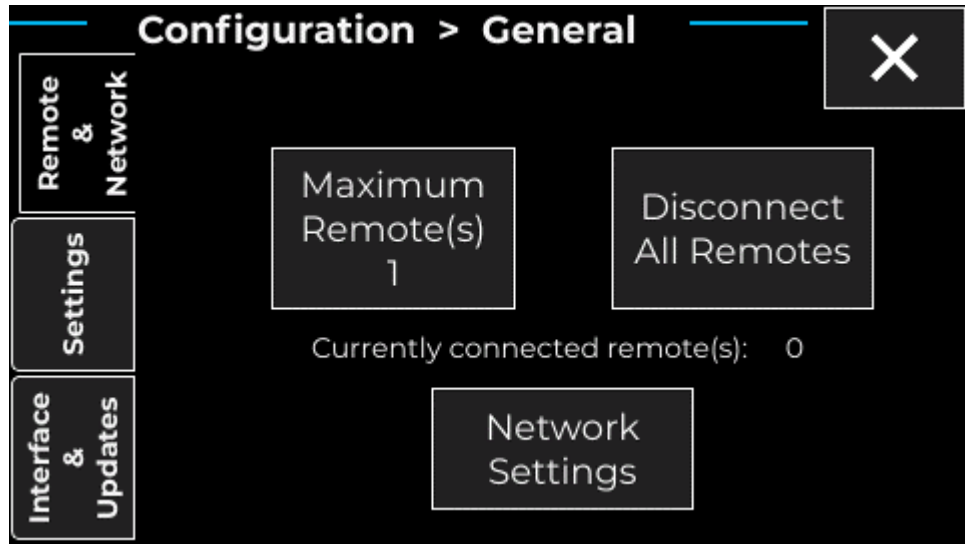


Figure 15: Remote & Network tab

This menu allows you to manage the remote connections. You may also change some **Network Settings** by pressing the bottom button:

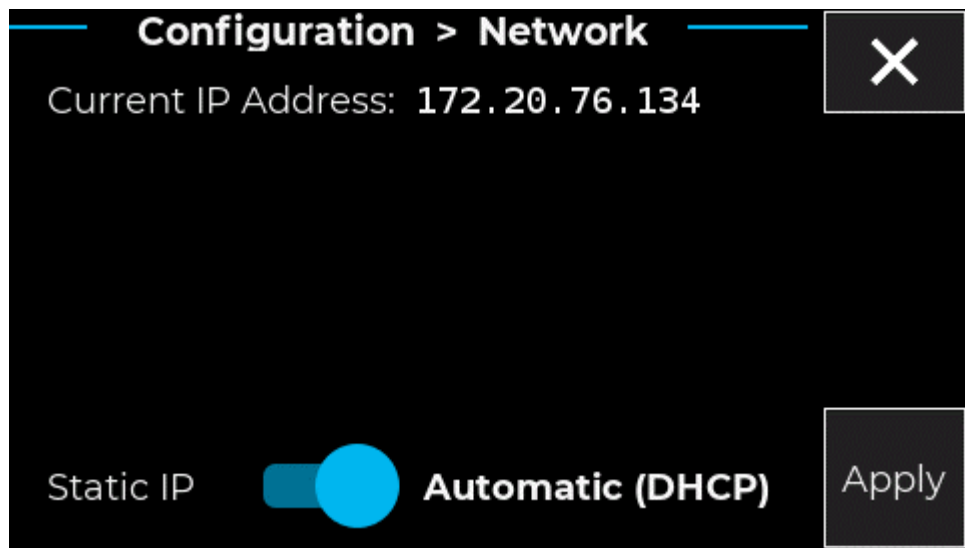


Figure 16: Automatic Network Settings

The current IP Address is shown at the top of screen (if no ethernet cable is plugged in the rear panel, then “No Network” is displayed instead).

