User Manual

SLICE-DLC Dual Laser Controller

Revision 04

VESCENT

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Contents

1 Introduction

This manual contains information for operating the Vescent SLICE-DLC Dual Laser Controller. The SLICE-DLC is a dual-channel precision diode laser controller. Each channel offers an ultra-low-noise current source and two independent temperature controllers.

This section has information for safely operating the SLICE-DLC. Please carefully read this section before using the SLICE-DLC. Section 2 introduces the user to the instrument and defines all hardware connections. Section 3 discusses the graphical user interface (GUI) for the SLICE-DLC. Section 4 helps users immediately get started using the SLICE-DLC in their application by showing an example of typical setup and operation. Section 5 contains further detail about the operation of the SLICE-DLC. Section 6 covers remote operation of the SLICE-DLC. Troubleshooting help can be found in Section 7. For further information, including product specifications, additional resource links, and warranty information, see the appendices.

1.1 Symbol Definitions

The following symbols may be encountered in this manual or on the device.

Symbol	Description
	Caution: Follow instructions to avoid injury or damage to equipment
	Caution: Risk of electric shock.
	Caution: Laser beam.
	Warning: Do not connect indicated port to earth ground. Doing so will result in nonconforming operation and may cause permanent damage to the instrument.
	Alternating Current
	Fuse
	Chassis Terminal
	The user manual should be referenced when operating this device
	WEEE: Separate collection for waste electric and electronic equipment is required
	Circle Indicator: Indicates relevant item in image
	Pointer Indicator: Points to relevant item in image

1.2 Safety

1. This instrument is intended for use by qualified personnel who recognize shock hazards and laser hazards and are familiar with safety precautions required to avoid possible injury. Read the instruction manual thoroughly before operating the SLICE-DLC to become familiar with the instrument's operations and capabilities.

2. If this instrument is used in a manner not specified by the manufacturer in this manual or other relevant literature, protection provided by the instrument may be impaired.

3. For indoor use only, within a (maximum) Pollution Degree 2, Overvoltage Category II, 30°C ($T_{amb,max}$), with the SLICE-DLC installed on a flat, level surface.

4. The SLICE-DLC is not intended for fail-safe operation in hazardous environments or life-threatening situations. The user assumes full responsibility for correct and safe usage of the SLICE-DLC in accordance with any applicable laws, codes, regulations, and standards pertaining to their specific application. Vescent is not liable for any consequential damage due to misapplication or failure of the SLICE-DLC.

5. Proper grounding must be ensured prior to energization of the SLICE-DLC.

6. Never connect or disconnect any hardware to/from this device while it is energized. Always power down the SLICE-DLC completely before making connections to external hardware.

7. To avoid electrical shock hazard, connect the instrument to an approved, TN-S configured, properly earth-grounded, three prong receptacle only. Failure to observe this precaution can result in severe injury or death.

8. Backup short-circuit protection is to be provided via the building branch circuit overcurrent protective device. The fuse within the SLICE-DLC is for overload protection only, but has been selected, and is only considered valid, as a high-interrupt capacity fuse (per IEC 60127).

9. Before replacing the fuse on the SLICE-DLC, turn off the power switch and disconnect the unit from mains power.

10. Except for the fuse, there are no field-serviceable parts inside the instrument. Maintenance on the SLICE-DLC is to be performed by trained personnel only, and with the power cord to the SLICE-DLC removed. Maintenance performed by non-Vescent personnel will void the warranty.

11. All additional Lockout/Tagout (LOTO) conditions (in addition to the above-mentioned removal of the input power cord), in accordance with all local codes and jurisdictional requirements, are also to be followed.

12. Any input/output connections to the SLICE instrument, other than the AC MAINS inlet, must be derived from a Safety Extra Low Voltage (SELV) source.

13. Do not obstruct the fan exhaust. Leave clearance around fan for proper ventilation.

14. Appropriately setting Load Limits protects the heating/cooling element from damage. Review Load Limits when connecting a new temperature plant.

15. No flammable liquids are permitted to be used on the SLICE-DLC (for cleaning or maintenance).

16. WARNING: Do not connect any of the Temp Control pins to earth ground. Doing so will result in nonconforming operations and may cause permanent damage to the instrument.

17. The SLICE-DLC is intended to be recycled at the end of its lifecycle, per all local codes and jurisdictional requirements.

2 Hardware

This section discusses the hardware features and connections of the SLICE-DLC and the other items that are shipped with the unit.

2.1 Package Contents

The SLICE-DLC is shipped in a package designed to provide excellent protection. The shipping box should be saved for future transportation or storage needs.

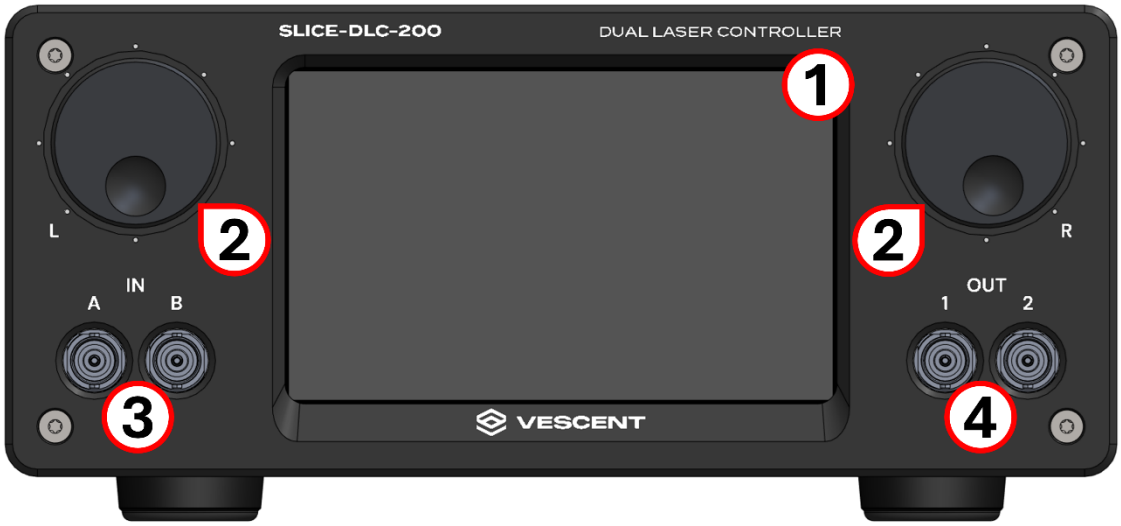
Carefully remove and inspect the following items that are contained in the shipping box:

- SLICE-DLC Dual Laser Controller
- Two Operator Keys
- 50 Ω BNC terminator
- AC Power Cord, region specific
- Final Test Documentation

2.2 Controls and Connections

This section introduces all the hardware controls and connection ports on the SLICE-DLC.

2.2.1 Front Panel



1. Touchscreen

The primary way to interact with the SLICE-DLC is via its front panel touchscreen. General instructions for touchscreen control are discussed in Section 3.

2. Parameter Input Adjustment Knobs

Two rotary knobs allow the user to quickly cycle through parameter list settings and enter numeric inputs. In general, the right knob (R) changes the current selection or the value of a digit, and the left knob (L) changes the digit selection. Additionally, an L or R symbol (see left) on the touchscreen display indicates instances where knob control can be used.

