MX35E Series

Reference Transmitters with Linear RF Amplifiers

User Guide

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Chapter 1 Introduction

1.1 Description

The MX35E series of linear reference transmitters are designed for high-speed fiber optic test and measurement applications. These transmitters provide a fully-integrated and user-configurable solution based on proven lithium niobate ($LiNbO_3$) modulator technology driven by a high-fidelity linear RF amplifier. The MX35E series is optimized for linear applications. Its amplifier has a variable gain, whose control ensures the output of the amplifier remains linear over a broad variety of input conditions. This instrument features a built-in telecom-grade tunable or fixed-wavelength laser and full featured modulator bias control. In addition, integrated variable optical attenuators (VOAs) and power monitors enable fully automatic output power control and stabilization.

The MX35E, MX35E-LB, and MX35E-1310 include a C-band tunable laser, an L-band tunable laser, and a 1310 nm fixed-wavelength laser, respectively. Both the C- and L-band laser sources are tunable on the ITU 50 GHz grid and include a dither feature for wavelength stabilization. An external laser source, operating from 1250 nm to 1610 nm, can also be used with all models to provide the optical input.

This instrument can be controlled in two ways. The simplest method is directly via the built-in graphical user interface (GUI) and touchscreen. The instrument can also be operated remotely via the RS-232 or USB ports on the back panel. Remote control is enabled using simple SCPI-type serial commands from a PC. See the remote control user guide (RCUG), which can be downloaded from https://www.thorlabs.com/manuals.cfm.

The most recent firmware and remote control software tool can be downloaded by visiting https://www.thorlabs.com/navigation.cfm?Guide_ID=2191 and entering the appropriate Item # into the search field. Thorlabs' technical support can provide up-to-date information on available firmware revisions and control functions.

1.2 Parts List

Inspect the shipping container for damage. If the shipping container seems to be damaged, retain it until all contents have been inspected and the unit has been mechanically and electrically tested. Verify receipt of the following items:

1. MX35E Series Linear Transmitter Main Unit
2. Power Cord According to Local Power Supply
3. PM Loopback Fiber Optic Cable
4. Interlock Keys
5. 2.5 mm Interlock Pin (in Back Panel)
6. 1.25 A 250 VAC Fuse
7. USB Type A to Type B Cable, 6' Long

1.3 Block Diagram

The MX35E series of linear reference transmitters is fully integrated and contains both a laser source and a lithium niobate ($LiNbO_3$) Mach-Zehnder intensity modulator (MZM); the only required external input is the signal source to the Amplifier RF In port. Either the internal laser or an external laser source may be coupled to the Laser In port, which uses PM fiber with light linearly polarized along the slow axis, as shown on the front panel. The maximum input power to the Laser In port is 20 dBm (100 mW). Optical power is monitored in three places (Mon-1,-2,-3) for the purpose of enabling bias and power control. These power values are also available at the I/O port. Mon-1 is at the Laser Input, Mon-2 is at the MZM Output, and Mon-3 is at the final Optical Output.

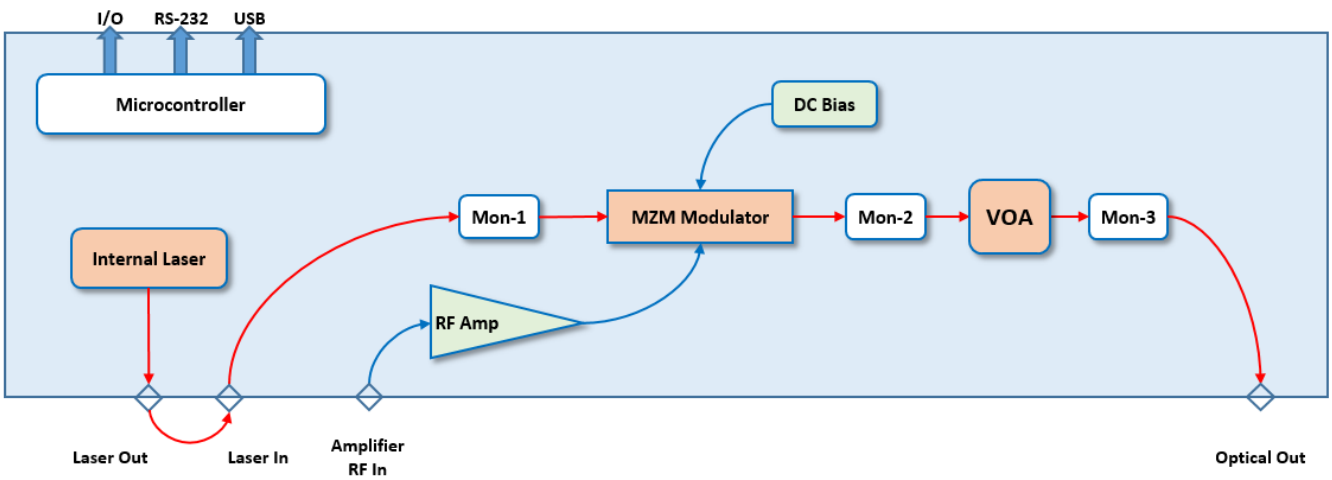


Figure 1 Key Components of the MX35E Linear Reference Transmitter Series

1.4 Front and Back Panel Overview

Figure 2 Front Panel

Callout	Description
F1	Touchscreen Display
F2	Adjustment Knob
F3	Key Switch and Indicator 🔒 Lasing Disabled; 🔓 Lasing Enabled
F4	Grounding Jack (Banana Connector) ⏚ Earth Ground
F5	Laser Output (PM FC/PC Connector)
F6	Laser Input (PM FC/PC Connector)
F7	Optical Output (FC/PC Connector)
F8	Amplifier RF Input (SMA Connector)
F9	Standby Button

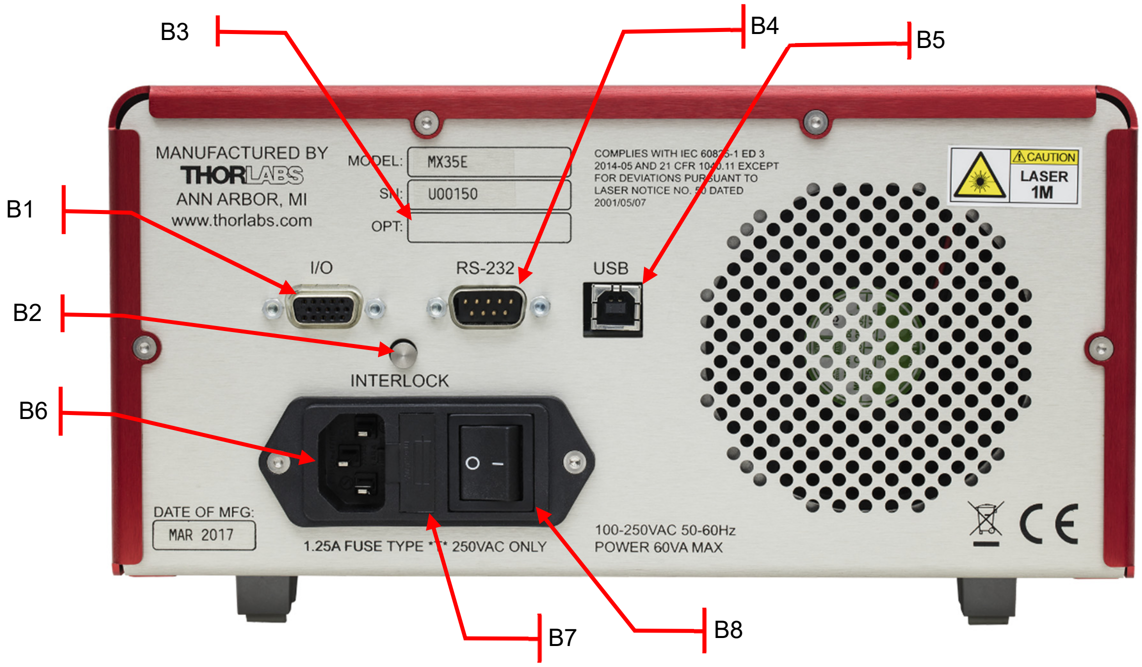


Figure 3 Back Panel

Callout	Description
B1	I/O Port (DB15 Connector)
B2	Laser Interlock (2.5 mm Connector)
B3	Option Label
B4	RS-232 Port (DB9 Connector)
B5	USB Port (USB Type B Connector)
B6	Power Connector
B7	Fuse Tray
B8	Power Switch **I** Supply On; **O** Supply Off

Chapter 2 Safety

All statements regarding safety of operation and technical data in this instruction manual will only apply when the unit is operated correctly. If equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired. Only with written consent from Thorlabs may changes to single components be carried out or components not supplied by Thorlabs be used

Warning: Risk of Electrical Shock
Before applying power to the instrument, make sure that the protective conductor of the 3 conductor mains power cord is correctly connected to the protective earth contact of the socket outlet. Improper grounding can cause electric shock with damage to your health or even death. Only use mains cable with sufficient current and voltage ratings for this instrument. The local supply voltage must be in the range specified on the rear panel, and the correct fuse must be installed in the fuse holder. If not, please replace the main fuse (see Section 8.3). Do not position equipment in a way that makes it difficult for the user to operate the disconnecting device. Do not remove covers. Refer servicing to qualified personnel.

Warning: Risk of Explosion
The instrument must not be operated in explosion endangered environments.

Warning: Laser Radiation
Avoid Exposure – Radiation emitted from apertures. Do not look into the laser aperture while the laser is on. Injury to the eye may result. Laser should not be turned on unless there is an optical fiber connected to the laser output port.

Caution – Use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.

INVISIBLE LASER RADIATION
DO NOT EXPOSE USERS
OF TELESCOPIC OPTICS

CLASS 1M LASER PRODUCT

Caution: ESD Sensitive Component
The components inside this instrument are ESD sensitive. Take all appropriate precautions to discharge personnel and equipment before making any connections to the unit. A front panel grounding jack is provided for connection to a wrist strap.

Caution: Components not Water Resistant
This instrument should be kept clear of environments where liquid spills or condensing moisture are likely. It is not water resistant. To avoid damage to the instrument, do not expose it to spray, liquids, or solvents.

Caution: Follow Intended Usage Guidelines
This product is not suitable for household room illumination.

Inputs and outputs must only be connected with shielded connection cables.

Do not obstruct the air ventilation slots in housing.

Mobile telephones, cellular phones or other radio transmitters are not to be used within the range of three meters of this unit since the electromagnetic field intensity may then exceed the maximum allowed disturbance values according to IEC 61326-1.

2.1 Precautions

The following statement applies to the products covered in this manual, unless otherwise specified herein. The statement for other products will appear in the accompanying documentation.

Note: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation.

This product has been tested and found to comply with the limits according to IEC 61326-1 for using connection cables shorter than 3 meters (9.8 feet).

Thorlabs is not responsible for any radio television interference caused by modifications of this equipment or the substitution or attachment of connecting cables and equipment other than those specified by Thorlabs. The correction of interference caused by such unauthorized modification, substitution or attachment will be the responsibility of the user. The use of shielded I/O cables is required when connecting this equipment to any and all optional peripheral or host devices. Failure to do so may violate FCC and ICES rules.

This precision device should only be shipped if packed into the complete original packaging including the custom cut foam padding. If necessary, ask for replacement packing material.

Chapter 3 Quick Start Guide

3.1 Hardware Set Up

For first use, plug the main power cable into the back panel connector, and then plug the other end into an AC wall receptacle. Flip the power switch on the back panel to the ON (I) position. The unit will now be in the “Standby” mode, and the front panel standby button should glow amber.

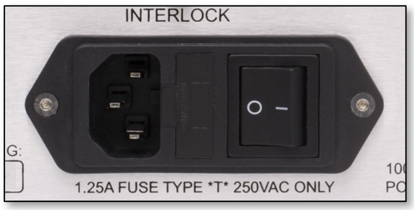


Figure 4 Power Cable Port, Fuse, and Power Switch

Figure 5 Indicator Glows Amber When Instrument Is in Standby

Attach the PM loop-back fiber optic cable between the Laser Out and Laser In FC connectors on the front panel. Be sure to clean both ends of the fiber as described in the Maintenance Section of this manual.

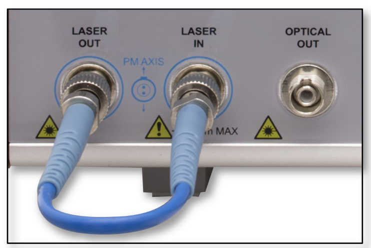


Figure 6 PM Loopback Fiber Cable Installed

Insert the key into the interlock switch and turn it towards the unlock symbol (🔓).This allows the laser to be turned on, but the LASER ON indicator will not glow green until the laser is actually turned on by the touchscreen button. Turn on the unit by pressing the amber standby button on the front panel which will then turn green to indicate the unit is fully on. The touchscreen display will come up with a boot screen for about 5 seconds and then go to the home page. The unit will initialize in the factory default state with all functions OFF.

Figure 7 Interlock Key Switch

Figure 8 Indicator Glows Green When Instrument Is Fully Enabled

3.2 Controls on the Home Page

This allows the laser to be turned on, but the LASER ON indicator will not glow green until the laser is actually turned on by the touchscreen button. Turn on the unit by pressing the amber standby button on the front panel which will then turn green to indicate the unit is fully on. The touchscreen display will come up with a boot screen for about 5 seconds and then go to the home page. The unit will initialize in the factory default state with all functions OFF.

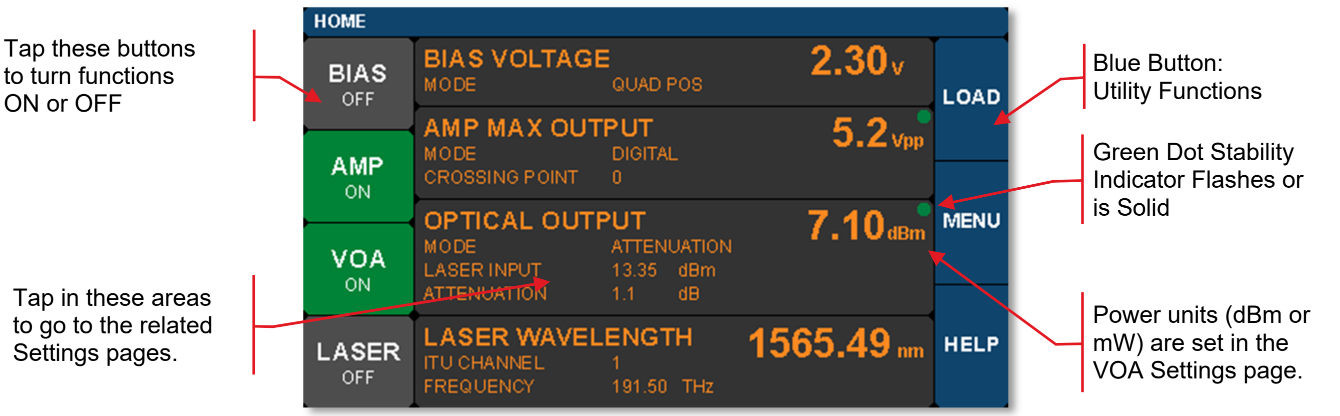


Figure 9 Home Screen Features

The Home screen (or dashboard) is organized into three main sections.