In most cases, an automatic configuration will work just fine. However, should you want to setup a static IP address, you will need to toggle the bottom switch to **Static IP**:

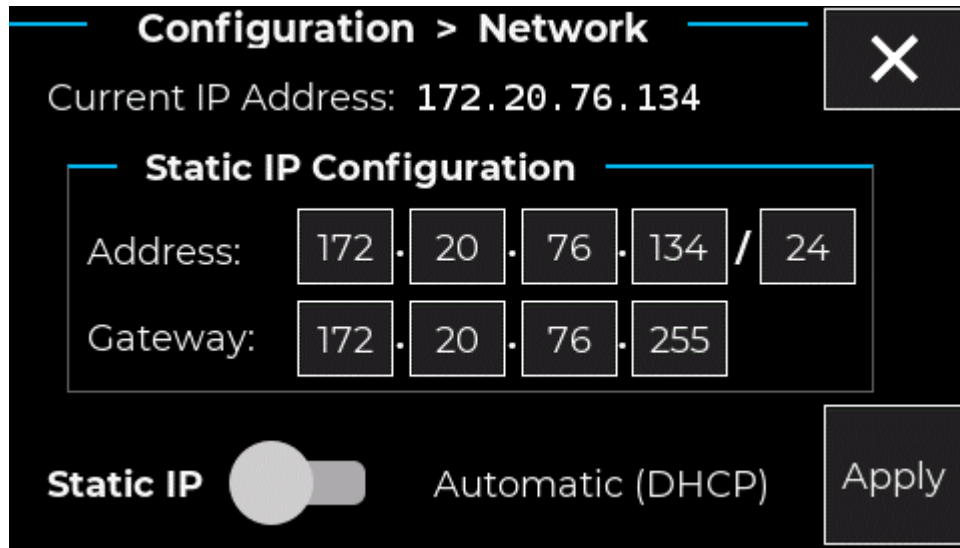
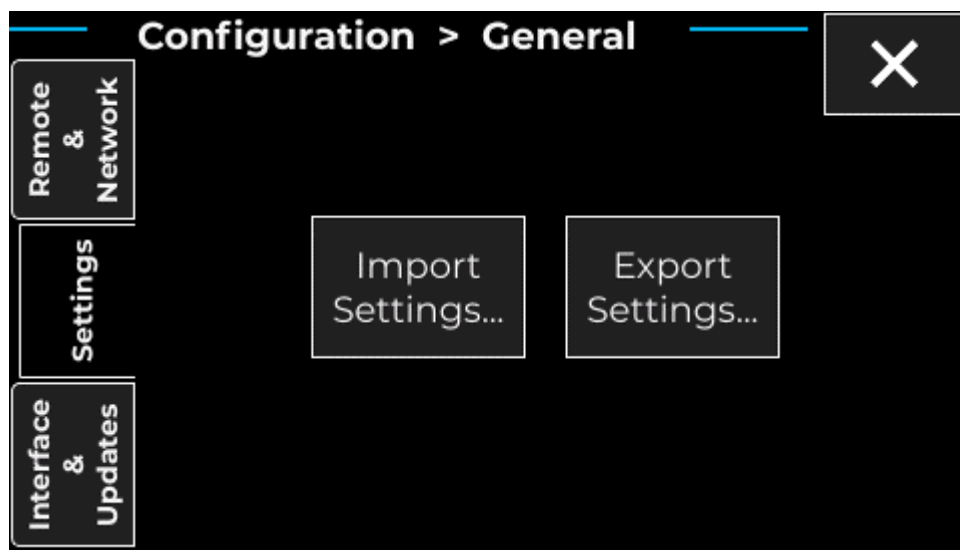


Figure 17: Manual Network Settings

You are now able to edit those settings as you wish.