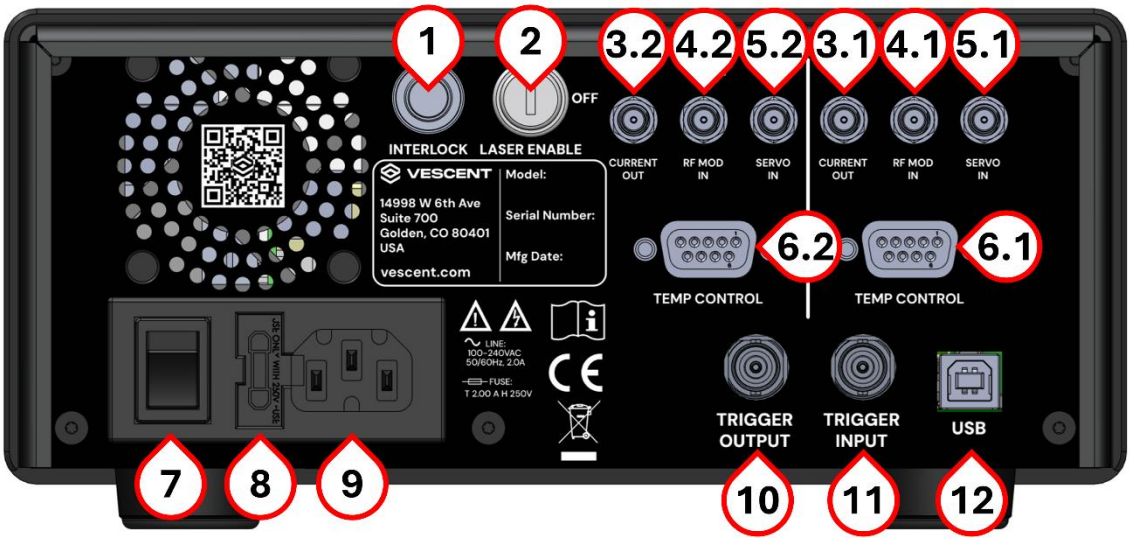
3. Selectable Input Ports (BNC)

Two BNC connectors on the front panel provide optional functionality that is specific to the type of SLICE product. This functionality can be selected on the I/O Programming screen (see Section 3.3.2) and impedance is chosen on the System Settings screen (see Section 3.3.3). Both channels have an input voltage range of ±10 V and a selectable input impedance of 1 MΩ or 50 Ω.

4. Selectable Output Ports (BNC)

Two BNC connectors on the front panel provide signal monitor outputs that are selectable on the I/O programming screen (see Section 3.3.2). The output voltage range of these channels is ±10 V.

2.2.2 Rear Panel



1. Remote Interlock Port (BNC)

This port is for disabling the laser diode output via a remote interlock control. The SLICE-DLC will only output current if this port is shorted. When the connection is broken, the SLICE-DLC Safety Interlock System (SIS) will trigger.

If not using a remote interlock, leave a 50 Ω BNC terminator on this port.

2. Access Control Lock

This access control lock restricts use of the SLICE-DLC to authorized operators. The SLICE-DLC will only output current if an Operator Key is inserted and oriented vertically ('Laser Enable'). When the key is removed or oriented horizontally ('Off') the SLICE-DLC Safety Interlock System (SIS) will trigger.

3. Current Outputs (SMA)

The laser current for channels 1 and 2 are output on the ports labeled 3.1 and 3.2 respectively. The current returns to the instrument through the cable shielding.

4. RF Modulation Inputs (SMA)

Radio frequency modulation for laser current dithering is applied to channels 1 and 2 on the ports labeled 4.1 and 4.2 respectively. The RF input is AC coupled to the laser diode through 24 Ω series resistor and a 100 nF capacitor.

Large voltage transients to this input may damage a connected laser diode. Do not exceed 0.71 V_{RMS} from a 50 Ω source or 10 mW of power on this port.

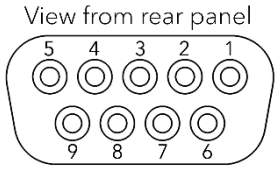
5. Current Servo Inputs (SMA)

Apply a current servo signal to channel 1 or 2 through the ports labeled 5.1 and 5.2 respectively. Laser modulation is equal to 1 mA/V applied at this input.

6. Laser Temperature Controls (DB-9)

Temperature control for channels 1 and 2 is facilitated by the ports labeled 6.1 and 6.2 respectively. Each channel allows for two temperature control plants that are referred to as Case and Laser in the GUI. A temperature control plant is comprised of a temperature transducer (heater/TEC) and an NTC thermistor (Rth) that provides feedback.

The connections to the transducers and thermistors are made via a DB-9 female connector on the SLICE-DLC. The pin assignments are as follows:



Pin	Signal
1	Case Heater/TEC-
2	Case Heater/TEC+
3	N/C
4	Laser Heater/TEC-
5	Laser Heater/TEC+
6	Case Rth-RTN
7	Case Rth
8	Laser Rth-RTN
9	Laser Rth

WARNING: Do not connect any of the temperature plant pins to earth ground. Doing so will result in nonconforming operations and may cause permanent damage to the instrument.

7. Power Switch

While the Power port is connected to mains power, toggle this switch to | to turn on the SLICE-DLC.

8. Fuse

The SLICE-DLC has a factory-installed fuse. To replace the fuse, follow the procedure below:

- Flip the SLICE-DLC Power switch off.
- Disconnect the SLICE-DLC from mains power.
- Remove the fuse cover.
- Replace the blown fuse with a high breaking capacity 5mm x 20mm fuse rated to 250 V and 2A.
- Replace the fuse cover.

9. Power Port

Use the provided AC power cord to connect this port to a properly grounded mains receptacle.

10. Trigger Output (BNC)

The Trigger Output can be programmed to output a +5 V TTL signal under certain conditions. Configure the trigger conditions on the I/O Programming screen. For further information see Section 3.3.2.

11. Trigger Input (BNC)

The Trigger Input can be programmed to respond to a +5 V TTL signal. Configure the trigger conditions on the I/O Programming screen. For further information see Section 3.3.2.

12. Serial Port (USB-B)

Use a standard USB-A to USB-B cable to connect the SLICE-DLC to a computer for remote operation and updating firmware. For further information see Section 6.

3 Graphical User Interface

This section discusses how the user interacts with the SLICE graphical user interface (GUI) and introduces the different types of buttons, windows, and screens a user will see on the touchscreen display.

3.1 Control Bar

On the left edge of the SLICE-DLC touchscreen is the Control Bar. The table below briefly explains the functionality of each Control Bar button.

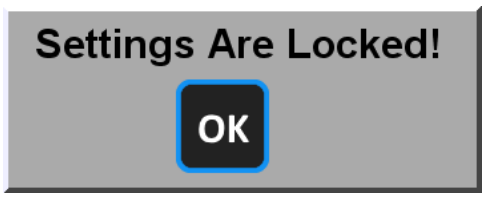
Symbol	Button Name	Function When Tapped
	Home	Returns to Home screen. Home is the screen which appears when the user powers up the unit. See Section 3.3.1.
	Back	Returns to previous screen.
	Parameter Lock	Toggles the Parameter Lock. The Parameter Lock prevents certain fields from being edited. See Section 3.1.1.
	Input/Output	Enters the I/O Programming screen. See Section 3.3.2.
	System Settings	Enters the System Settings screen. See Section 3.3.3.

3.1.1 *Parameter Lock*

The Parameter Lock is a toggle button that helps prevent accidental settings changes.

The symbol to the left indicates the Parameter Lock is in the unlocked state. In the unlocked state it is possible to interact with any field bordered in blue. Tap the symbol to switch the Parameter Lock to the locked state.

The symbol to the left indicates the Parameter Lock is in the locked state. In the locked state certain fields will be locked so they cannot be changed until the lock is released. Interacting with a locked button will open the following alert window:



Navigation buttons and many toggle buttons will still be operable in the locked state. Tap the symbol to switch the Parameter Lock to the unlocked state.

3.2 Button Types

The types of GUI buttons and their functionality are discussed here.

Tap a button to interact. It is possible to select the functionality or edit the values of a field bordered in blue. Some buttons have a second parameter edit mode that activates after touching and holding the button for a couple seconds. Interacting with a button will cause the unit to beep.

3.2.1 Navigation Buttons

Navigation buttons change the screen shown on the display.

Tapping a Navigation button will take the GUI to the corresponding screen. Most Navigation buttons are in the Control bar (see Section 3.1) located on the left of all screens.

3.2.2 Toggle Buttons

Toggle buttons allow the user to switch a parameter between two states.

Tapping a toggle button will switch its state between two options or between a disabled and an enabled state.