The left side contains the ON/OFF buttons for each of the main instrument functions. Tapping any of these buttons will toggle the function on and off. The same ON/OFF functionality is also available on the individual Settings pages. The power buttons turn green to indicate the function is ON, and turn red to indicate the function is disabled.

The central section is the main dashboard for reporting operational values of each section. Tapping the screen in this middle area will take the user to the corresponding Settings page for each section. Note that the green dot in each of these sections indicates the function is stable. A blinking green dot indicates the function is still stabilizing.

The right side of the screen provides access to the main utility functions of the box.

The screen shot below shows some of the common warning indicators on the HOME page. Some functions can be disabled when the laser power is low. In this case, buttons may be disabled and warnings indicators may appear.

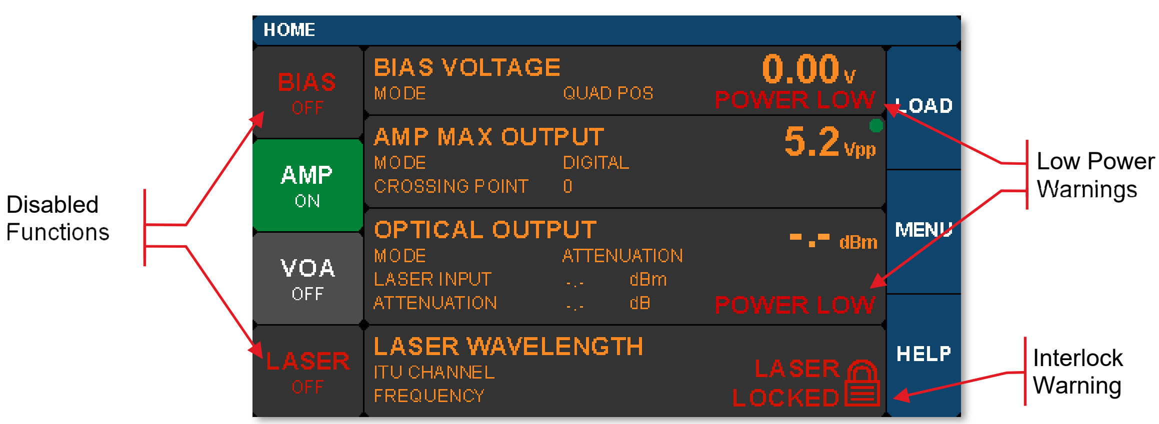


Figure 10 Home Screen Warnings and Indicators

3.3 System Wavelength Setting

The operational wavelength range of the MX35E series extends from 1250 nm to 1610 nm. The three calibration wavelengths of the power monitors, 1310 nm, 1550 nm, and 1590 nm, represent the centers of the O-band, C-band, and L-band and provide the user with accurate power readings at or near those wavelengths.

The system wavelength should always be set to the wavelength closest to that of the laser source coupled to the Laser In bulkhead. The MX35E series' system wavelength is factory-preset to correspond to the wavelength band of the integrated laser source. If an external laser is to be used with the MX35E series, the system wavelength may need to be changed. This function exists in the Utility Menu.

From the Home screen, tap the MENU button to bring up the Utility Menu as shown.

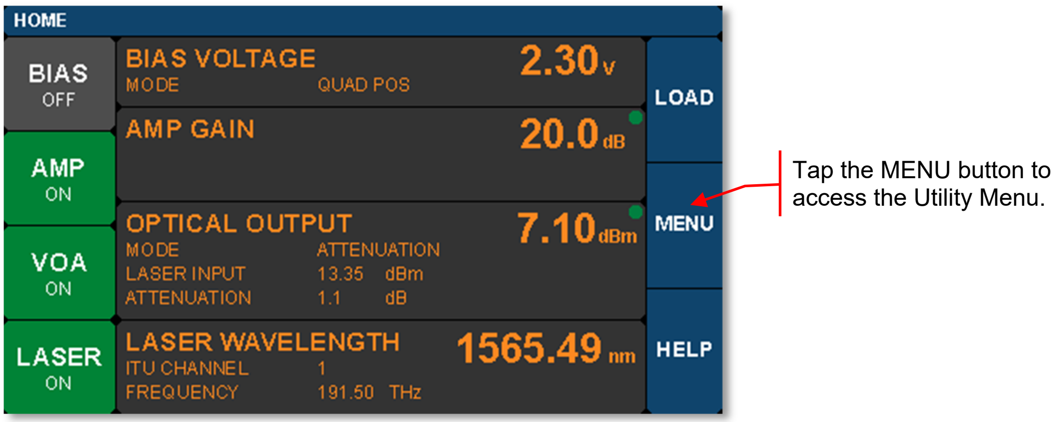


Figure 11 Accessing the Utility Menu from the Home Screen

Then tap the System Wavelength bar as shown below to bring up the three wavelength choices. Tap the desired wavelength to set the System Wavelength.

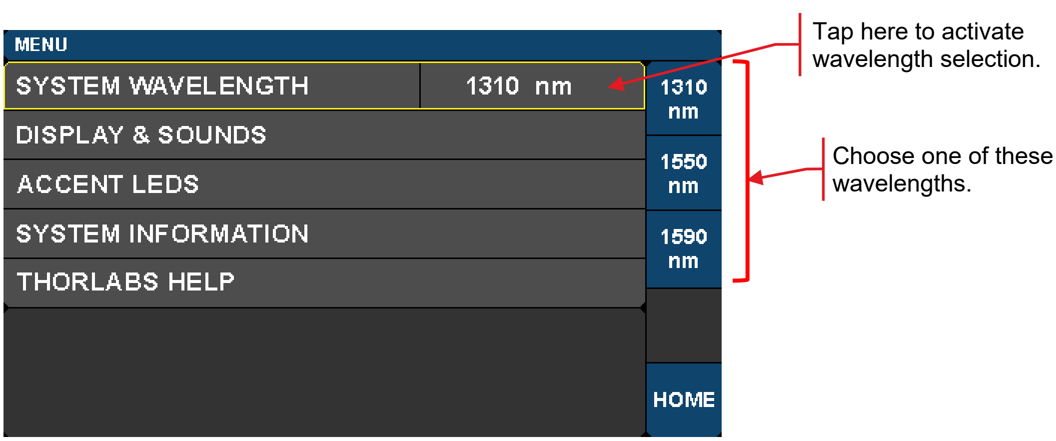


Figure 12 System Wavelength is Selected from the Utility Menu

3.4 Controls on the Settings Pages

The Settings pages all possess the same general design and functionality as shown in the example screen shot below. The upper section with white letters displays the parameters that can be changed. Simply tap on the parameter of interest. A yellow border highlights the choice and controls for that parameter are presented.

The lower section with amber letters displays selected related values convenient to monitor from the page.

The right-hand column provides the controls for changing the values for the selected parameters. The main control knob on the front panel can also be used to adjust and confirm selected values. The screen shots below show examples of the touch-screen controls.

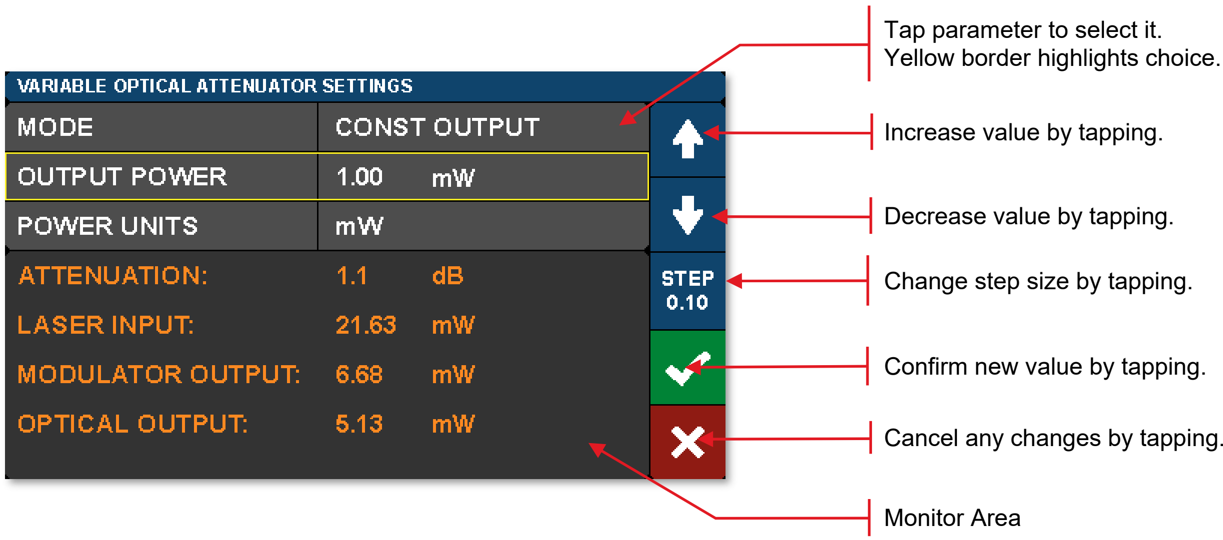


Figure 13 Setting Parameter Values: Design and Functionality of the Settings Pages

Fields that have adjustable values will show a flag if the minimum or maximum values have been reached. These are set by firmware at the factory.

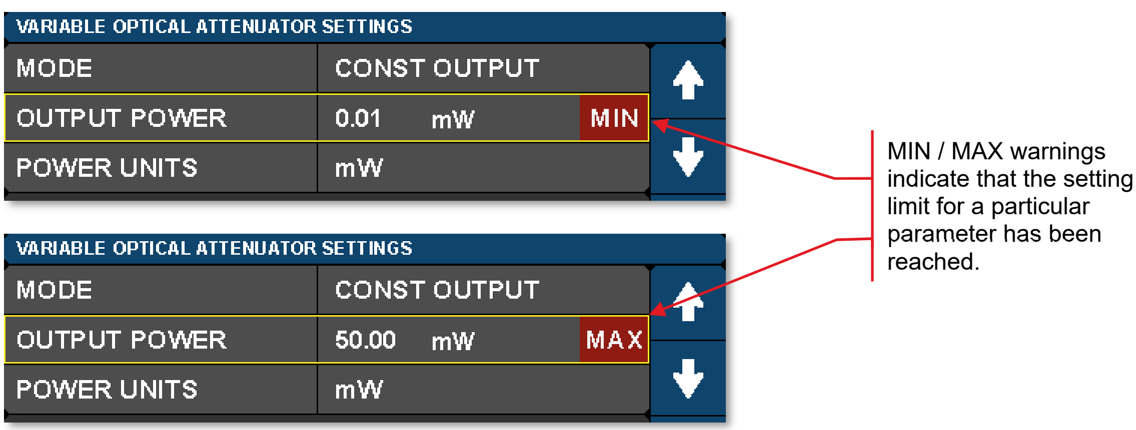


Figure 14 MAX and MIN Warnings Indicate Parameter's Upper or Lower Setting Limit Reached

3.5 Quick Start

The following steps summarize the setup procedure required to operate the MX35E series in the standard mode. Please refer to previous sections in this chapter and the expanded operating instructions in Chapter 4 for additional information.

1. Turn on power to the MX35E series transmitter via the power switch on the back panel (Figure 4).

2. Press and hold the button on the front panel until the indicator light changes from amber to green (Figure 5 and Figure 8).

3. Turn the key switch to unlock (Figure 7).

4. Turn the laser on by tapping the lower-left touchscreen button on the Home page (Figure 9). Use the utility menu page to adjust the calibration wavelength if desired (Section 3.3).

5. Enable the bias controller by tapping the top-left touchscreen button on the Home page (Figure 9). Wait for completion of the calibration process. The instrument will enable the default Quadrature mode with positive slope bias point (Section 4.3).

6. Take note of the output power, which is shown in the center right section of the Home page (Figure 9).

7. Turn on the VOA controller to adjust output power, if desired, by tapping the center-left touchscreen button on the Home page (Figure 9 and Section 4.5).

8. Turn on the AMP controller to set desired gain level (Figure 9 and Section 4.4).

9. Apply the input RF signal to the female SMA connector on the front panel (Figure 6), noting the specified limits linear response (Chapter 5).

10. For additional information on a lower-noise operating mode, see information about Ratio Mode in 4.3.4

Figure 15 The MX35E Series Linear Transmitter

Chapter 4 Operating Instructions

4.1 The Modulator Transmission Function

The Mach-Zehnder modulator (MZM) has a repetitive transmission function with applied voltage, as can be seen in the diagram below. In order for it to work correctly, a DC bias voltage must be applied and maintained at the desired set point. The high-frequency AC signal can then be applied to the modulator to enable the correct optical modulation of the laser beam. The most common operating points are the peak, null, and quadrature points as shown below.

The purpose of the Bias settings is to hold the modulator at one of these chosen points. Note that a real transmission function does not go perfectly from 0% to 100%. This is characterized by the Extinction Ratio of the modulator (Peak power / Null power). The efficiency of the modulator is also characterized by V_π, which is defined as the voltage necessary to change the transmission from Null to Peak. The most linear response of the modulator is achieved by biasing it at one of the Quadrature points where the transmission is closest to 50%. Some non-linear, frequency doubling, and phase modulation applications require biasing at the Null or Peak.

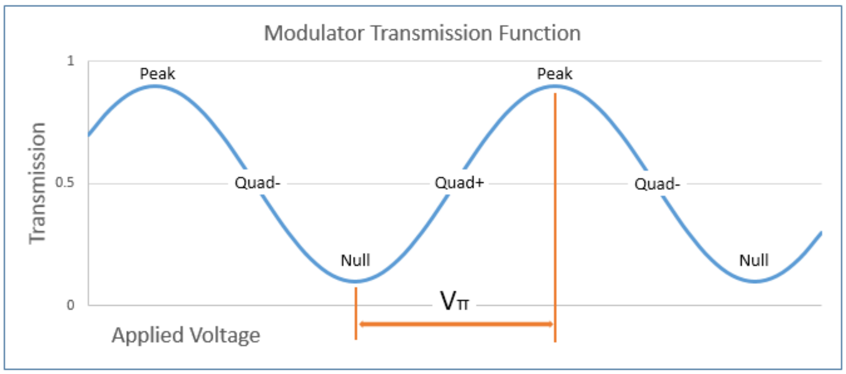


Figure 16 Bias Points on the Modulator Transmission Function

4.2 Control Loop Diagram

The following diagram shows the control loops added to the block diagram. From this picture, the user can see how the power monitors and VOA are used to provide stability and control to the whole system. It will be helpful to refer to this diagram to gain a better understanding of the functionality of the unit as described in the upcoming sections of the manual.