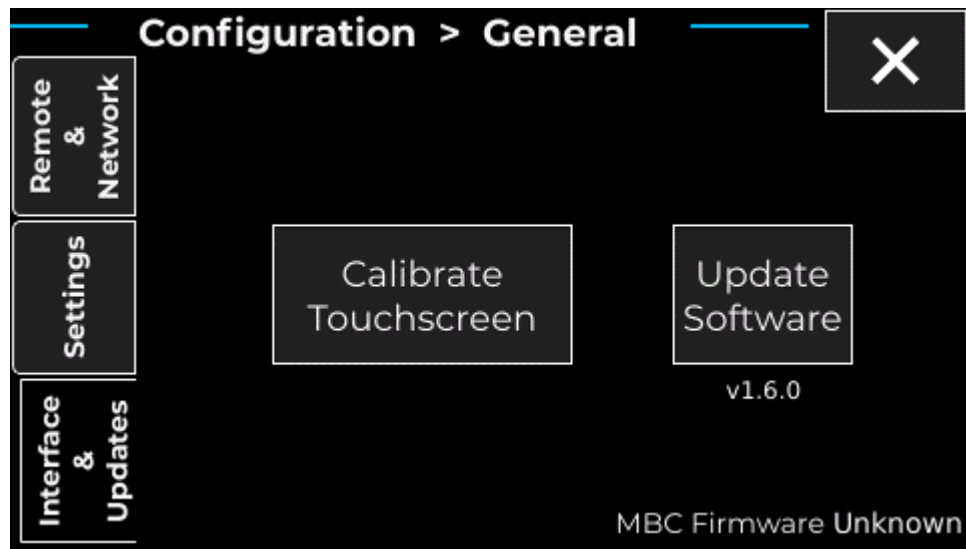
If you want your changes to have any effect, **you must press the Apply button**, and **restart the system**. Upon pressing the Apply button, you will be prompted to properly reboot the system.

Settings:



This menu Allow to import or export all ModBox settings from/to a USB storage device.

Interface & Updates:



This last menu allows you to recalibrate the touchscreen or upgrade ModBox software. You rarely should have to use those features on your own.

4.3 AN MBC manual calibration:

Not applicable for a DG MBC.

Step	Action
I.	Check that a laser is turned on.
2.	Go into Configuration (Settings gear) > MBC > Feedback tab and set the MBC in manual mode. Find the maximum light on the output modulator by changing DC bias value.
3.	After that go to PD Gain tab, adjust PDL gain to obtain 2V for VPDL and adjust PDM gain to obtain 4V for VPDM.
4.	Go back to Feedback and set MBC in AUTO mode. Modulator locking point will be QUAD.

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Appendices

A MACH-ZEHNDER INTENSITY MODULATORS

Lithium niobate (LiNbO_3) Mach-Zehnder Modulators (MZM) are external modulator that have been widely used since the mid-nineties, mostly in long haul optical networks for their ability to modulate optical signal from 1300 and 1550 nm laser diodes with short transition times and without chirp compared to directly modulated diode lasers. Thanks to their broad wavelength performance, they currently also offer modulation solutions in the NIR band, and for even shorter wavelengths.

MZM are 2-waves interferometer devices that exhibit a sine transfer function (Fig.13). Although MZMs are highly stable components, their operating point suffers from slow drifts due to variations of external conditions (mechanical strengths, temperature, radiation ...). Those drifts may induce key performances time fluctuations (extinction ratio for example).

In order to adjust MZM operating point independently from the applied RF modulating signal, we could use a RF design based on 2 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 electrodes are used to set the modulator's operating set point. Fig.14 illustrates the typical electrode architecture of LiNbO_3 MZM.