For a toggle button which toggles between enabled and disabled states, the button background and text indicate the current state of the button. White text on a black background indicates the toggle is in the disabled state. Black text on a colored background indicates the toggle is in the enabled state.

3.2.3 Dropdown Menus

Dropdown menus allow the user to choose a parameter setting from a list of values.

Tapping a dropdown menu will reveal the list of available choices. The current selection will be bordered in white. Tapping one of the choices selects it and closes the dropdown menu. Tapping outside the dropdown menu closes the dropdown menu and retains the original choice.

3.2.4 Numeric Fields

Numeric fields allow the user to choose a custom numeric value for a given parameter.

Tapping a numeric field will change its border from blue to yellow. Rotary knob editing mode is active while the border is yellow. The underlined digit is the currently active digit.

Rotating the L-knob changes the currently active digit. Rotating the R-knob changes the value of the currently active digit. Tap anywhere on the display to disable rotary knob editing mode and change the field border back to blue.

If the rotary knob editing mode is active for 60 consecutive seconds without user input, then the unit will beep and rotary knob editing mode will deactivate. The border of the button will turn red momentarily before returning to blue.

Touching and holding a numeric field launches the numeric keypad. The desired value can be typed into the numeric field by using the keypad. Tapping the Confirm key confirms the value and updates the parameter. When an invalid value is entered into a keypad, the value will be coerced to the nearest valid value. Keypad buttons are described in the table below.

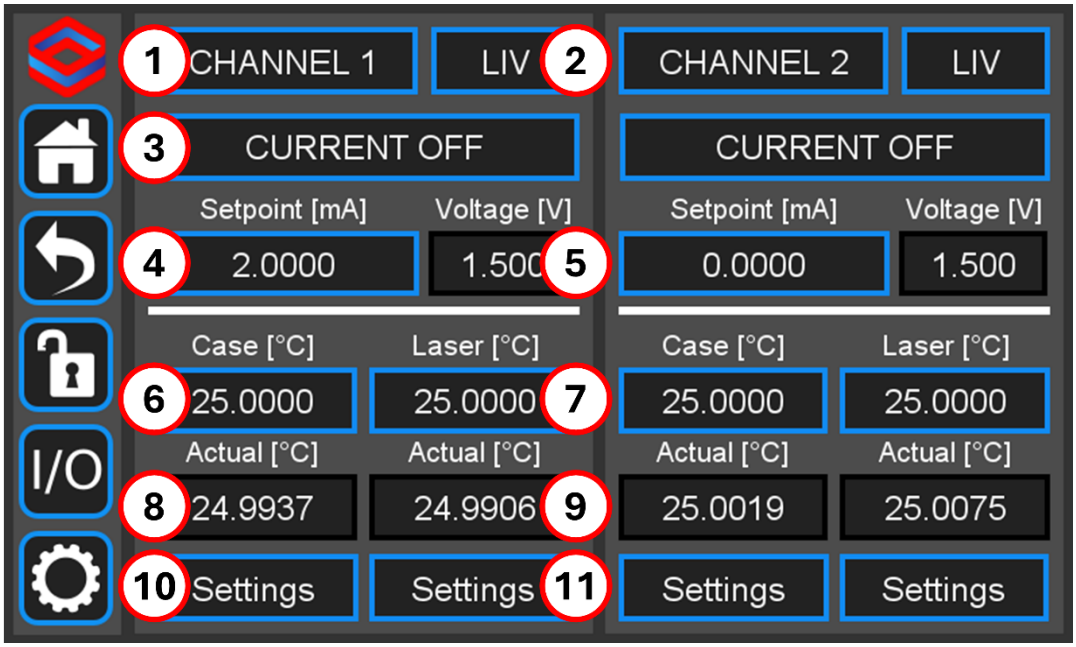
Numeric Keypad Buttons

Symbol	Button Name	Function When Tapped
	Plus/Minus	Changes sign of the value.
	Numeric	Inputs tapped number as the next digit.
	Decimal Point	Inputs decimal point as the next digit.
	Delete	Deletes last digit in the numeric field.
	Clear	Clears numeric field.
	Back	Exits keypad without accepting changes.
	Confirm	Accepts value in numeric field and exits keypad.

3.3 Screens

Each of the following sections introduces a screen encountered during operation of the SLICE-DLC and describes the function of the contained displays and controls.

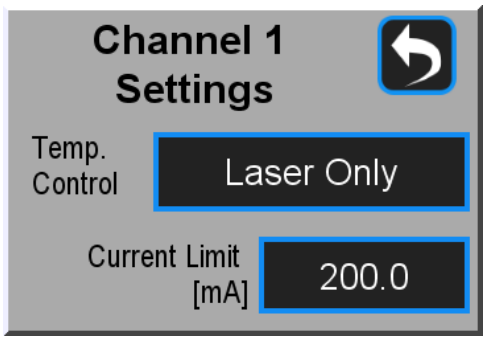
3.3.1 Home Screen



After start-up the SLICE-DLC will display the Home screen. This view summarizes the present state of the SLICE-DLC.

The indicators and controls for Channel 1 (2) are on the left (right) side of the Home screen. Channel 1 elements, labeled above, are described below. All Channel 2 elements are similar to those for Channel 1.

1. Channel 1: Opens the Channel 1 Settings window.



Temp. Control - Selects which types of temperature control are active on this channel. 'Current On' mode can only be activated when the temperatures of all

the channel's active temperature controls are stable as defined by the Locked Range in the Temperature Limits Settings window (see Section 3.4.2).

This setting is locked while the temperature controllers are on. Switch the channel to 'Current Off' mode on the Home screen before making changes to this setting.

Current Limit [mA] - Sets the current limit for this channel's Current Output port. Choose an appropriate value that protects the connected diode from excess current. This setting prevents the operator from choosing a current setpoint that is too high for the diode and prevents excess current from reaching the diode during modulation.

Note: Output current noise increases as the operating current approaches the user-defined current limit.

2. LIV: Navigates to the LIV Sweep screen. See Section 3.3.4.

3. Operation Mode selector: Dropdown menu for the SLICE-DLC mode setting. The behavior while in each mode is as follows:

CURRENT OFF - Initial mode when starting up the SLICE-DLC. Temperature is not being controlled and current is not supplied to the laser diode.

If temperature control has been turned off for this channel then it is possible to switch directly to Current On mode. Otherwise, only Standby Mode will be available.

STANDBY - In Standby mode the SLICE-DLC will stabilize the temperature of the laser. Current is not supplied to the laser diode.

Upon initiating Standby mode, the Operation Mode button flashes white and the active temperature indicators turn yellow. When the active temperature controllers stabilize around their setpoints, their indicators will turn green and the Operation Mode button will stops flashing. At this point it is possible to switch to Current On mode.

If there are no active temperature controllers, then Standby mode is not available.

CURRENT ON - In Current On mode the SLICE-DLC will stabilize the temperature of the laser and supply current to the laser diode.

This mode is only available after the active temperature controllers have been stabilized. Upon switching to this mode, the Operation Mode control will flash for 5 seconds. After this safety delay the SLICE-DLC will begin supplying current to the laser diode.

ERROR - If an error condition is triggered, the SLICE-DLC will enter an error state. The Operation Mode selector will flash red and display an error message. No other operation mode can be selected.

To exit the error state, the condition causing the error must first be resolved. Then tap on the error message to return to normal operation. For more information on error states, see Section 5.2.