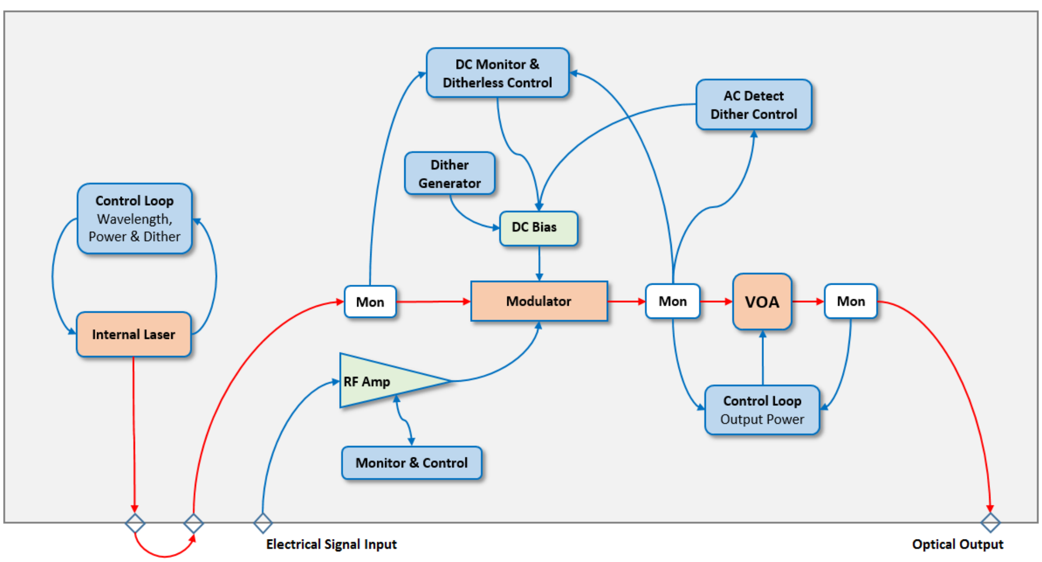


Figure 17 Block Diagram of the MX35E Series Transmitter Showing Control Loops

4.3 Bias Settings Page

The Bias Settings page is accessed by tapping the center bias monitors pane on the Home page. When the MZM Bias control is first turned on, the MX35E series transmitter performs a calibration routine to determine the approximate bias voltages required for the various MZM operating points. This allows the instrument to quickly and effectively switch between bias modes. The user may perform this calibration anytime by pressing the Reset Auto Bias button on the right side of the Bias Settings page. This button is not available if the Bias is off or in Manual mode.

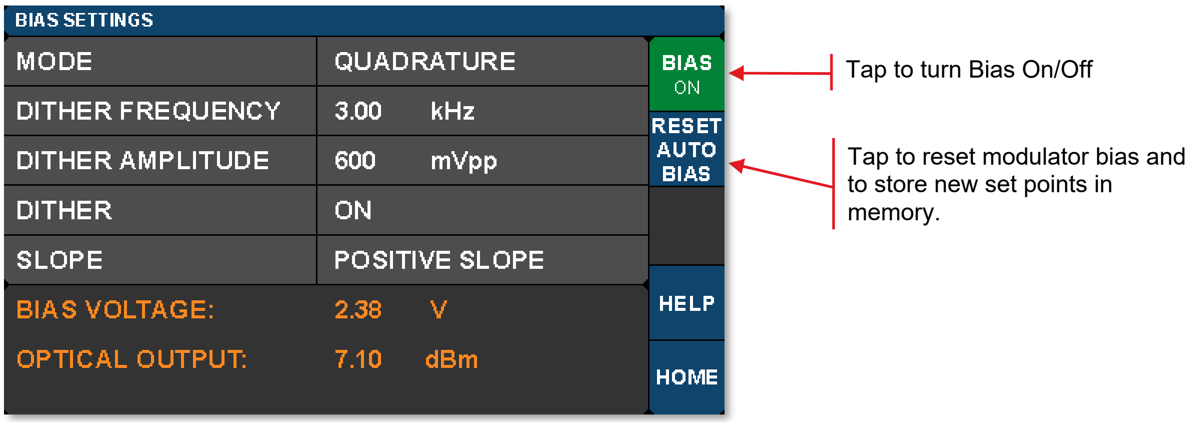


Figure 18 Bias Settings Home Screen

The Bias Settings page contains the settings for controlling the modulator bias and operating modes. There are four modes for MZM bias control: 1) Quadrature, 2) Peak, 3) Null, and 4) Manual. The screen shot below is an example of the information presented and the controls available when the Mode field is selected while the controller is operating in Quadrature mode. The blue buttons enable switching between modes.

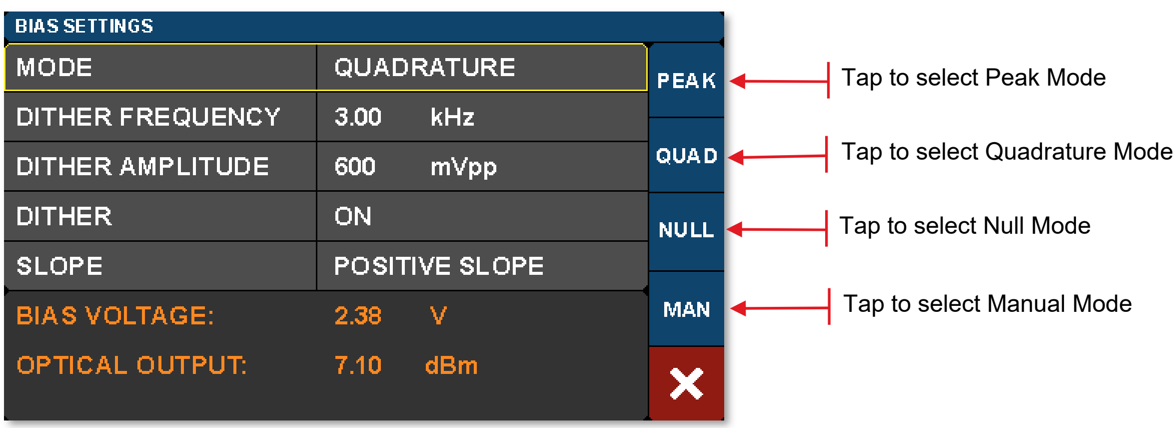


Figure 19 Buttons to Manually Initiate Modulator Calibration Routine

Active control of the MZM bias point is essential, as the modulator is temperature sensitive and will drift over time. The Quadrature, Peak, and Null modes use a dither tone as part of a lock-in control scheme to keep the MZM bias stable. The dither tone allows the control algorithm to track the drifting, but at the cost of decreased signal-to-noise ratio (SNR) due to the injection of a single frequency tone into the MZM bias.

4.3.1 Quadrature Mode

Quadrature is the default mode and biases the MZM at the 50% point on the MZM transmission curve shown in Figure 21. Quadrature mode is recommended for digital signals such as On-Off-Keying (OOK) that require a high extinction ratio. The screen shot below shows the parameters that can be controlled in the Quadrature mode.

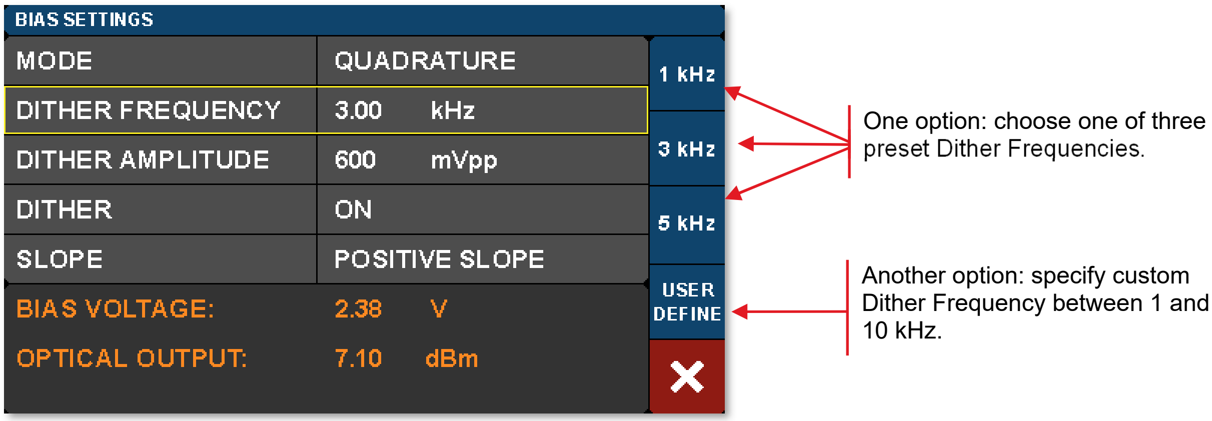


Figure 20 Dither Frequency Selection while Quadrature Mode Enabled

The bias control circuit uses an AC dither tone to stabilize the bias point of the modulator, as illustrated below. A small AC voltage is applied to the DC bias so that the optical output is also slightly modulated. Both the amplitude and the frequency of AC dither tone can be selected by the user. The modulated optical output is detected by a frequency and phase sensitive detector, which can then interpret whether the DC bias is at the correct level for the chosen set-point (Quadrature, Peak or Null). The DC bias voltage is then continuously adjusted to maintain the correct set-point.

The frequency of the dither tone will not exceed 10 kHz. This frequency limit, which is usually well below the low frequency cut-off for the RF signal of interest, is chosen to prevent interference. As described in the following, the dither tone can also be turned if other methods of bias control are desired (e.g. manual or input/output ratio control).

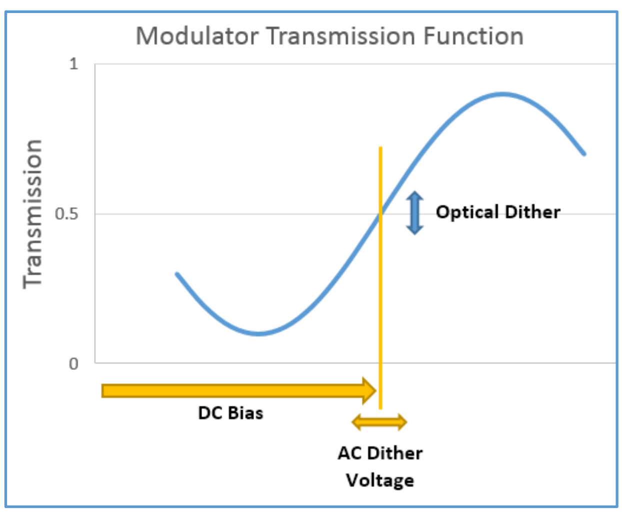


Figure 21 AC Dither Tone Stabilizes the Bias Point of the Modulator

The dither tone frequency may be changed by tapping the Dither Frequency field, which is highlighted in Figure 20. Standard frequencies are selected using the blue buttons, or a custom frequency may be chosen by pressing User Define. The dither tone frequency usually has very little effect on the accuracy of the bias control, but in some cases a different frequency may work better or be desirable depending on the RF signal applied or on the specific application. The User Define button allows for the selection of an arbitrary frequency between 1 kHz and 10 kHz with 10 Hz resolution.

The dither tone amplitude can also be adjusted to any amplitude between 20 mV and 2 V with 1 mV resolution by tapping the Dither Amplitude field highlighted in Figure 22. Higher amplitudes will typically be more stable in the presence of MZM drift and broadband RF signals, but larger dither tones also decrease SNR. If the amplitude is too low, the MZM bias may not stay locked. Typically, a value from 300 mV to 500 mV is a good starting point.

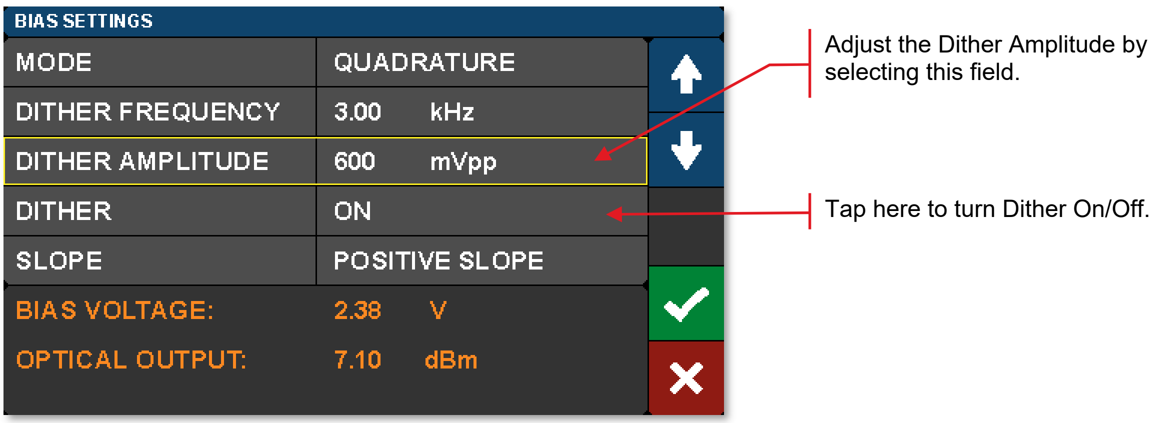


Figure 22 Dither Amplitude Adjustment

The dither tone can be optionally disabled to accommodate applications requiring the highest SNR. The user may quickly turn the dither off, perform a measurement requiring low noise, and then turn the dither back on. When the dither is turned off, the bias is simply held at the previous bias voltage. Manual Mode should be used for longer-term measurements without dither, so that a constant ratio method can be used to stabilize the bias point, as described in Section 4.3.4.

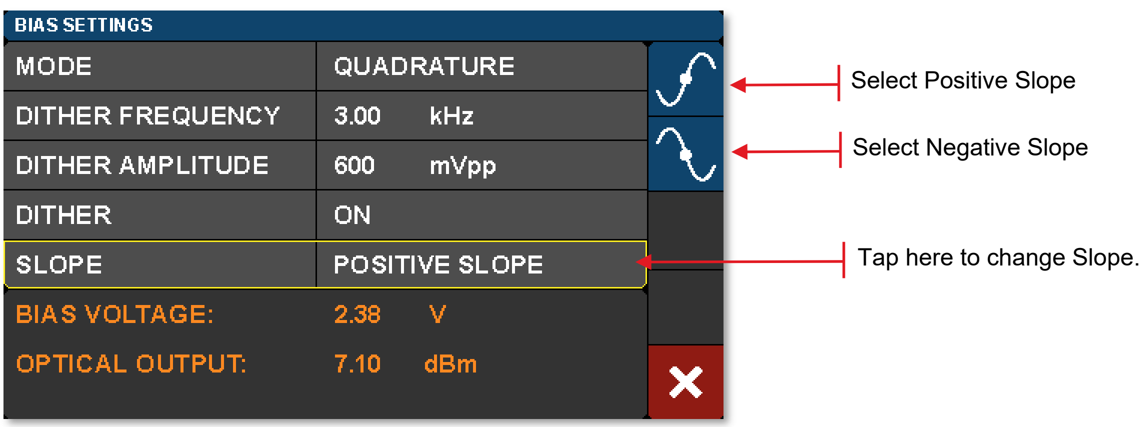


Figure 23 Locate Bias Point on Positive or Negative Slope

Quadrature mode also allows the user to select between two operating points by selecting the Slope field. Positive slope is the non-inverting operating point where increasing voltage on the MZM results in increasing optical output power. Negative slope is the inverting operating point where increasing voltage on the MZM results in decreasing optical output power. This effectively changes the phase of the response function.