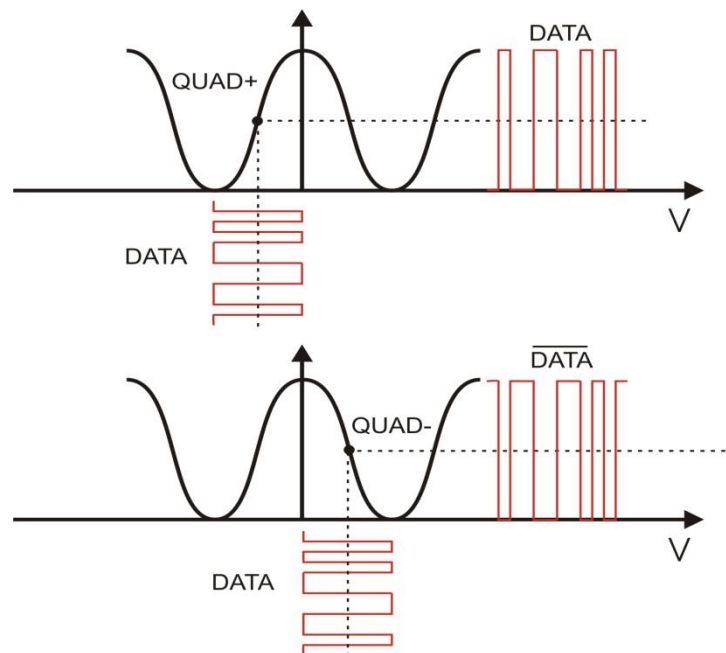


Figure 18: MZM transfer function and data output vs data input at QUAD+ and QUAD- operating point

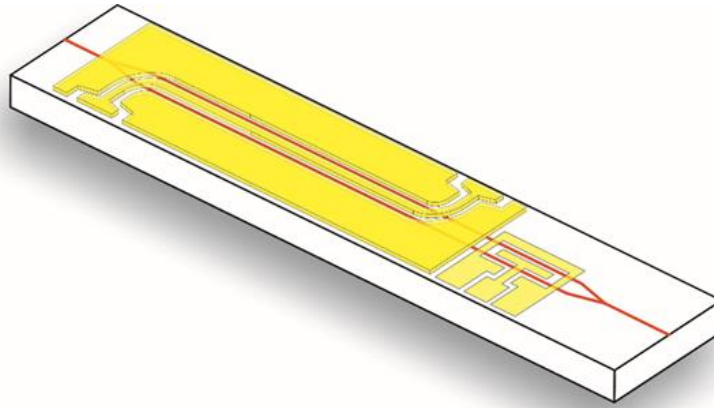


Figure 19: Typical electrode and waveguide architecture of an MZM

B DRIFT EFFECTS

DC drift is the optical output power variation under the constant DC bias voltage application. Fig.15 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: ΔV is the measure of the DC drift.

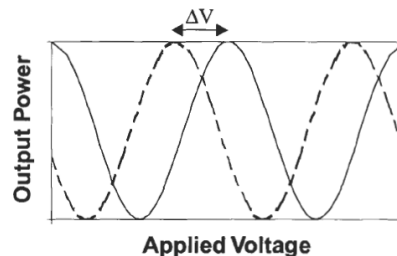


Figure 20: MZM output power vs driving voltage w and w/o DC voltage

The DC drift physical mechanism and its root causes are not yet very well understood. But this can be attributed to the ions' movement, including 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 fig.16. It was also reported that the DC drift is more affected by the buffer layer. In the circuit model of fig.16, all layers, including the LiNbO_3 substrate, the Ti: LiNbO_3 optical waveguide and the buffer layer are represented in terms of resistances R and capacitances C , in both the vertical and horizontal directions of the crystal.

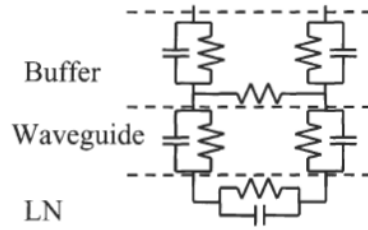


Figure 21: RC equivalent circuit model of the MZM with vertical and horizontal components

Thermal or humidity drift stands for optical output power fluctuations induced by thermal or humidity variations. Local temperature variations induce pyroelectric charge growth inside the LiNbO3 crystal. These charges migrate to the outermost surfaces of the crystal and between the electrodes, thus leading to a charge growth across the arms of the interferometer. This results on a modified electric field seen by the crystal. This then shifts the sinusoidal transfer curve as seen on fig.15, this thermal drift is then very similar in terms of the physics consequences to the drift seen when applying a DC voltage on the DC electrodes. One direction to mitigate this charge accumulation on the crystal surfaces is to use elements meant at dissipating those charges.