4. Current Setpoint: Tap to change the current setpoint for the laser.

5. Laser Voltage: Display showing the measured load voltage.

6. Case Temperature Setpoint: Temperature setpoint for the laser case.

7. Laser Temperature Setpoint: Temperature setpoint for the laser diode.

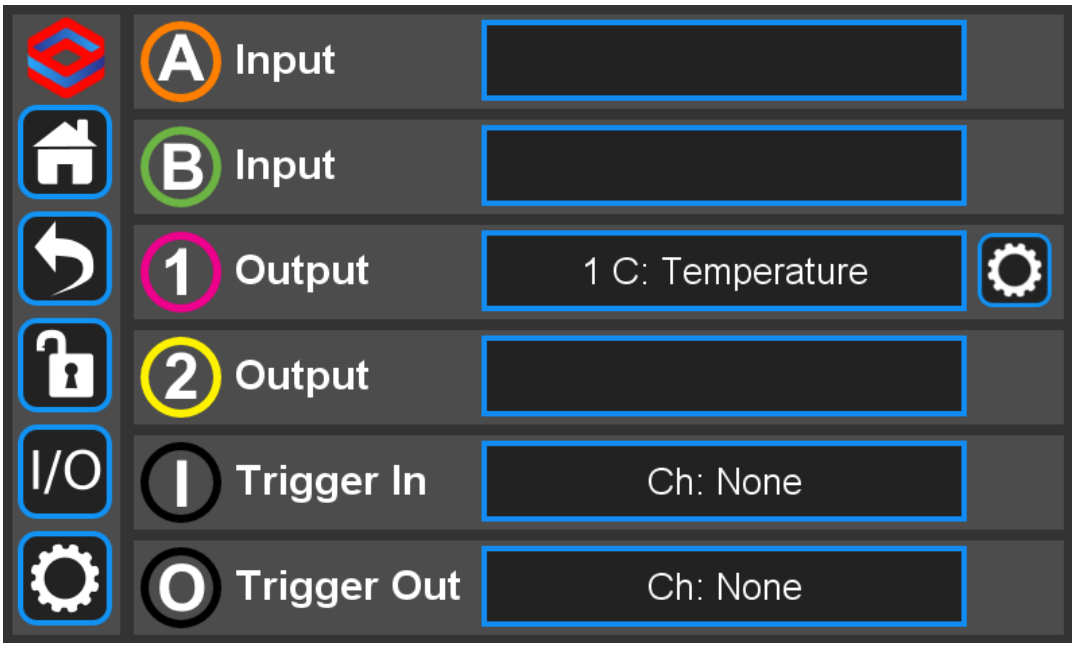
8. Actual Case Temperature: Measured temperature of the laser case.

9. Actual Laser Temperature: Measured temperature of the laser diode.

10. Case Temperature Settings: Navigates to the Channel 1 Case Temperature Detail screen. See Section 3.3.5.

11. Laser Temperature Settings: Navigates to the Channel 1 Laser Temperature Detail screen. See Section 3.3.5

3.3.2 I/O Programming Screen



The Input/Output (I/O) button navigates the user to I/O Programming screen. Each of the front panel input, front panel output, and rear trigger ports can be programmed to deliver or receive signals by tapping its blue-outlined control box and selecting an option from the menu. After selecting an input control or output monitor, a gear icon may appear (e.g. see Output 1 above). Tap this icon to open an additional configuration window.

The I/O Programming screen uses the following shorthand notation:

Shorthand	Definition
Ch 1	Channel 1 Current Controller
1 C	Channel 1 Case Temperature Controller
1 L	Channel 1 Laser Temperature Controller
Ch 2	Channel 2 Current Controller
2 C	Channel 2 Case Temperature Controller
2 L	Channel 2 Laser Temperature Controller

The input ports are as follows:

A Input: Select the input control for Front Panel Selectable Input A. A field with the Input A indicator (left) is presently affected by Input A.

B Input: Select the input control for Front Panel Selectable Input B. A field with the Input B indicator (left) is presently affected by Input B.

The configuration options for the input ports are as follows:

Off - Disables the input port.

Modulation Input - Moves current modulation control from the Servo In port to the front panel. Voltage defines the modulation for the indicated current driver. The transfer function is 1mA/V.

Note, for best signal to noise performance use the rear panel Servo In port for current modulation.

The output ports are as follows:

1 Output: Select the monitor output for Front Panel Selectable Output 1. A field with the Output 1 indicator (left) is presently monitored on Output 1.

2 Output: Select the monitor output for Front Panel Selectable Output 2. A field with the Output 2 indicator (left) is presently monitored on Output 2.

The configuration options for the output ports are as follows:

Off - Disables the output port.

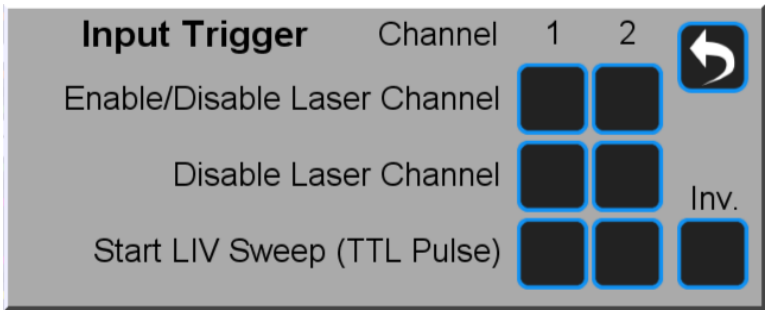
Temperature - Converts actual temperature to an output voltage.

Error Signal - Converts the error temperature to an output voltage.

Temperature Current Output - Converts the temperature transducer current to an output voltage.

Laser Current Output - Converts the laser current to an output voltage. The transfer function is fixed and depends on the SLICE-DLC model. The transfer functions for the SLICE-DLC-200 and SLICE-DLC-500 are 20 mV/mA and 8 mV/mA, respectively.

I Trigger In: Opens the Input Trigger window (below). Select the desired behavior to be executed when a +5 V TTL trigger signal is applied to the Trigger Input port. A field with the Trigger In indicator (left) is programmed to respond to a trigger input.



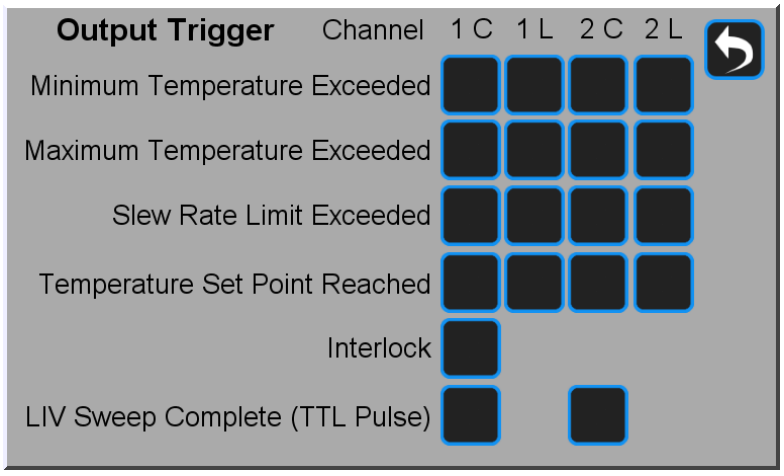
Enable/Disable Laser - Shunts the laser current to ground on a high signal and enables current flow on a low signal. The channel remains in Current On mode.

Disable Laser Channel - Disables the laser channel on a high signal and returns to Standby Mode. This is a one-way trigger.

Start LIV Sweep - Starts an LIV sweep when the Trigger Input port observes a rising edge. Only records data if GUI is on the LIV Sweep screen.

Invert - Inverts the TTL logic when checked.

O Trigger Out: Opens the Output Trigger window (below). Select the conditions that will cause a +5 V TTL trigger signal to be output on the Trigger Output port. If multiple boxes are selected, then the TTL trigger signal is set high when any of the conditions is met. A field with the Trigger Out indicator (left) is programmed to output a trigger signal.



Minimum Temperature Exceeded - Outputs a TTL pulse when the Minimum Temperature Limit is exceeded.

Maximum Temperature Exceeded - Outputs a TTL pulse when the Maximum Temperature Limit is exceeded.