4.3.2 Peak Mode

The Peak Mode adjusts the DC bias voltage so the transmission is centered at a nearby transmission maximum. In this mode only dither frequency and amplitude settings are available. These controls and settings are the same as previously described for the Quadrature mode.

Peak and Null modes are often used to obtain phase modulation and non-linear frequency doubling. The optical phase is 180° shifted on opposite sides of the Null point

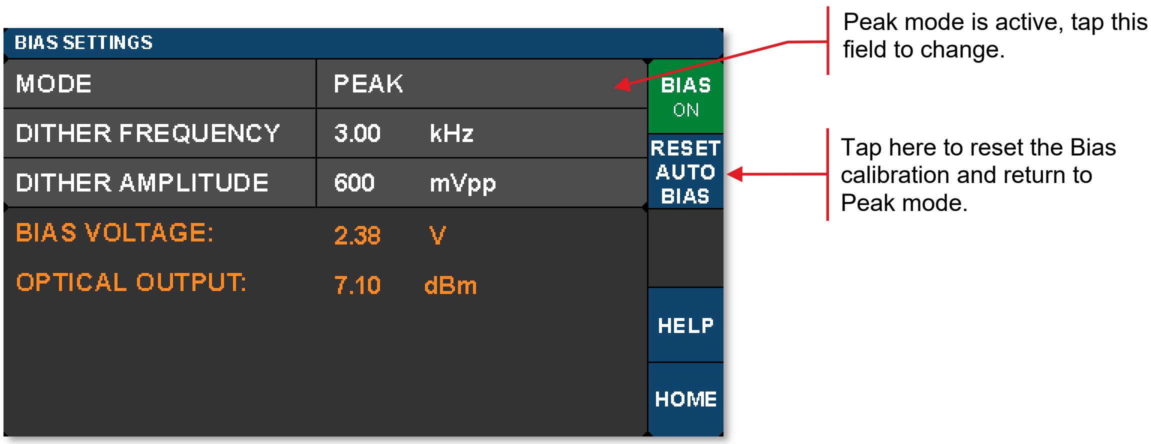


Figure 24 Peak Mode Settings

4.3.3 Null Mode

The Null Mode adjusts the DC bias voltage so the transmission is centered at a nearby transmission minimum. In the Null mode only dither frequency and amplitude settings are available. These settings are the same as previously described for the Quadrature mode.

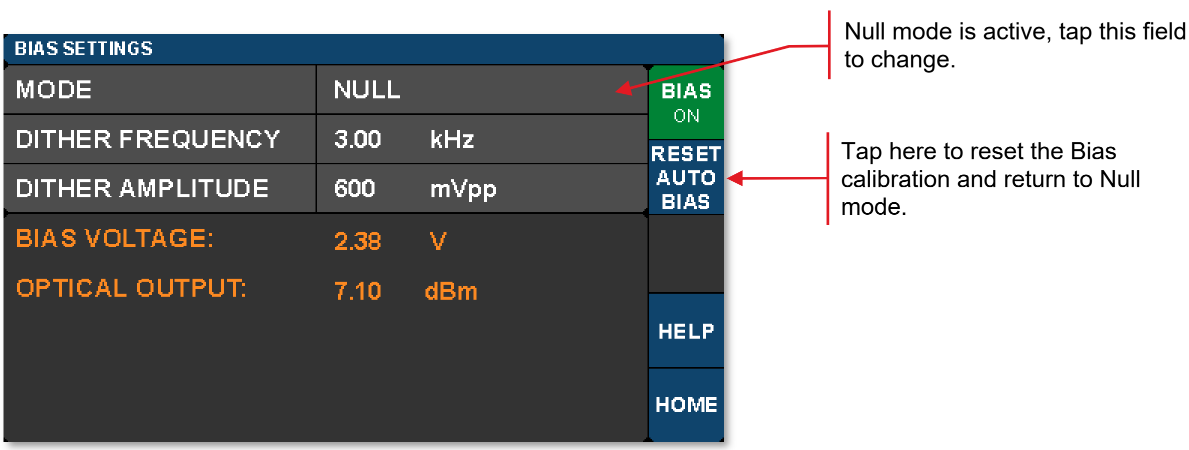


Figure 25 Null Mode Settings

4.3.4 Manual Mode

The Manual mode allows the user to bias the modulator at any desired point of the transmission function. Manual mode offers two operation options: 1) Constant Bias, or 2) Constant Ratio. In both of these options, the dither function is not active, and the controller uses different techniques to hold the bias steady. The desired option is chosen by selecting the HOLD field.

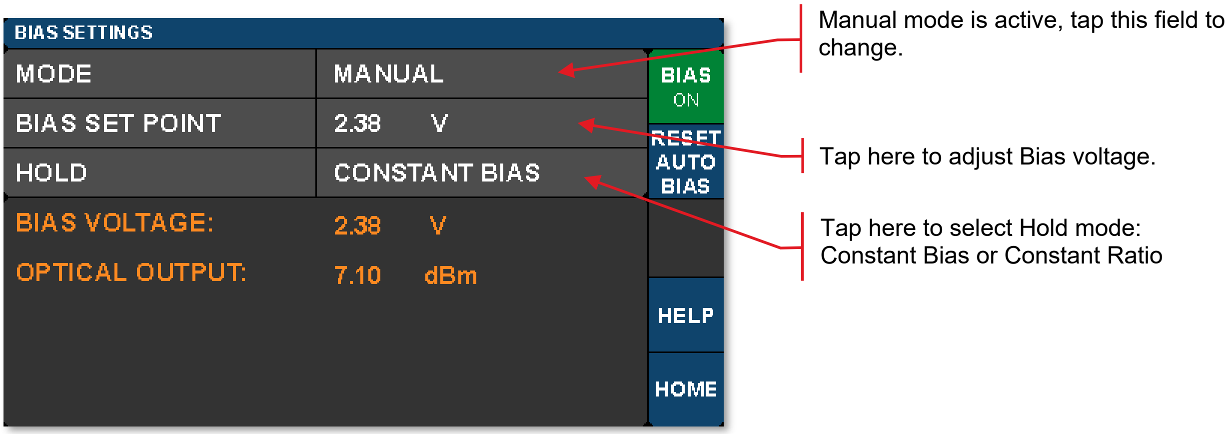


Figure 26 Constant Bias Manual Mode Settings

Constant Bias is the most basic mode of operation and will apply a user selected DC voltage to the MZM. This can be useful for performing brief measurements that only take a few minutes. During longer duration experiments, the MZM is more likely to drift.

The Constant Ratio mode employs active control of the MZM bias, but without using a dither tone. As a result, it can achieve superior SNR compared to the Quadrature mode. This mode is recommended for analog signals or higher level Pulse-Amplitude Modulation (PAM) formats.

Constant Ratio works by holding the MZM ratio of input light (at Mon-1) to output light (at Mon-2), see Figure 1 for reference, at a constant value (typically at or close to Quadrature). Note that Constant Ratio does NOT take into account the insertion loss (IL) of the MZM. Therefore, the user must have some knowledge of the IL between Mon-1 and Mon-2, which is equivalent to the IL of the modulator. For example. If the modulator has an IL of 3 dB, then the I/O ratio at maximum transmission is already 2:1. To bias the modulator at the 50% point, the ratio must be doubled to 4:1. The MZM insertion loss is listed in the specifications.

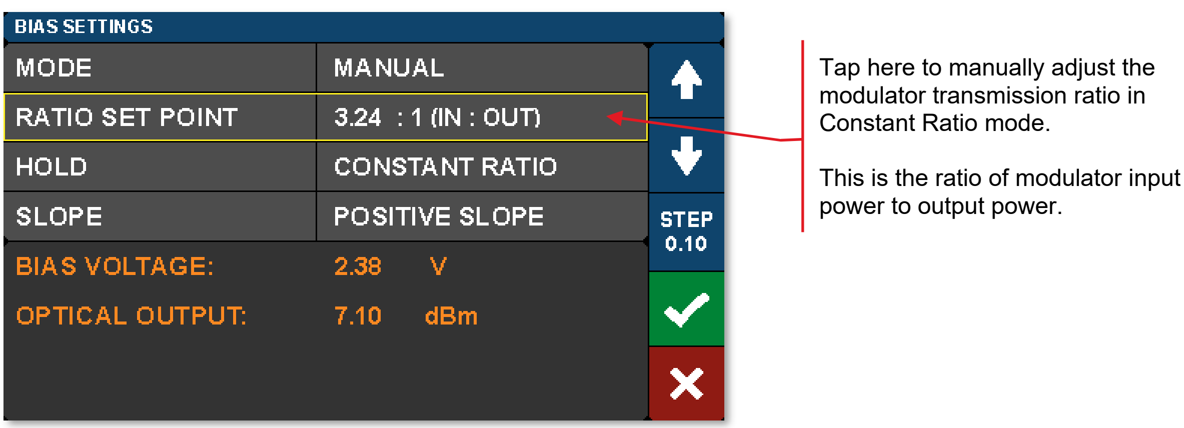


Figure 27 Constant Ratio Manual Modes Settings

In the Constant Ratio mode there is an option to select between the two available operating regions by selecting the Slope field. Positive slope is the non-inverting operating point where increasing voltage on the MZM results in increasing optical output power. Negative slope is the inverting operating point where increasing voltage on the MZM results in decreasing optical output power.

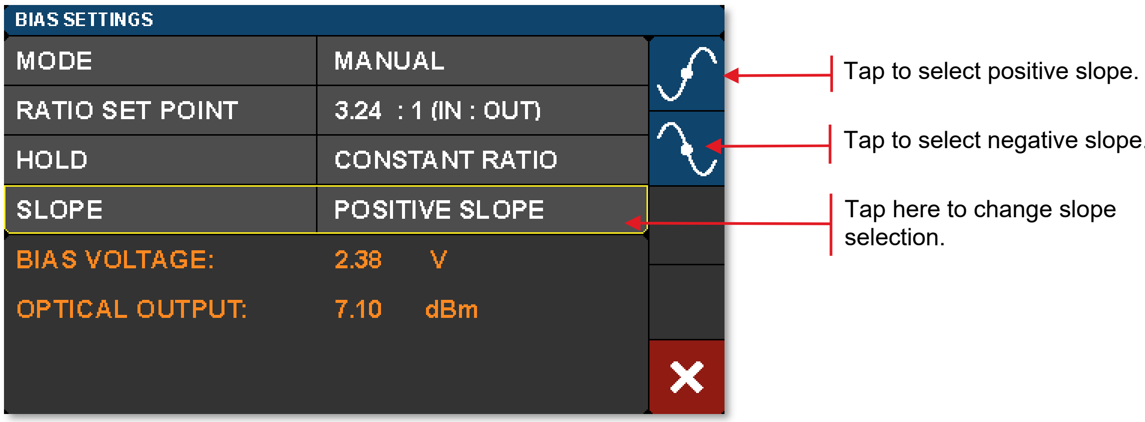


Figure 28 Selecting Operating Point in Constant Ratio Mode

When switching to one of the Manual modes from a different bias mode, the Manual mode set point is automatically calculated to keep the MZM at the same location on the transmission function. For example, in order to switch to Constant Ratio mode at the Quadrature location, follow these steps:

- Turn the bias on, and choose Quadrature mode.
- Wait for the green indicator dot to stop blinking (indicating the bias is locked at quadrature).
- Optional: For greater accuracy at this point, slowly reduce the dither tone amplitude to ~100 mV in order to remove errors that can occur due to second order effects with a large dither tone. Make sure the green dot is not blinking.
- Now change the bias mode to Manual and select Constant Ratio.
- The instrument will calculate the ratio to keep the MZM biased at the Quadrature location.
- From here, the ratio set point can be adjusted to further tune performance.

4.4 Amplifier Settings Page

The Amplifier Settings page is accessed by tapping on the Amplifier monitor pane on the Home page.

The Amplifier has a variable gain that it applies to a user input signal before signal is routed to the RF input port of the MZM. The Gain field of the Amplifier Settings page allows the user to set the gain of the amplifier. Gain is an important control, as it allows the output of the amplifier to remain linear across a broad variety of input conditions.

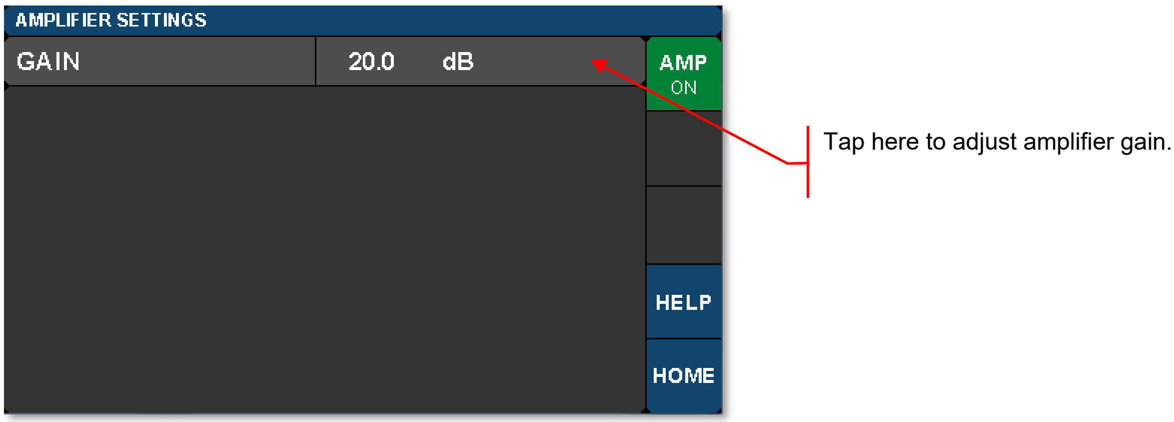


Figure 29 Amplifier Gain Adjustment

Linear Transmission: The amplifier gain curves plotted in Figure 30 show the relationship between the input and output signals of the amplifier for multiple gain settings. To achieve linear transmission, the output swing of the amplifier must be significantly less than the V_π of the modulator. As the output swing of the amplifier approaches the V_π of the modulator, nonlinearities will be added by the modulator. Alternatively, pre-compensation can be added to the electrical signal to allow for both a good extinction ratio and a linear response despite the non-linear behavior of the modulator. Please contact Thorlabs technical support for additional information or assistance in implementing this technique.