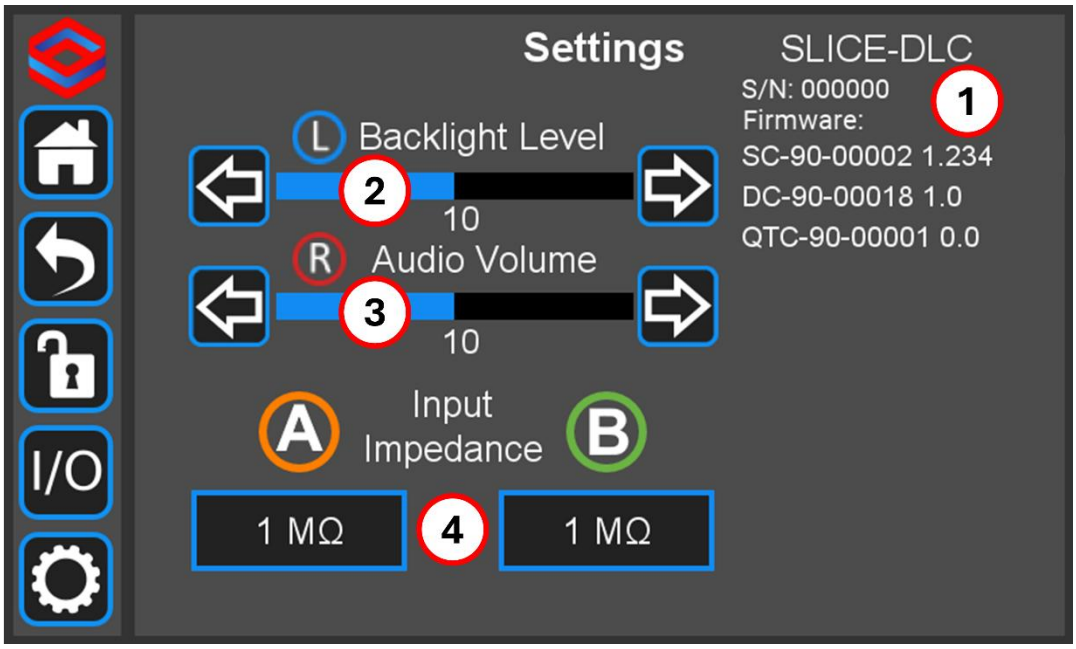
Slew Rate Limit Exceeded - Outputs a TTL pulse when the Slew Rate Limit is exceeded.

Temperature Set Point Reached - Outputs a high TTL signal while the Temperature Error magnitude is less than the Locked Range and a low TTL signal otherwise.

Interlock - Outputs a high TTL signal when an Interlock Error is active.

LIV Sweep Complete - Outputs a high TTL signal immediately following the LIV Sweep and automatically resets after a short time.

3.3.3 *System Settings Screen*



The System Settings (gear) icon navigates the user to the System Settings screen. This screen displays information specific to the unit and has controls for general settings.

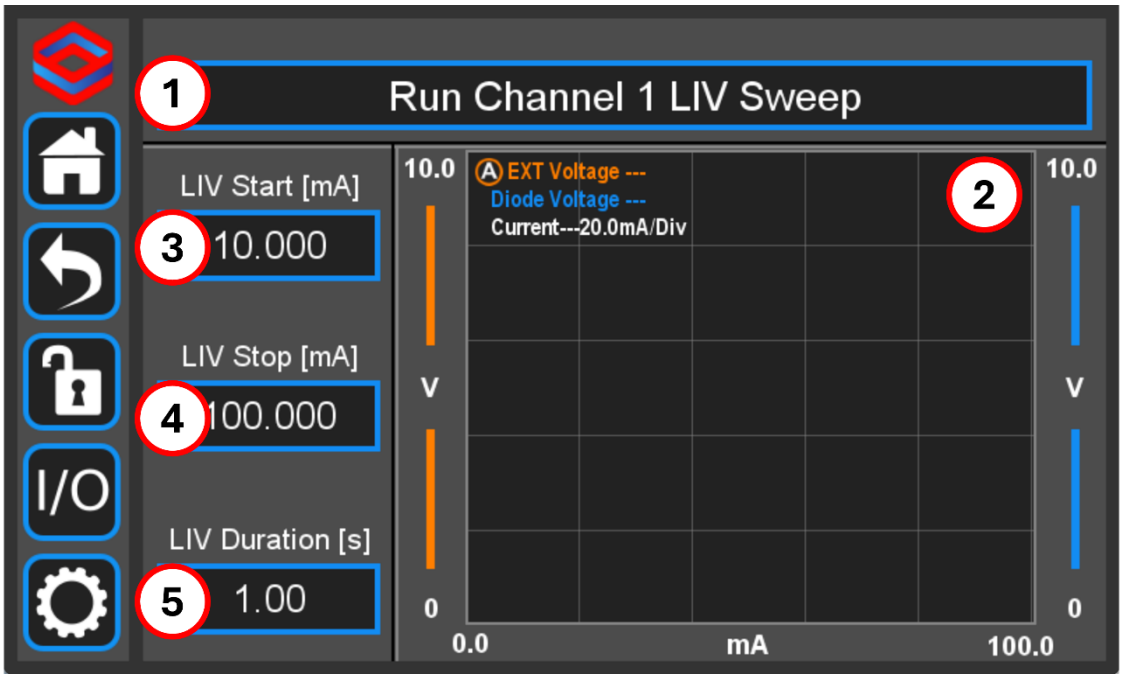
1. Unit Information: Includes the Serial Number (S/N) of the unit, and the system controller (SC), current controller (DC), and temperature controller (QTC) firmware versions.

2. Backlight Level: The arrows adjust the backlight level of the touchscreen display. The Left knob also adjusts the backlight level.

3. Audio Volume: The arrows adjust the volume of the feedback beeps. The Right knob also adjusts the volume. To completely mute the unit, turn the volume down all the way.

4. Input Impedance: Sets the input impedance for the front panel input ports.

3.3.4 *LIV Sweep Screen*



Each channel has a LIV button that navigates to the LIV Sweep screen. This screen enables the operator to quickly generate an LIV curve for their laser that measures the diode laser forward voltage as a function of the current provided to the diode laser.

1. Run LIV Sweep: Tap to start an LIV Sweep. During a sweep the current of the laser ramps from LIV Start current to the LIV Stop current over LIV Duration seconds in steps of 1 mA (SLICE-DLC-200) or 2.5 mA (SLICE-DLC-500). The results of the sweep are shown on the LIV Data Graph.

In order to start an LIV Sweep the laser must first be enabled i.e. in Current On mode. To terminate the sweep for any reason, tap this button again to abort the sweep.

2. LIV Data Graph: After the completion of an LIV sweep the data is plotted on this graph. The blue line shows the voltage across the laser diode plotted against the current applied to the laser diode.

During an LIV Sweep the voltage on Front Panel Selectable Input Port A is measured. The orange line shows this voltage plotted against the current applied to the laser diode.

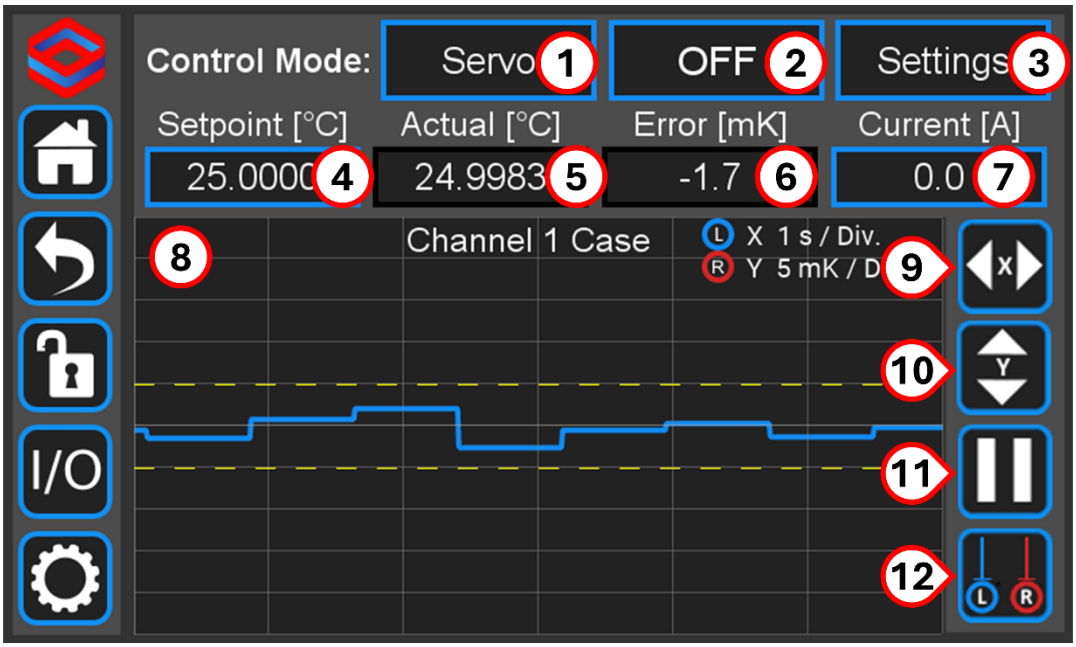
When the SLICE-DLC is connected via USB, the datapoints for both lines are recorded and printed to the PC Terminal at the conclusion of the sweep.