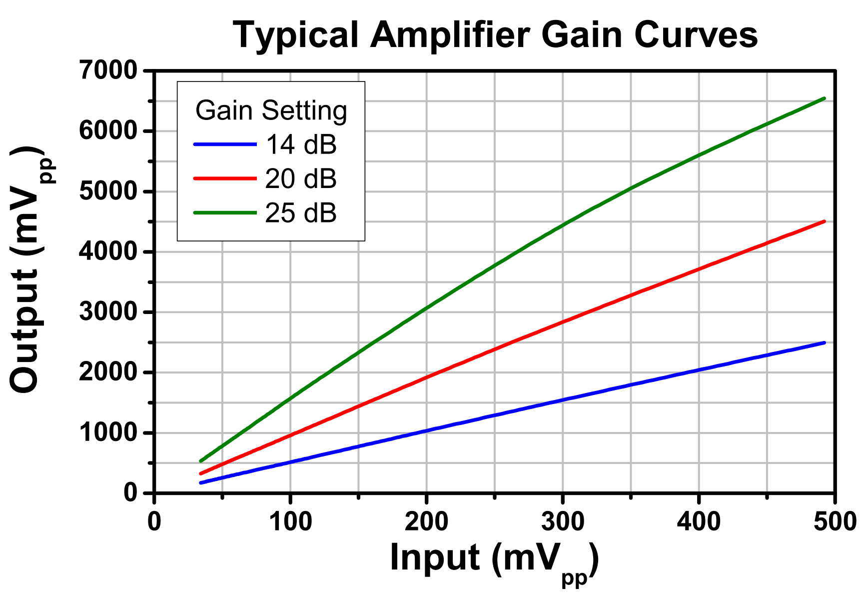


Figure 30 Amplifier Gain Curves

Digital Transmission: For optimal response with on-off keying (OOK) symbols, the gain of the amplifier should be adjusted so that the output swing of the amplifier is equal to the V_π voltage of the modulator. As the output swing of the amplifier increases to approach the V_π of the modulator, the system response will become nonlinear, but this will not have an adverse impact on the eye diagram. However, increasing output swing beyond the V_π of the modulator may result in degraded eye quality.

Gain Conversion: While gain is expressed in terms of dB, it can be more convenient to reference gain in terms of output to input voltage ratio (V_{out}/V_{in}). The following lookup table, which converts between dB and V_{out}/V_{in}, is provided to simplify the calculation of the optimal gain for achieving the desired output voltage swing for a given input voltage swing. The values are calculated using the following relationship.

$$Gain\left(\frac{Vout}{Vin}\right) = 10^{\frac{Gain\,(dB)}{20}}$$

$$Gain\,(dB) = 20 * \log_{10} Gain\left(\frac{Vout}{Vin}\right)$$

Gain (dB)	Gain $\left(\frac{V_{out}}{V_{in}}\right)$
10	3.16
11	3.55
12	3.98
13	4.47
14	5.01
15	5.62
16	6.31
17	7.08
18	7.94
19	8.91
20	10.00
21	11.22
22	12.59
23	14.13
24	15.85

4.5 Variable Optical Attenuator Settings Page

Tap in the VOA monitors pane on the Home page to access the Variable Optical Attenuator (VOA) Settings page shown below. The VOA provides the means for adjusting and stabilizing the output power after the MZM. The VOA can operate in either of two modes: 1) Constant Attenuation, and 2) Constant Output Power.

Note that units of all power measurements are determined by the Power Units setting this page, see Figure 32.

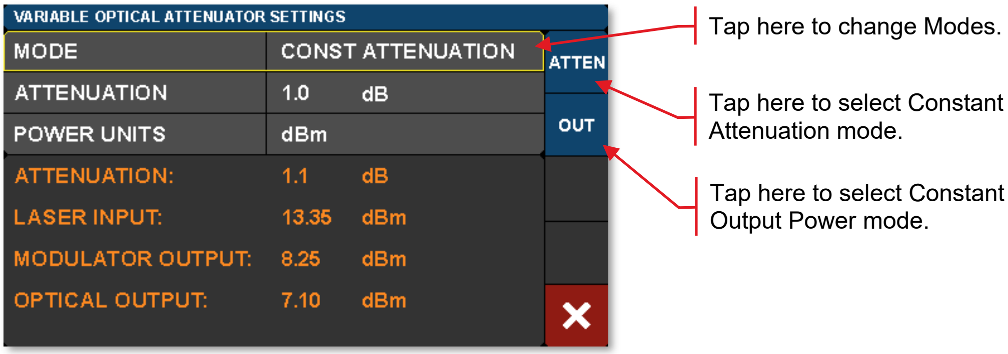


Figure 31 Constant Attenuation Mode of the VOA

Constant Attenuation Mode maintains a fixed attenuation level between the output of the MZM and the output port on the front panel. Any fluctuations at the input are transferred to the output.

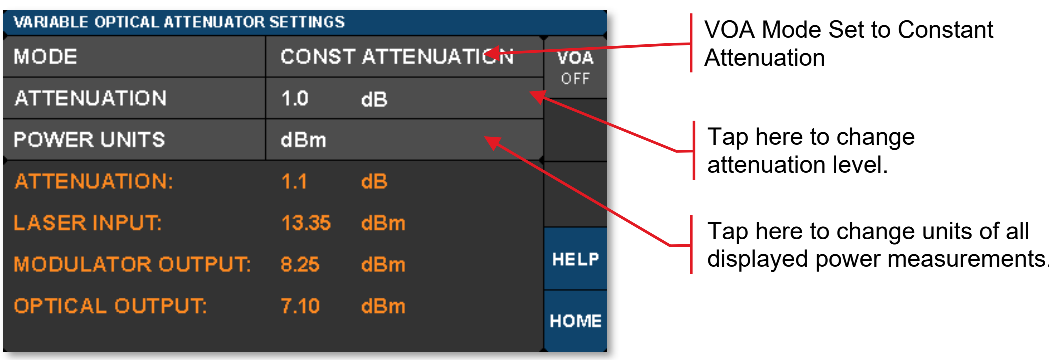


Figure 32 Constant Attenuation Mode Settings

Constant Output Power Mode acts as a stabilizer by holding the final optical power constant independent of input fluctuations (within controllable limits such as input power and attenuation).

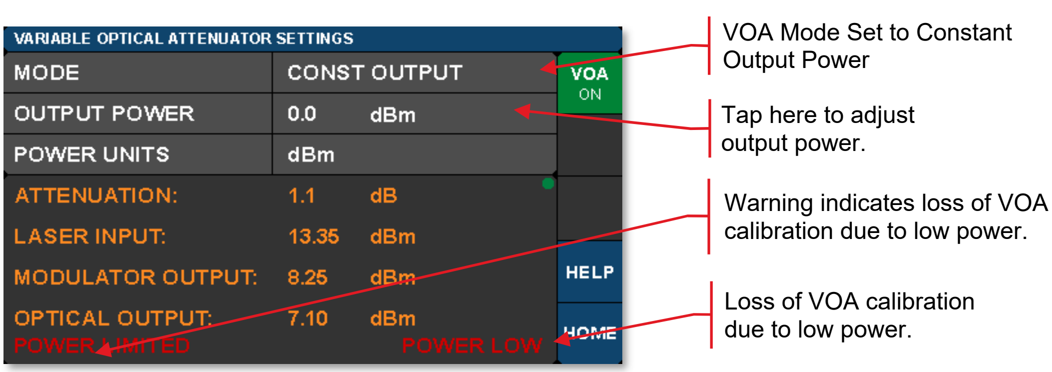


Figure 33 Constant Optical Output Mode of the VOA

4.6 Laser Settings Page

To access the Laser Settings page, tap on the Laser monitors pane on the Home page. Here the user can control the laser wavelength and choose whether or not to use the dither feature (available for transmitters with C-band or L-band lasers only) to stabilize the wavelength. Turning the dither off will result in lower phase and intensity noise, but the wavelength may drift slightly over time. The monitors on this page provide live readings of many parameters.

Caution: The laser should not be turned on unless there is an optical fiber connected to the laser out port.

When the internal laser source is a C-band (MX35E) or L-band (MX35E-LB) tunable laser, tap on the Laser Monitors pane on the Home page to access the Laser Settings page. This page is not available when the 1310 nm (MX35E-1310) fixed-wavelength source is the internal laser. The laser type is denoted in the Options label on the rear panel of the instrument (please see Figure 3 for location of the Options label).

Optical frequency can be set at increments of 50 GHz for C-band or L-band tunable internal lasers. C-band and L-band lasers also support a fine tuning frequency offset feature, allowing the frequency to be adjusted by an offset from -30.000 GHz to +30.000 GHz. The ITU channel number on these pages is an index number given only for convenience, which is unique to this instrument; actual frequencies and spacings are specified by the ITU standard.

To adjust the ITU channel, tap on the ITU CHANNEL row and use the arrow buttons to increment or decrement the channel. Press the green check mark to accept the new channel, or the red cancel button to abort the change. You may also use the adjustment knob. Note that you are initially editing by channel, as indicated by the STEP CHAN button. Note that the frequency and wavelength value are estimated based on the laser's nominal 50 GHz channel spacing, not measured by the instrument.

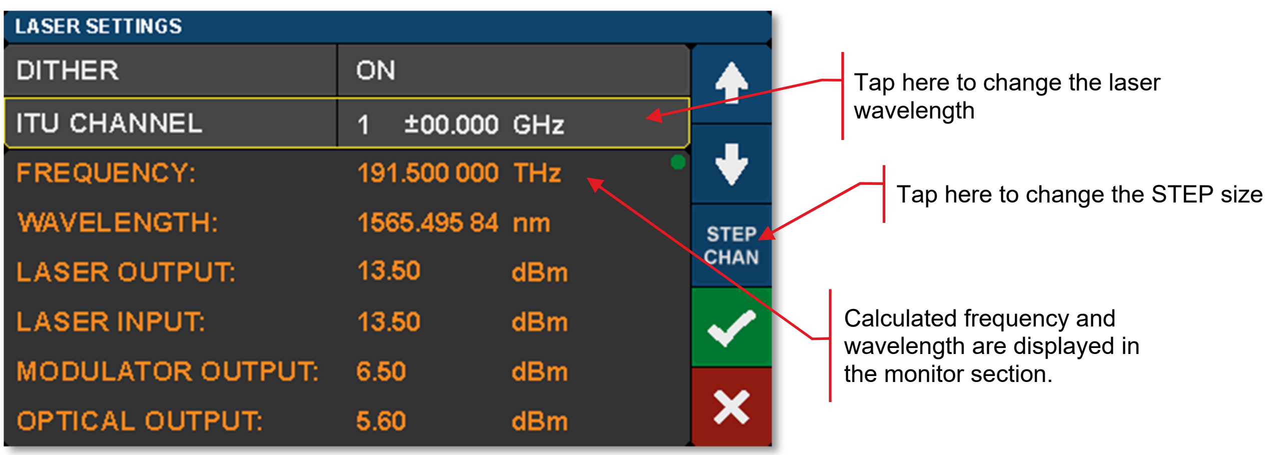


Figure 34 Changing the ITU Channel Number

To apply a fine-tuning frequency offset, tap the STEP CHAN button. The button will cycle to the next mode, STEP 10GHz. In this mode, using the up or down arrows or control knob will adjust the most significant digit of the frequency offset. Tapping the button repeatedly will cycle through the STEP 1GHz, STEP 100MHz, STEP 10MHz, and STEP 1MHz modes, allowing you to edit the offset in finer units of 1GHz, 100MHz, 10MHz, or 1MHz. Tapping the button one more time will cycle back to STEP CHAN mode.

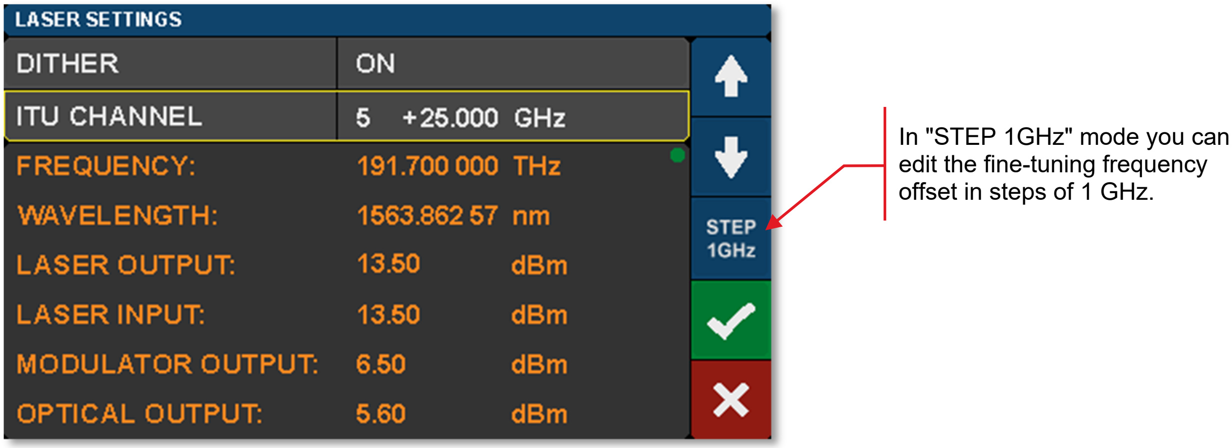


Figure 35 Changing the Fine-Tuning Step Size

Note that while the L-band and C-band lasers can have their frequency adjusted by increments as small as 1 MHz, the laser’s actual tuning accuracy is not this fine. See Section 5.4 below for more information.

To turn the dither setting on or off, tap on the DITHER row and use the ON or OFF buttons to change the setting, or the red cancel button to abort the change.

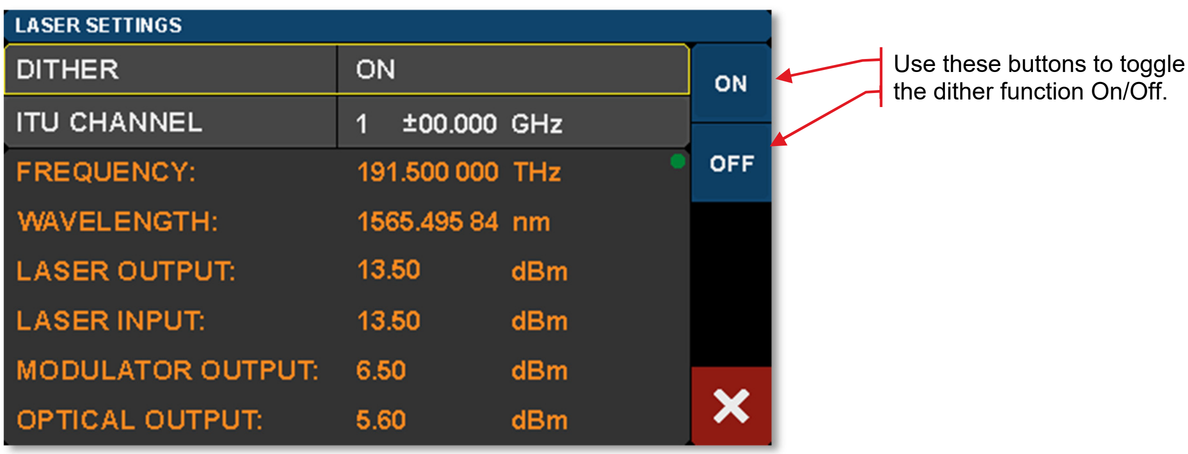


Figure 36 Enabling and Disabling Laser Dither

Figure 37 shows laser frequency noise as a function of optical frequency when the laser is operated with and without dither enabled. The red trace shows low noise operation when dither is turned off. Wavelength stability is improved by operating with dither, but the blue trace shows that this comes at the expense of added noise.

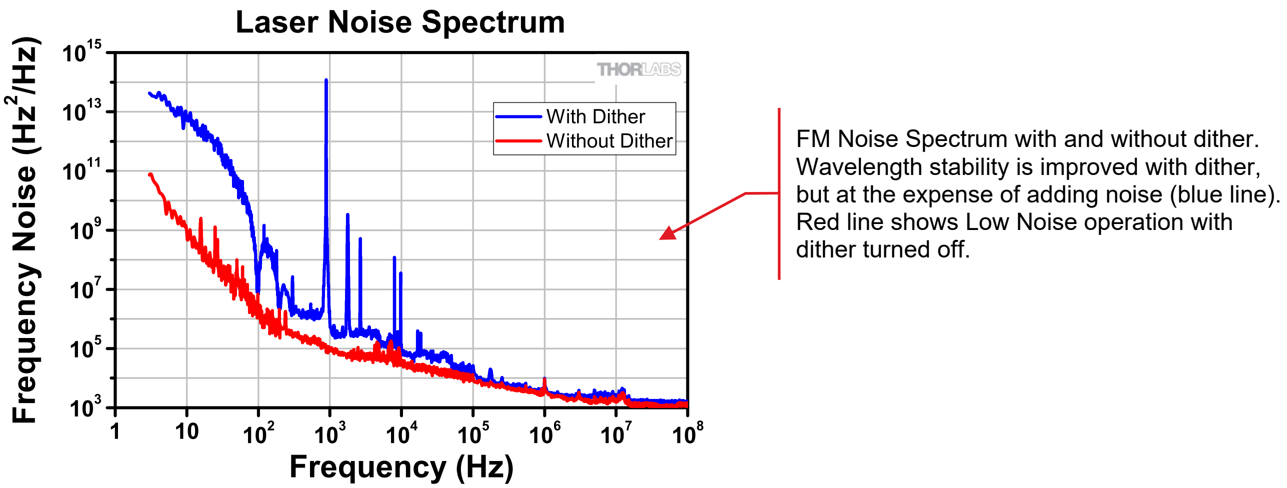


Figure 37 FM Noise Spectrum of the Laser

4.7 Load Page

Access the Load page by tapping the blue Load button on the Home page. The Load page has a factory-defined, standard operating mode stored as a preset. Applying the preset configures the MX35E series transmitter with the stored instrument settings and is a fast way to put the instrument in a known state. Future firmware revisions will have the ability to store instrument states defined by the user as well.

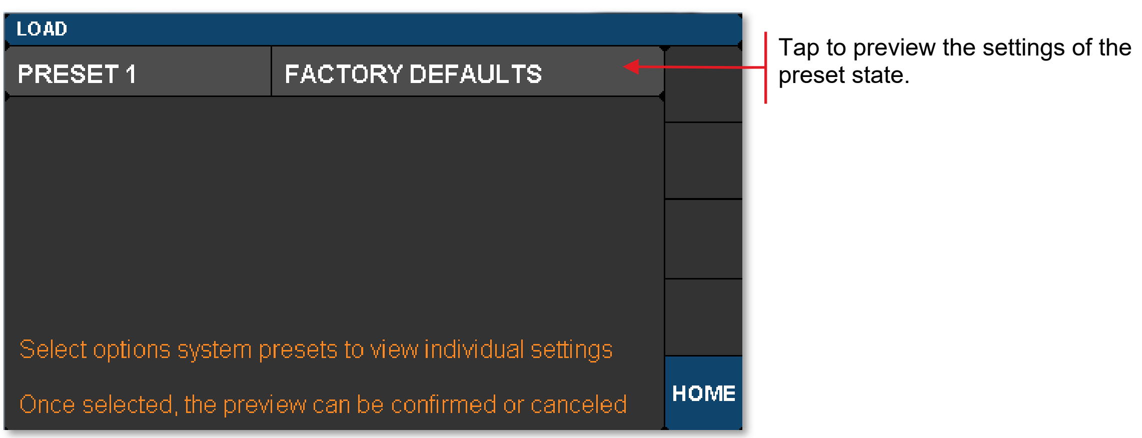


Figure 38 Preset State Options on the Load Page

Tapping on one of the presets will bring up a window that displays all the stored settings. The user can then review the choice before confirming with the green check-mark.

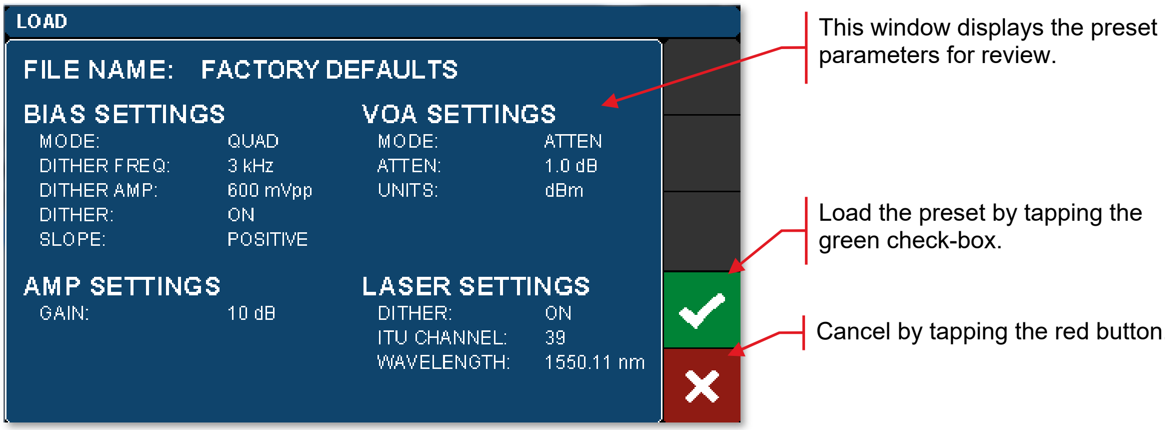


Figure 39 Reviewing the Parameter Values Set by a Preset State

4.8 Menu Page

To get to this page tap the blue Menu button on the Home page. The Menu page has links to several pages that allow the user to control the display, sounds, lights, and get help information. The following sections describe these functions in more detail.

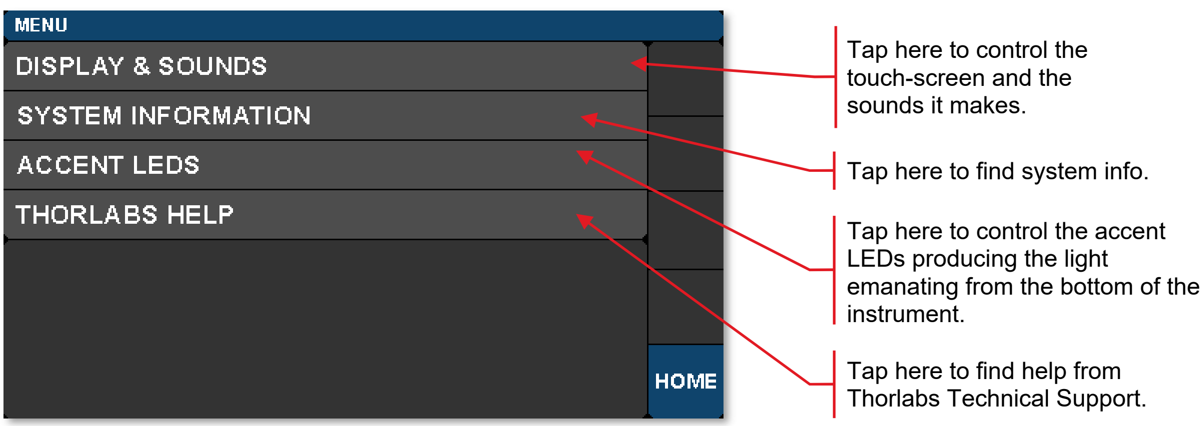


Figure 40 Controls on the Menu Page

4.8.1 System Wavelength

To get to this page, tap the SYSTEM WAVELENGTH button on the Menu page. The operational wavelength range of the MX35E series extends from 1250 nm to 1610 nm. The three calibration wavelengths of the power monitors, 1310 nm, 1550 nm, and 1590 nm, represent the centers of the O-band, C-band, and L-band and provide the user with accurate power readings at or near those wavelengths.

The system wavelength should always be set to the wavelength closest to that of the laser source. The MX35E series' system wavelength is factory-preset to correspond to the wavelength band of the integrated laser source. If an external laser is used with the MX35E series of transmitters, the system wavelength may need to be changed as shown in Figure 41.

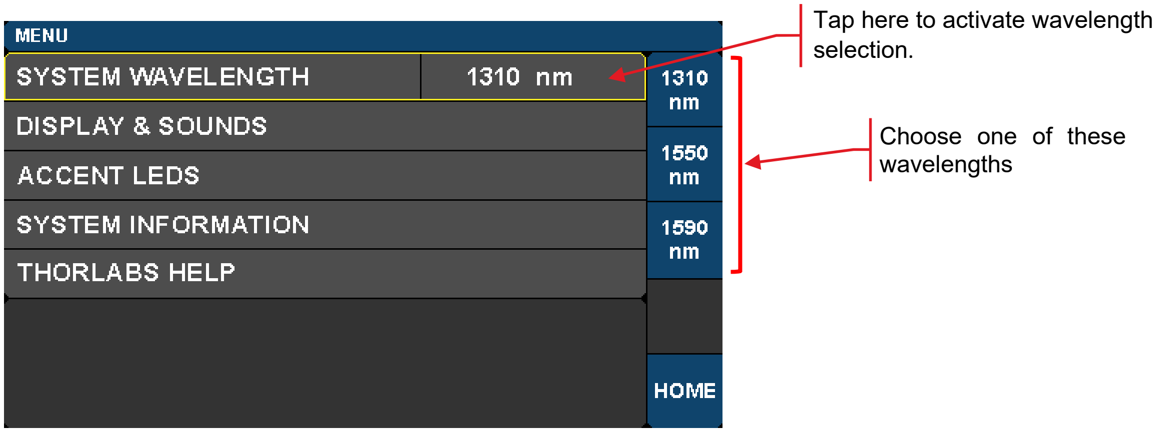


Figure 41 Selecting the System Wavelength

4.8.2 Display and Sound Settings Page

To get to this page, tap the DISPLAY AND SOUNDS button on the Menu page.

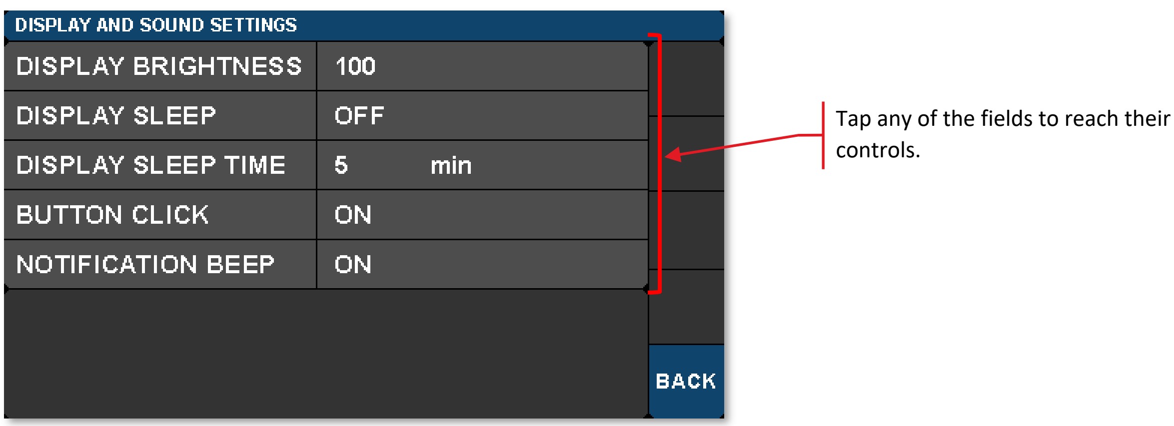


Figure 42 Page to Change Display and Sound Settings

- DISPLAY BRIGHTNESS controls the overall brightness of the touch-screen display.
- DISPLAY SLEEP TIME controls how long the touchscreen display is visible before it sleeps.
- BUTTON CLICK toggles the sound produced when tapping buttons (On/Off).
- NOTIFICATION BEEP toggles the sound associated with certain on screen notifications (On/Off).

4.8.3 System Information Page

To open the screen shown below, tap the SYSTEM INFORMATION button on the Menu pane.

The System Information page displays the installed hardware and software versions. This is useful information to reference when speaking with Thorlabs' tech support or when verifying firmware revisions. The image shown in Figure 43 illustrates the format of the System Information page, but this example is given for informational purposes only and does not show valid configuration information.

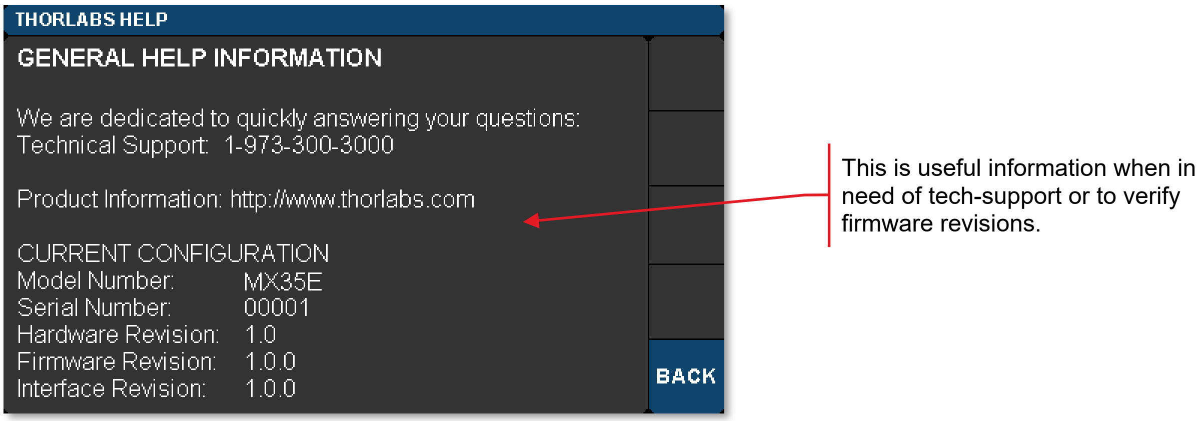


Figure 43 System Information Page

4.8.4 Accent LED Settings Page

To open the screen shown below, tap the ACCENT LEDS button on the Menu pane.

The accent LED settings control the intensity of the color LEDs that emanate from the bottom of the instrument. These are a fun aesthetic feature. You can set them to your favorite color.