3. LIV Start [mA]: Starting current during the LIV sweep.

4. LIV Stop [mA]: Stopping current during the LIV sweep. The SLICE-DLC will coerce this value to the channel Current Limit if the operator attempts to enter a current greater than this protective limit.

5. LIV Duration [s]: Duration of the LIV sweep.

3.3.5 *Temperature Detail Screen*



Each SLICE-DLC channel has one case temperature controller and one laser temperature controller. Each temperature controller is designed to operate one temperature transducer (e.g. resistive heater or TEC) and one negative temperature coefficient (NTC) thermistor. Collectively the transducer and thermistor are the temperature plant. The settings and parameters for a temperature controller are found on its Temperature Detail screen. An example Temperature Detail screen is shown above.

1. Temperature Control Mode: Selects the temperature control mode. The temperature controller can be run in Servo (closed-loop), Manual (open-loop), and Auto Tune modes. Each of the modes operates as follows:

> *Servo (closed-loop)* - The user decides the setpoint temperature and the system controls the current provided to the heating/cooling element in order to minimize temperature fluctuations on the thermal sensor.
>
> While the laser current is on, the Temperature Control Mode is locked to Servo.
>
> *Manual (open-loop)* - The user directly controls the current to the heating/cooling element, but not the temperature. Laser current cannot be enabled while operating in this mode.
>
> Caution should be exercised while in Manual mode as it is possible to create a thermal runaway condition.
>
> *Auto Tune* - Automated method for determining PID control parameters for operation in Servo mode. See Section 5.1.

2. Current Enable/Disable: Turns on and turns off the current control to the temperature transducer.

3. Settings: Opens the Temperature Detail Settings window which contains several submenus for setting temperature control parameters. See Section 3.4.

4. Setpoint Temperature/Current: Control for the temperature (Servo mode) or current (Manual mode) setpoint.

5. Actual Temperature indicator: Measured temperature of the temperature plant. If the actual temperature exceeds the temperature limits, the background of this indicator will turn red.

6. Temperature Error indicator: Temperature difference between the temperature setpoint and actual temperature. The background color of this box changes depending on the present state of the temperature plant:

Black - The temperature plant is not under active Servo control.

Red - An error has occurred.

Yellow - The temperature plant is under active Servo control and the present Temperature Error magnitude is greater than the Locked Range.

Green - The temperature plant is under active Servo control and the present Temperature Error magnitude is less than the Locked Range.

7. Output Indicator: Tap to cycle through displaying the current through, voltage across and power delivered to the transducer.

8. Temperature Error Graph: Displays a rolling update plot of the Temperature Error as a blue line. The solid white horizontal line at center represents no temperature difference between the Setpoint Temperature and Actual Temperature. The dotted yellow lines are the Locked Range as set in the Temperature Limits Settings window (see Section 3.4.2). If a red dotted line is visible, it indicates a temperature limit as set in the Temp Limits Settings window.

The X and Y-axis scaling are shown in the top right corner of the plot.

Ignore this plot if operating in Manual mode.

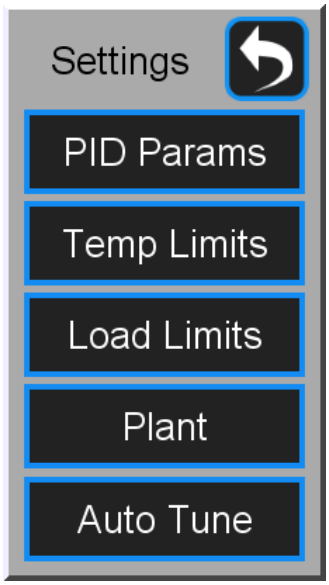
9. Adjust X Scale: Tap to see additional scaling options for the X-axis of the Temperature Error Graph.

10. Adjust Y Scale: Tap to see additional scaling options for the Y-axis of the Temperature Error Graph.

11. Pause/Restart: Tap to pause updates to the Temperature Error Graph. Tap again to resume updates.

12. Cursor Display: While active (white background), two cursors are displayed on the Temperature Error Graph. Turn the Parameter Adjustment Knobs to change the position of the cursors.

3.4 Temperature Detail Settings Window



Each Temperature Detail screen has a Settings button that opens the Temperature Detail Settings window as shown above. The buttons on this window open additional settings windows that are described in this section.

PID Params: Opens the PID Parameters Settings window. See Section 3.4.1.

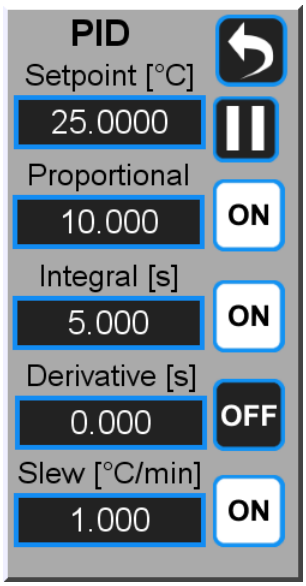
Temp Limits: Opens the Temperature Limits Settings window. See Section 3.4.2.

Load Limits: Opens the Load Limits Settings window. See Section 3.4.3.

Plant: Opens the Plant Settings window. See Section 3.4.4.

Auto Tune: Opens the Auto Tune Results window. See Section 3.4.5.

3.4.1 PID Parameters Settings Window



These parameters control the behavior of the feedback while in Servo (closed-loop) mode. Each of these parameters needs to be tuned specifically for the thermal plant, either manually or with the Auto Tune feature (see Section 3.4.5***).***

Setpoint [°C]: Temperature setpoint for Servo mode. Tap the pause/play button to pause/resume the rolling update on the Temperature Error graph.

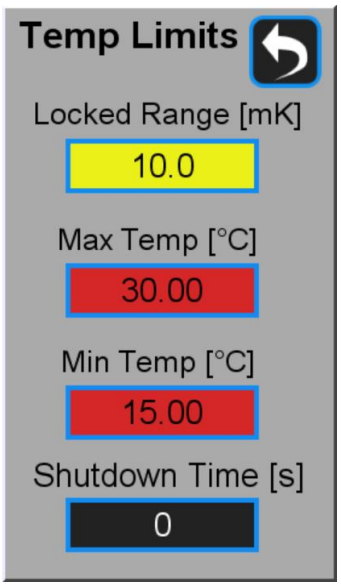
Proportional: Sets the proportional gain. Toggle the on/off button to enable/disable the proportional gain.

Integral [s]: Sets the integral time constant. Toggle the on/off button to enable/disable the integral gain.

Derivative [s]: Sets the derivative time constant. Toggle the on/off button to enable/disable the derivative gain.

Slew [°C/min]: Sets the maximum slew rate for the plant temperature. Toggle the on/off button to enable/disable the maximum slew rate.

3.4.2 *Temperature Limits Settings Window*



These parameters set the relative temperature limits for the Locked Range as well as the absolute temperature limits for the temperature plant.

Locked Range [mK]: An active temperature plant is considered locked when the temperature controller is in Servo mode and the Temperature Error magnitude is less than the Locked Range value. When the temperature is locked, several quick-reference visual indicators across the GUI (e.g. Temperature Error indicators) turn green.