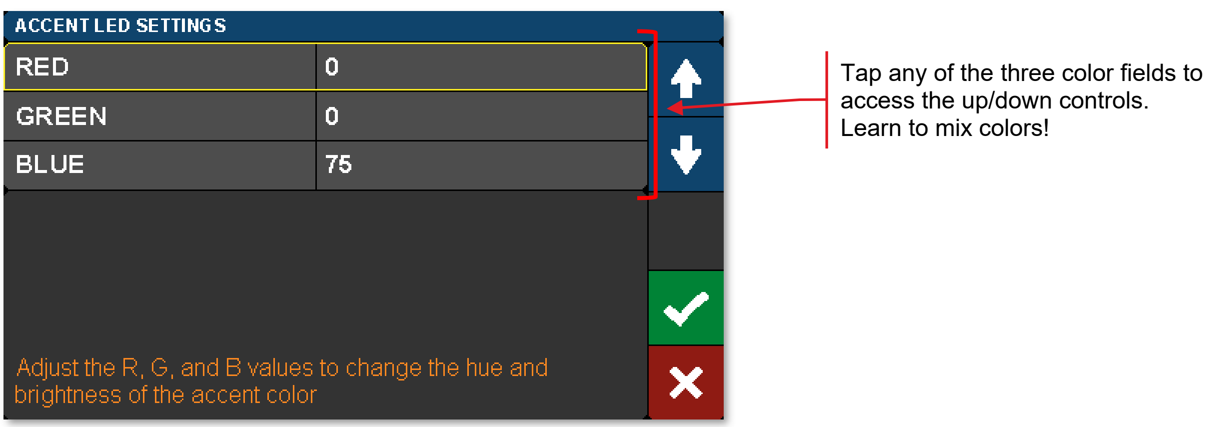


Figure 44 Controls to Adjust the LEDs Providing the Under-Instrument Accent Light

4.8.5 Thorlabs Help Page

To open the screen shown below, tap the THORLABS HELP button on the Menu pane. The Thorlabs Help page displays the Thorlabs Tech Support phone number, Thorlabs web site URL, and the installed hardware and software versions. This information will be useful when speaking with Tech Support. The image shown in Figure 45 illustrates the format of the Thorlabs Help page, but this example is given for informational purposes only and does not show valid configuration information.

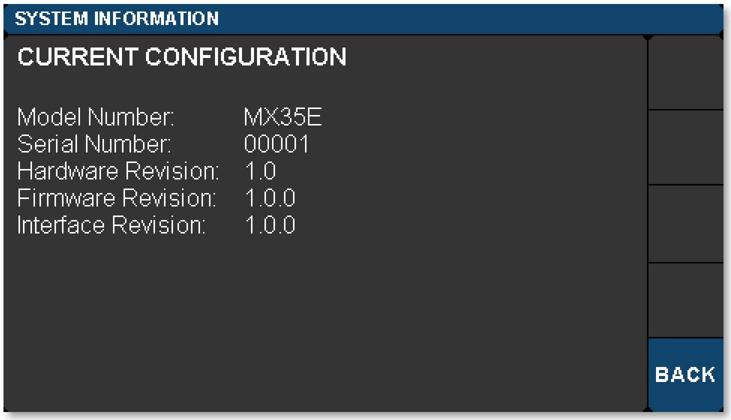


Figure 45 Thorlabs Help Page

Chapter 5 Specifications

All Specifications are at 1550 nm and 25 °C ambient temperature, unless otherwise noted.

5.1 General System Specifications

Parameter		Typical Values	Additional Information
Laser Output Power (Max)		13.5 dBm	From Internal Laser
Optical Input Power (Max)		20 dBm	22 dBm Absolute Max from External Laser
Optical Output Power[1,2]		8.5 dBm at 1550 nm 6.5 dBm at 1310 nm	Biased for Peak Optical Output
Internal Laser Wavelength Range[3]	MX35E	C-Band	Tunable in 50 GHz Steps
	MX35E-LB	L-Band	Tunable in 50 GHz Steps
	MX35E-1310	1310 nm	Fixed-Wavelength
External Laser Wavelength Range[4]		1250 nm - 1610 nm	-
Calibrated Wavelengths		1310 nm, 1550 nm, 1590 nm	User Selectable
Bit Rate (Max, Digital)		46 Gb/s	-
RF Optical Extinction Ratio		13 dB	At 32 Gb/s
Small Signal Bandwidth		35 GHz	Linear, Analog Response
Low Frequency Cutoff		200 kHz	-
Amplifier Linearity		<3.5% THD[5] at 1 GHz	<500 mV Input, <5.0 V Output
Amplifier RF Input (Peak-to-Peak)		250 mV 500 mV Maximum	700 mV Absolute Maximum
Amplifier Gain		10 dB to 23 dB	Small Signal
Amplifier Output Swing (Max)		5 V_{pp} for <3.5% THD[5]	7 V_{pp} Absolute Maximum
Amplifier DC Input (Max)		±10 V	Input is AC Coupled
Modulator V_π		5.5 V_{pp}	At 1 GHz
Optical Insertion Loss		5 dB at 1550 nm 7 dB at 1310 nm	Laser IN to Optical OUT

[1] *Specified when using internal laser and supplied loopback cable.*
[2] *Output power is typically 3 dB lower when bias is set at quadrature point.*
[3] *An 850 nm fixed-wavelength laser can be substituted upon request: contact Thorlabs' technical support.*
[4] *Using the modulator at another wavelength (e.g. visible light) may cause an increase in insertion loss and will void the warranty.*
[5] *Total Harmonic Distortion (THD)*

5.2 Power and Environmental Specifications

Parameter	Min	Max
Main AC Voltage	100 VAC	250 VAC
Power Consumption	-	60 VA
Line Frequency	50 Hz	60 Hz
Operating Temperature	10 °C	40 °C
Storage Temperature	0 °C	50 °C
Relative Humidity	5%	85%

5.3 Internal Control Specifications

Parameter	Typical	Notes
Power Monitor Accuracy	±0.5 dBm	Each Monitor, At Calibrated Wavelength
Power Monitor Resolution	0.01 dBm	Each Monitor
Power Monitor Insertion Loss	0.1 dB Typical	Per Monitor
VOA Attenuation Range	1 dB - 20 dB	-
VOA Response Time	1 s	-

5.4 Laser Specifications

Parameter	Unit	Min	Typ.	Max
C-Band Tunable Laser (MX35E)				
Optical Output Power	dBm	12.5	13.5	14.5
Frequency Range	THz	191.50	-	196.25
Wavelength Range	nm	1527.6	-	1565.5
Frequency Accuracy	GHz	-1.5	-	1.5
Tuning Resolution	GHz	-	50	-
Tuning Speed (Between Wavelengths)	s	-	10	-
Fine Tuning Resolution	MHz	-	1	-
Fine Tuning Speed	GHz/s	-	1	-
Fine Tuning Range	GHz	-30	-	30
Side Mode Suppression Ratio (SMSR)	dB	40	55	-
Optical Signal to Noise Ratio (OSNR)	dB	40	60	-
Intrinsic Linewidth	kHz	-	10	15
Relative Intensity Noise (RIN)	dB/Hz	-	-	-145
Back Reflection	dB	-	-	-14
Polarization Extinction Ratio (PER)	dB	18	-	-
L-Band Tunable Laser (MX35E-LB)				
Optical Output Power	dBm	12.5	13.5	14.5
Frequency Range	THz	186.35	-	190.95
Wavelength Range	nm	1570.0	-	1608.8
Frequency Accuracy	GHz	-1.5	-	1.5
Tuning Resolution	GHz	-	50	-
Tuning Speed (Between Wavelengths)	s	-	10	-
Fine Tuning Resolution	MHz	-	1	-
Fine Tuning Speed	GHz/s	-	1	-
Fine Tuning Range	GHz	-30	-	30
SMSR	dB	40	55	-
OSNR	dB	40	60	-
Intrinsic Linewidth	kHz	-	10	15
RIN	dB/Hz	-	-	-145
Back Reflection	dB	-	-	-14
PER	dB	18	-	-
1310 nm Fixed-Wavelength Laser (MX35E-1310)				
Optical Output Power	dBm	12.5	13.5	14.5
Wavelength	nm	-	1310	-
SMSR	dB	35	-	-
Intrinsic Linewidth	MHz	-	2	3
PER	dB	-	20	-

5.5 Typical Eye Diagrams

To obtain the eye diagrams displayed in Figure 47 through Figure 50, an electrical signal generated by a pseudorandom binary sequence (PRBS) generator was input to the MX35E series' Amplifier RF In port. The MX35E series' bias controller was set to hold a Constant Ratio after being biased at the positive quadrature point, and the amplifier gain was set to optimize signal swing for the given input conditions. The eye diagrams were measured using a 70 GHz sampling oscilloscope, with a high-speed photodetector used as the optical to electrical (O-E) converter.

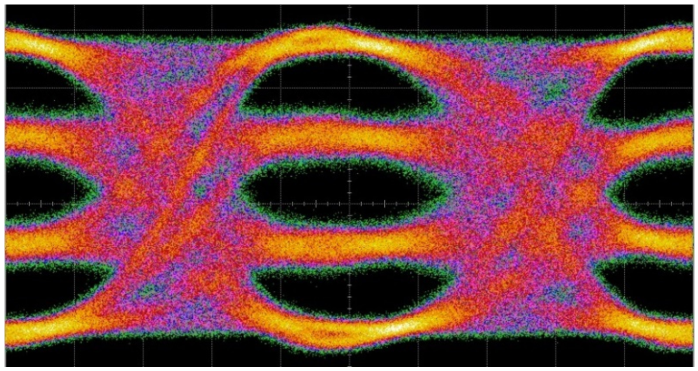


Figure 46 10 GBaud/s PAM4 Performance

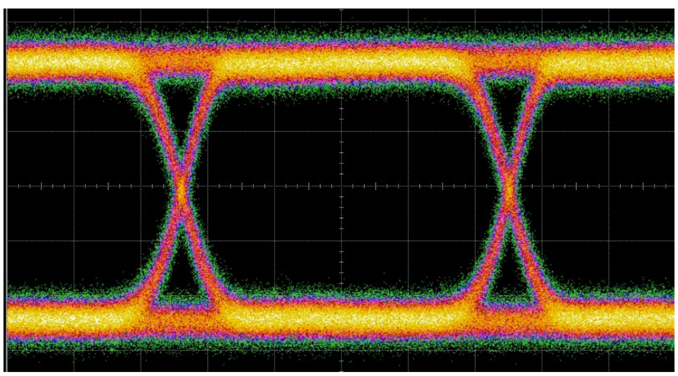


Figure 47 10 Gb/s Bit Rate Performance

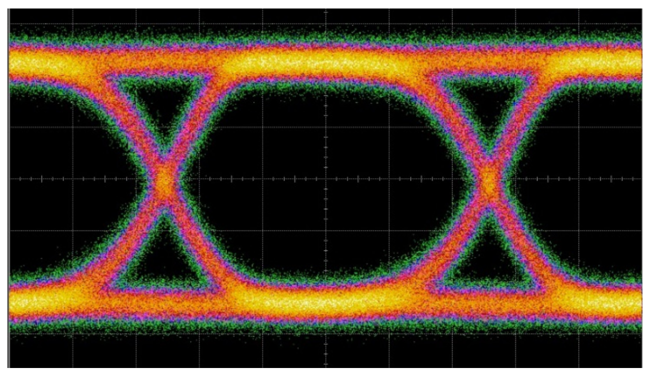


Figure 48 20 Gb/s Bit Rate Performance

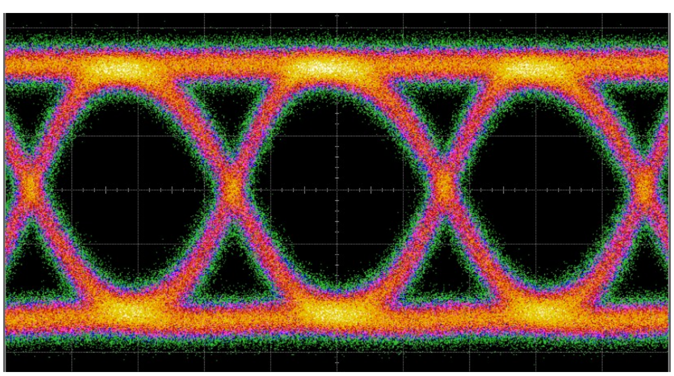


Figure 49 32 Gb/s Bit Rate Performance

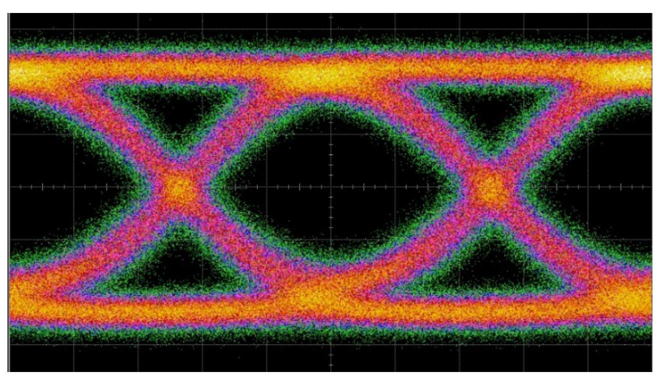


Figure 50 40 Gb/s Bit Rate Performance

Chapter 6 Control and PC Connections

6.1 General Purpose I/O, RS-232, and USB Connections

The back panel has connectors for monitor and control functions, as well as for upgrading the firmware. Both the RS-232 and the USB connections can be used for remotely controlling the MX35E series transmitter via SCPI type serial commands. Which connector to choose for remote control operation depends on the demands of the application and the user's preference. See the remote control user guide (RCUG), which can be downloaded from https://www.thorlabs.com/manuals.cfm, for information about the commands and connecting the unit to a PC.

The most recent firmware and remote control software tools are available through Thorlabs' website: please visit https://www.thorlabs.com/navigation.cfm?Guide_ID=2191 and enter the Item # into the search field. The instrument's firmware can be updated by uploading the new version from a PC via the USB port. Thorlabs' technical support can provide up-to-date information on available firmware revisions and control functions.

The 15-pin I/O connector provides outputs from the power monitors in the optical path (see the block diagram in Chapter 3). The power monitors provide a voltage that is proportional to the optical power with one of two gain settings. These values are available on the I/O DB15 connector. The gain setting for each monitor is determined by software, and reported on the corresponding Gain Indicator pins. 0.0 V indicates Low Gain (40 V/W) and 3.3 V indicates High Gain (4000 V/W). Maximum output voltage at the monitor pin is less than 12 V (into a high impedance). Power monitor bandwidth is limited to about 150 Hz.

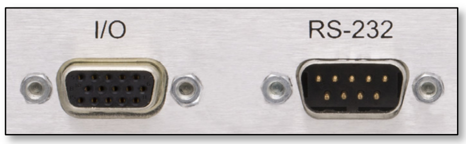


Figure 51 15-Pin I/O and RS-232 Connectors on the Back Panel

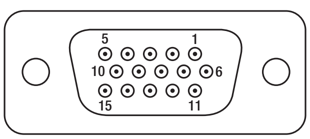


Figure 52 15-Pin I/O Connector Pin Configuration

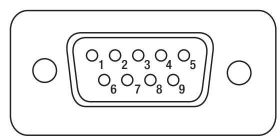


Figure 53 RS-232 Connector Pin Configuration

I/O Conn.	Pin #	Description
HD DB15	1	Power Monitor 1 (Mon-1)
HD DB15	2	Power Monitor 2 (Mon-2)
HD DB15	3	Power Monitor 3 (Mon-3)
HD DB15	4	Reserved for Future Use
HD DB15	5	Analog Ground
HD DB15	6	Analog Ground
HD DB15	7	Analog Ground
HD DB15	8	Analog Ground
HD DB15	9	Analog Ground
HD DB15	10	Analog Ground
HD DB15	11	Reserved for Future Use
HD DB15	12	Reserved for Future Use
HD DB15	13	Power Monitor 1 (Mon-1) Gain Indicator
HD DB15	14	Power Monitor 2 (Mon-2) Gain Indicator
HD DB15	15	Power Monitor 3 (Mon-3) Gain Indicator

RS-232	Pin #	Description
DB9	1	Not Connected
DB9	2	RS-232 Input
DB9	3	RS-232 Output
DB9	4	Not Connected
DB9	5	Digital Ground
DB9	6	Not Connected
DB9	7	Not Connected
DB9	8	Not Connected
DB9	9	Not Connected

6.2 The Laser Safety Interlock

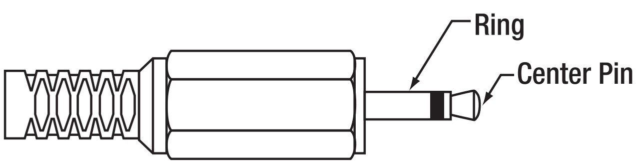
The instrument is equipped with a remote interlock connector located on the rear panel. In order to enable the laser source, a short circuit must be applied across the terminals of the Remote Interlock connector. In practice this connection is made available to allow the user to connect a remote actuated switch to the connector. The switch (which must be normally open) has to be closed in order for the laser to be enabled. If the switch changes to an open state, the laser source will automatically shut down. If the switch returns to a closed condition the laser source must be turned on again in the touchscreen GUI.

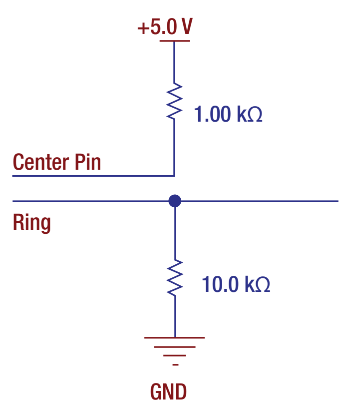
All units shipped from Thorlabs are configured with a shorting device installed in the Interlock connector. If you are not going to use this feature, then leave the shorting device installed. The unit will operate normally as described in the procedures above.

If you wish to make use of the Interlock feature you will need to acquire the appropriate 2.5 mm plug, wire it to the remote interlock switch, and then plug it in to the back-panel interlock jack in place of the shorting plug. This type of plug is readily available at most electronics stores. The electrical specifications for the interlock input are shown in the following table.

Specification	Value
Interlock Switch Requirements	Must be Normally Open Dry Contacts Apply no External Voltages to the Interlock Input
Type of Mating Connector	2.5 mm Mono Phono Jack
Open Circuit Voltage	<5 VDC (Center Pin is at 5 VDC, Ring is Ground)
Short Circuit Current (Typical)	7 mA
Connector Polarity	Tip is Ground, Barrel is at 5 VDC Max

The user's safety circuit must be attached to the phono plug and wired such that the ring and center pin are shorted when it is safe to enable the laser. The laser will be enabled when connection is closed. If it changes to an open state, the laser source will turn off.





(a) Diagram of a Phono-Type Plug   **(b) Internal Electrical Connections of the Interlock Jack**

Figure 54 The interlock circuitry internal to the laser head applies a 5 VDC bias across the ring and center pin of the plug. An external circuit that shorts the ring and center pin enables the laser.

Chapter 7 Mechanical Drawings

7.1 MX35E Series

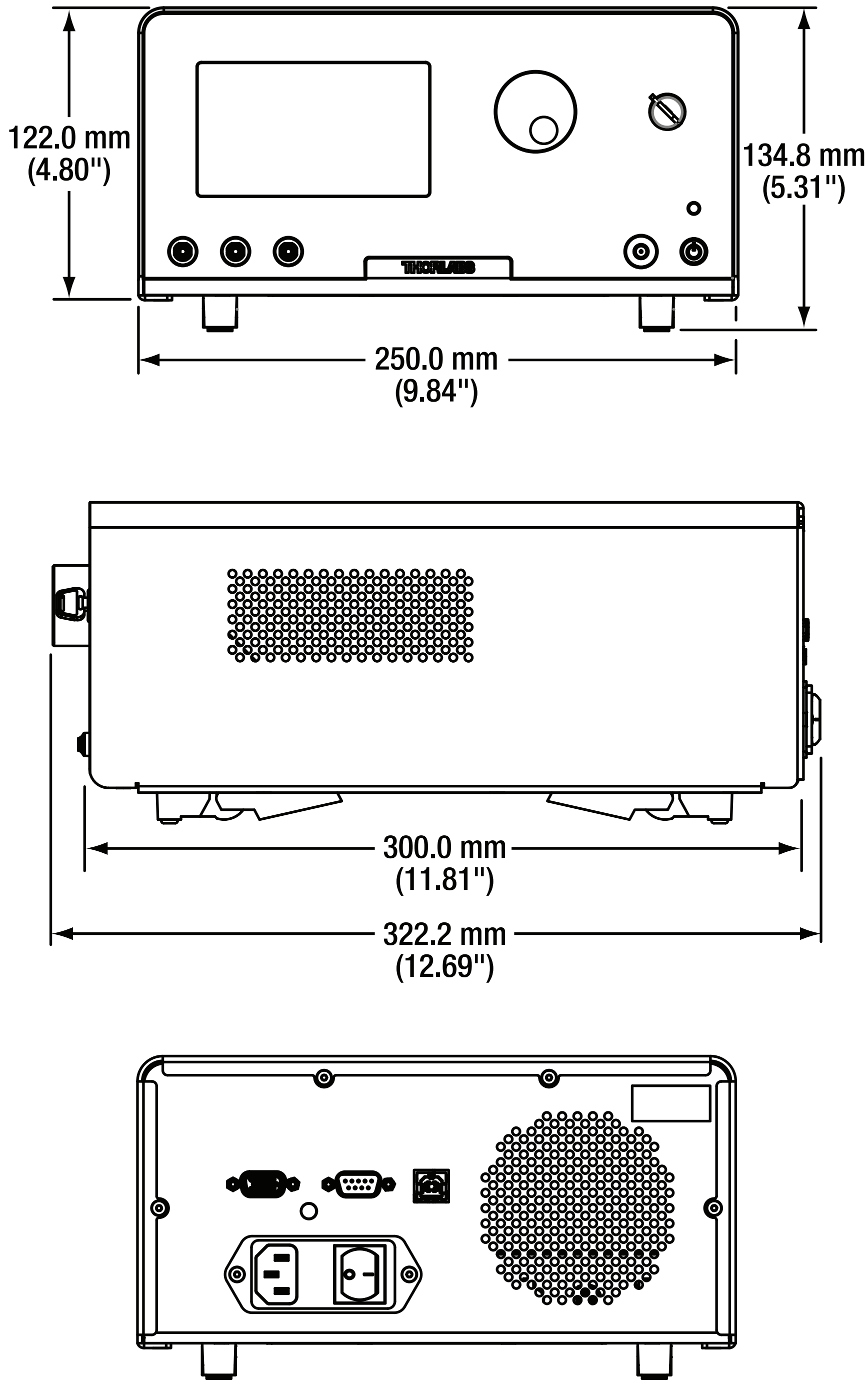


Figure 55 Mechanical Drawing of the MX35E Series Transmitter

Chapter 8 Maintenance, Repair, and Fuses

8.1 Maintenance and Repair

The instrument should not need regular maintenance by the user. If necessary the display, housing, and front panel can be cleaned using a soft cloth moistened with normal, mild glass cleaner. Do not use any chemical solvents or harsh cleaners on the display. Do not spray any cleaning solutions directly onto any part of the unit.

The instrument does not contain any modules that can be repaired by the user. If a malfunction occurs, please contact Thorlabs Technical Support and arrangements will be made to investigate the problem. Do not remove the cover. There are no user serviceable components inside.

Optical patch cords used to connect to the front panel of the instrument should have their end faces cleaned every time a new connection is made. The end faces of the internal fiber connectors can easily be damaged by the use of dirty fiber ends. If damage occurs, the instrument will need to be sent back for repair. We suggest using a fiber end-face cleaning product such as the Thorlabs FCC-7020 shown below. Alternatively, a lint-free cloth moistened with isopropyl alcohol or methanol can be used. Never use acetone.

Thorlabs FCC-7020
Fiber End-Face Cleaner for Patch Cords

The optical connectors on the front panel may be cleaned using a 2.5 mm bulkhead cleaner such as the Thorlabs FBC250. This allows the user to clean the fiber end-face without removing it from the internal bulkhead adapter.

Thorlabs FBC250
Fiber End-Face Cleaner for Bulkheads

8.2 Replacement Parts

The following parts can be obtained by contacting Thorlabs Technical Support

- SMA 50 Ω Loads (Used for Front Panel RF Connectors)
- PM Loopback Fiber Patch Cord for Front Panel
- Laser Interlock Keys for Front Panel Switch
- 2.5 mm Interlock Pin (for Back Panel)
- 1.25 A 250 VAC Fuse for Main Power
- Instrument IEC Main Power Cord
- Instrument Flip Foot

8.3 Replacing the Main Fuse

The system is protected by a main fuse located in the power entry module where the main power cable plugs into the back panel of the instrument. If the instrument does not appear to power-up, especially after a power outage or storm, you can check the condition of the main power fuse without removing the cover of the instrument by following the following steps.

1. Put the instrument in "Standby" mode by pressing the standby button on the front of the instrument. Wait until the button turns from green to amber.
2. Turn the power off using the switch on the back panel of the instrument.
3. Unplug the main power cable.
4. Carefully remove the fuse holder slide from the power entry module (use a flat screwdriver)

.

Figure 56 Power Entry Module

Figure 57 Removing the Fuse Holder Slide

5. Investigate the fuse. This can be done with a simple continuity check. If in doubt, replace the fuse. A spare fuse is stored in the fuse holder. Additional replacement fuses can be purchased from Thorlabs. **Always use fuses of the same type as the original**.

Figure 58 Fuse

6. Reinstall the fuse holder slide into the power entry module, taking care that it fully seats until the top is flush with the rest of the power entry module.
7. Plug the main power cable back into the unit and power on as described in the *Getting Started* section of the manual.

If the fuse blows repeatedly, it is likely that an internal failure has occurred. Do not attempt to bypass the fuse as this can create a dangerous situation that could further damage the instrument or harm personnel. In this case, please contact Technical Support for directions.

Chapter 9 Troubleshooting

Below is some information about status indicators and a few checks to help in troubleshooting general problems. If you have any questions, please contact your local Thorlabs Technical Support office.

If the unit does not appear to turn on correctly, please check the following items:

- Ensure that the main AC receptacle is powered
- Ensure that main power cable is fully seated at both ends
- Ensure that back power switch is in the “I” position
- Check the main power fuse (see Maintenance and Repair Section)

The color of the Standby Button, which is on the front panel, indicates several status conditions as follows:

Standby Button Color	Condition
Solid Green	Indicates normal ON state.
Solid Amber	Indicates unit is in Standby Mode. Press the button to turn the instrument ON.
Blinking Green	Indicates the main AC power is unstable. When the AC power is restored, the instrument will return to the standby mode (amber).
Blinking Amber	Indicates the instrument is overheated. Make sure the fan is running and none of the vents are blocked. If there are no ventilation issues, then the box should cool itself and return to the standby. Do not operate, or leave the instrument in standby mode, in an environment above 40 °C.
Blinking Amber/Green	Indicates the instrument is both overheated and the main AC power is unstable (see individual troubleshooting for these conditions above).
Fading Amber/Green	Indicates the instrument is in the firmware upgrade mode. If this condition appears after attempting to upgrade the firmware, the update may have failed, or the unit may have been left in the update mode. Try running the firmware update again. This condition may have also been reached by holding down the standby button for a long time while turning on the power. In this case, turn the unit off, wait for a few seconds, and turn it back on. If this condition for any other reason, turn the unit off, wait for a few seconds, and turn it back on. If these attempts to recover continue to fail, the instrument’s firmware may have been corrupted. Contact Tech Support for help.

If the optical power at any point of the system is lower than expected, resolving the problem always starts by cleaning the optical fiber ends. Contaminated fiber ends, which attenuates the intensity of the transmitted light, is a very common issue when using single-mode fibers. Follow the suggestions provided in the Maintenance and Repair section of this manual to clean the optical fiber ends.

Chapter 10 Declarations of Conformity

THORLABS
www.thorlabs.com

EU Declaration of Conformity

in accordance with EN ISO 17050-1:2010

We: Thorlabs Inc.

Of: 56 Sparta Avenue, Newton, New Jersey, 07860, USA

in accordance with the following Directive(s):

2014/35/EU	Low Voltage Directive (LVD)
2014/30/EU	Electromagnetic Compatibility (EMC) Directive
2011/65/EU	Restriction of Use of Certain Hazardous Substances (RoHS)

hereby declare that:

Model: ***MX35E, MX35E-1310, MX35E-LB***

Equipment: ***Linear Transmitter***

is in conformity with the applicable requirements of the following documents:

EN 61010-1	Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory Use.	2010
EN 61326-1	Electrical Equipment for Measurement, Control and Laboratory Use - EMC Requirements	2013
EN 60825-1	Safety of laser products	2014-05

and which, issued under the sole responsibility of Thorlabs, is in conformity with Directive 2011/65/EU of the European Parliament and of the Council of 8th June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment, for the reason stated below:

does not contain substances in excess of the maximum concentration values tolerated by weight in homogenous materials as listed in Annex II of the Directive

I hereby declare that the equipment named has been designed to comply with the relevant sections of the above referenced specifications, and complies with all applicable Essential Requirements of the Directives.

Signed: *On:* 15 March 2017

Name: Ann Strachan

Position: Compliance Manager *EDC - MX35E, MX35E-1310, MX35E-LB -2...*

CE

Chapter 11 Thorlabs Worldwide Contacts

For technical support or sales inquiries, please visit us at **www.thorlabs.com/contact** for our most up-to-date contact information.

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Thorlabs verifies our compliance with the WEEE (Waste Electrical and Electronic Equipment) directive of the European Community and the corresponding national laws. Accordingly, all end users in the EC may return "end of life" Annex I category electrical and electronic equipment sold after August 13, 2005 to Thorlabs, without incurring disposal charges. Eligible units are marked with the crossed out "wheelie bin" logo (see right), were sold to and are currently owned by a company or institute within the EC, and are not dissembled or contaminated. Contact Thorlabs for more information. Waste treatment is your own responsibility. "End of life" units must be returned to Thorlabs or handed to a company specializing in waste recovery. Do not dispose of the unit in a litter bin or at a public waste disposal site.

Annex I


UNLEASHED