A SLICE-DLC channel can switch to Current On mode only when all active temperature plants are locked.

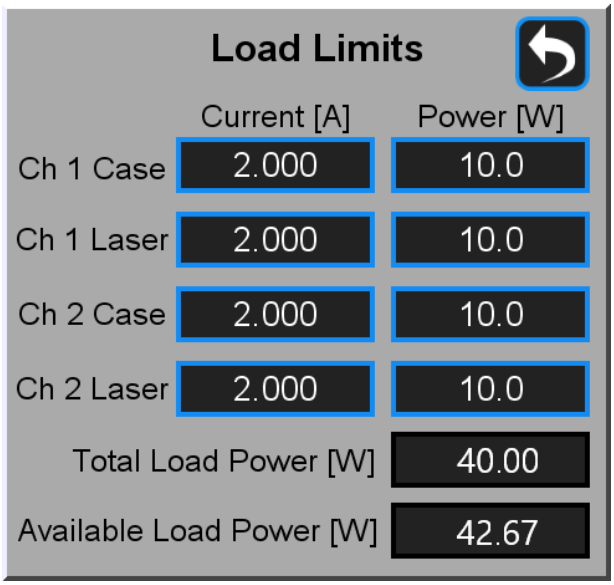
Max Temp [°C]: Sets the maximum operating temperature of the plant. The operator is prevented from adjusting Setpoint Temperature above this value. If Actual Temperature exceeds this value, the Shutdown Timer is activated and several quick-reference visual indicators across the GUI will turn red.

Min Temp [°C]: Sets the minimum operating temperature of the plant. The operator is prevented from adjusting Setpoint Temperature below this value. If Actual Temperature drops below this value, the Shutdown Timer is activated and several quick-reference visual indicators across the GUI will turn red.

Vescent recommends keeping the minimum operating temperature above the dew point for the ambient environment. Water will condense on surfaces that are below the dew point temperature.

Shutdown Time [s]: Sets the delay time between when the temperature exceeds the operating temperature range limits and when an active temperature plant's current is disabled. If the laser is on, current to the laser is also disabled.

3.4.3 *Load Limits Settings Window*



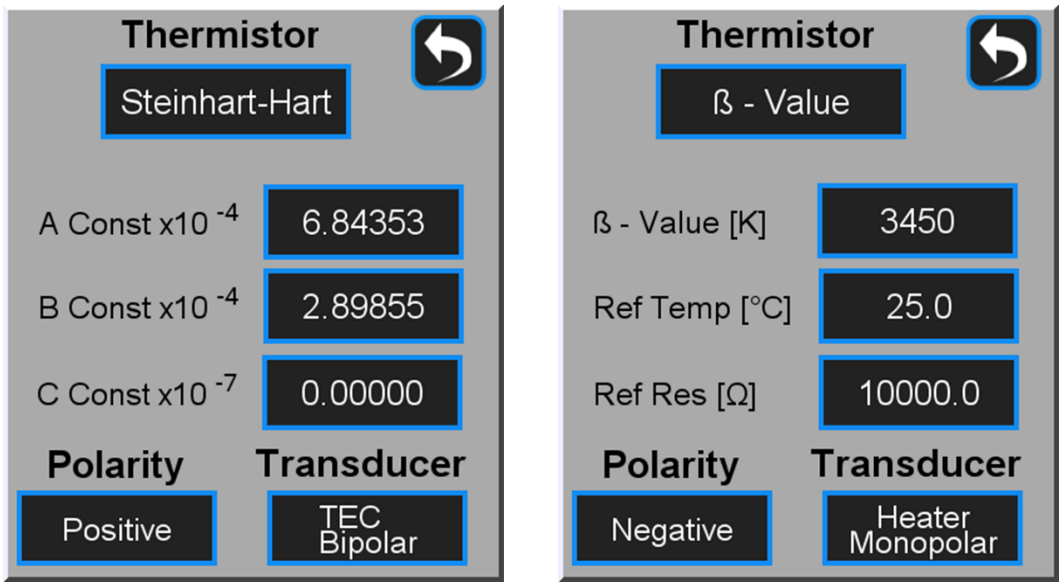
This window allows the operator to limit the control power available to each temperature controller. The first column limits the current to the indicated plant. The second column limits the power to the indicated plant.

Appropriately setting Load Limits protects the heating/cooling element from damage. Review Load Limits when connecting a new temperature plant.

Total Load Power [W]: Sum of power allocated to all temperature controllers.

Available Load Power [W]: Maximum power available to all temperature controllers. When the operator attempts to allocate Total Load Power in excess of Available Load Power, an alert will appear. Tap anywhere to close the alert.

3.4.4 Plant Settings Window



Settings for the NTC thermistor. The layout of the Plant Settings window changes depending on the choice of resistance-temperature transfer function. The two possible layouts are shown above.

Carefully review all thermistor settings whenever connecting a new temperature plant. Incorrect settings will very likely lead to thermal runaway.

Thermistor: Selects the transfer function that is used to calculate the measured temperature.

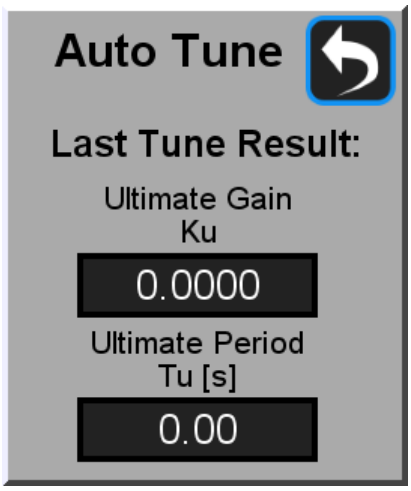
A, B, & C Constants: Steinhart-Hart equation constants.

Beta, Ref Temp, & Ref Res: Beta parameter equation constants.

Polarity: Sets the polarity of the TEC transducer.

Transducer: Sets the temperature transducer type as either monopolar (e.g. a resistive heater) or bipolar (e.g. a thermoelectric cooler (TEC)).

3.4.5 Auto Tune Results Window



Auto Tune performs a Ziegler-Nichols tuning procedure and records the ultimate period of oscillation (Tu) at the ultimate gain (Ku). This window shows the results of the latest completed Auto Tune run, even if the results were not accepted. For more details about Auto Tune see Section 5.1.

4 Getting Started

This section explains typical use of the SLICE-DLC Dual Laser Controller for new users. A brief theory of operation is followed by an example of typical setup and operation with the D2-200 DBR Laser Module. Keep in mind that the following are general guidelines for operating the SLICE-DLC. Exact settings will vary for your application and hardware.

4.1 Theory of Operation

The SLICE-DLC is a dual-channel precision diode laser controller. Each of its two channels offers an ultra-low-noise current source and two high-stability temperature controllers. The SLICE-DLC uses a Libbrecht-Hall current source topology that provides a current noise of <100 pA/√Hz and has extremely low drift. This performance is ideally suited to precision spectroscopy and metrology applications.

A DC-coupled current modulation input enables high-speed (≥10 MHz) feedback control of the laser frequency. An AC-coupled RF input provides modulation of the injection current up to 1 GHz, which is useful for placing sidebands on the laser light for frequency-modulation spectroscopy or Pound-Drever-Hall locking to external reference cavities.

4.2 Typical Setup: Hardware Setup for a D2-200 DBR Laser Module

To connect the SLICE-DLC to a Vescent D2-200 DBR Laser Module, refer to the following instructions:

- Secure the D2-200 to an optical table.
- Place the SLICE-DLC on a stable surface within reach of the D2-200.
- Check that the SLICE-DLC Power switch is in the off position.

- While taking care to avoid ESD damage, remove the 50 Ω SMA terminator from the Current In port on the D2-200 and connect the instruments according to the following table.

SLICE-DLC ports	Cable	D2-200 ports
Channel 1 Current Output	SMA to SMA	Current In
Channel 1 Temperature Control	DB9 to Micro-DB9	Temp Control

- Use the provided AC Power Cord to connect the SLICE-DLC to mains power.
- Flip the SLICE-DLC Power switch on.

4.2.1 Remote Interlock

- Use the Remote Interlock port to implement any required safety interlocks.
    - If interlocks are not required to comply with local safety requirements, place a 50 Ω BNC terminator on the SLICE-DLC Remote Interlock port.

4.3 Typical Setup: Configuring Software for a D2-200 DBR Laser Module

If your SLICE-DLC was purchased with a D2-200, then the SLICE-DLC is shipped with the current and temperature plant parameters already set. Vescent recommends reviewing the parameters discussed in this section to verify the settings are correct.

If the units were purchased separately, configure the current settings by referring to the following sections.

4.3.1 Setting the Diode Current Limit

- Open the Channel 1 Settings window by tapping Channel 1. Open the Channel 1 Settings window by tapping Channel 1.
    - Set the Temperature Control to Laser + Case.
    - In the D2-200 test documentation, find the Maximum Current on the Laser Module table.
    - Set the Current Limit to a value at or below the Maximum Current. This protects the diode from overcurrent damage.

4.3.2 Setting Temperature Plant Parameters

- Navigate to the Channel 1 Case Temperature Detail screen.
- Navigate to the Temperature Limits Settings window (Settings → Plant).
    - Set β - Value to 3380 K.
    - Set Ref Temp to 25 °C.
    - Set Ref Res to 10k Ω.
    - Set Polarity to Negative.
    - Set Transducer to TEC Bipolar.
- Navigate to the Channel 2 Case Temperature Detail screen.

- Set β - Value to 3892 K.
- Set Ref Temp to 25 °C.
- Set Ref Res to 10k Ω.
- Set Polarity to Negative.
- Set Transducer to TEC Bipolar.

4.3.3 Setting Temperature Limits

- Navigate to the Channel 1 Case Temperature Detail screen.
- Navigate to the Temperature Limits Settings window (Settings → Temp Limits).
  - Set the Locked Range to 5 mK.
  - Change the Maximum Temperature to 30 °C.
  - Change the Minimum Temperature to 15 °C or a couple degrees above the dew point, whichever is higher.
  - Set the Shutdown Time to 0 seconds.
- Repeat these instructions for the Channel 1 Laser Temperature Limits.

4.3.4 Setting Load Limits

- Navigate to the Channel 1 Case Temperature Detail screen.
- Navigate to the Temperature Limits Settings window (Settings → Load Limits).
  - Set the Ch 1 Case Current Limit to 1 A.
  - Set the Ch 1 Case Power Limit to 7.5 W.
  - Set the Ch 1 Laser Current Limit to 1 A.
  - Set the Ch 1 Case Power Limit to 7.5 W.

4.3.5 Setting PID Parameters

- Navigate to the Channel 1 Case Temperature Detail screen.
- Navigate to the Temperature Limits Settings window (Settings → PID Params).

  - Set the Temperature Setpoint to 25 °C.
  - Toggle Proportional, Integral, and Derivative filters ON.
  - Toggle Slew Limit OFF.
- Switch the Control Mode to Auto Tune.
  - Tap Next and then Start.
  - Wait for the Auto Tune function to complete. This may take several minutes.
  - Tap Next and then Accept.
- Switch the Control Mode to Servo.
- Turn the Servo on.
  - To further refine PID parameters fine tune the PID Settings (Settings → PID Params)
- Navigate to the Channel 1 Laser Temperature Detail screen.
- Navigate to the Temperature Limits Settings window (Settings → PID Params).
  - In the D2-200 test documentation, find the Laser Temp Setpoint under Spectroscopy Info.
  - Set the Temperature Setpoint to match the Laser Temp Setpoint.
  - Toggle Proportional, Integral, and Derivative filters ON.
  - Toggle Slew Limit OFF.
- Switch the Control Mode to Auto Tune.
  - Tap Next and then Start.
  - Wait for the Auto Tune function to complete. This may take several minutes.
  - Tap Next and then Accept.
- Switch the Control Mode to Servo.
- Turn the Servo on.

- To further refine PID parameters fine tune the PID Settings (Settings → PID Params)

- Turn off both temperature servos.

4.4 Typical Operation: Starting D2-200 Laser Emission

This section discusses typical operation of a SLICE-DLC that has been connected to and configured for a D2-200 DBR Laser Module on Channel 1. The instructions below assume that all the steps in the previous two sections (4.2 & 4.3) have been completed.

To start D2-200 laser emission, follow these instructions.

- Wear appropriate laser safety eyewear.
- Insert the Operator key into the Access Control lock and turn to 'Laser Enable'.
- Flip the SLICE-DLC Power switch on.
- Wait for the front panel GUI to start.
- Tap the Channel 1 Operation Mode button ('CURRENT OFF') and switch to Standby mode.
    - This turns on temperature control for the Case and Laser temperature plants.
    - The Operation Mode button will flash. The Case and Laser Actual Temperature indicators will turn yellow.
    - After a couple minutes, the Case and Laser temperatures will stabilize.
    - The Operation Mode button will stop flashing. The Case and Laser Actual Temperature indicators will turn green.

- Tap the Channel 1 Operation Mode button and switch to Current On mode.
    - The Operation Mode button will flash for five seconds to indicate the current output is enabled and laser emission is possible.
- Touch and hold the Current Setpoint numeric field.
    - Wait for the numeric keypad to appear.
    - Enter a value greater than the threshold current and less than the maximum current for the diode.

- Open the laser shutter and use an IR card or power meter to verify light is emitting from the laser.

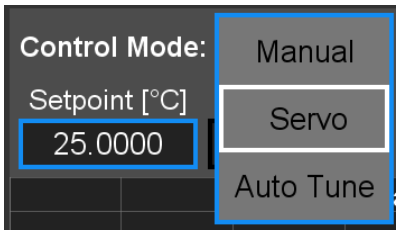
5 Detailed Operations

This section provides additional detail about the operation of the SLICE-DLC.

5.1 Temperature Auto Tune

The Auto Tune feature of the SLICE-DLC performs an automated Ziegler-Nichols tuning procedure to determine the PID temperature tuning parameters for the temperature plant. Perform an Auto Tune by following this procedure:

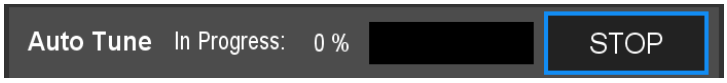
- Set the Operation Mode to Current Off.
- If tuning a laser temperature plant, first turn on the case temperature plant servo and wait for the temperature to stabilize.
- Navigate to the Temperature Detail screen.
- Tap the Temperature Control mode selector.



- Change the Temperature Control mode to Auto Tune.
- Tap Next.

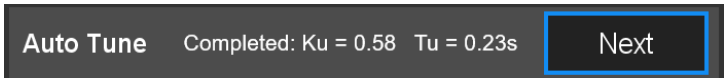
- Select Start.

- Wait for the Auto Tune procedure to reach 100% completion. This may take several minutes.



  - Note, tapping STOP will terminate the Auto Tune early without returning results.

- If the Auto Tune procedure was successful, the calculated values for ultimate gain (Ku) and ultimate period (Tu) are displayed.



  - To observe the updated PID values, tap Next and then Review.

- To accept the updated PID values, tap Next and then Accept.

  - Cancelling the result will exit Auto Tune without setting the PID parameters. If canceled, the results can still be seen on the Auto Tune Results window.

The success of the Ziegler-Nichols tuning method will depend on the design of the temperature plant and the desired filter loop behavior. While this approach will work for most use cases, it is not guaranteed to work for all plants. Additional PID parameter tuning may be necessary. To tune the PID parameters further go to the PID Parameters Settings window (Section 3.4.1).

5.2 Error States

When an error is triggered, the relevant Operation Mode button flashes red and warning text appears on the button. Use the warning text to identify the error from the section titles below.

5.2.1 Interlock Error and the Safety Interlock System

The Safety Interlock System (SIS) is designed to limit laser hazards and reduce risk of injury to human operators and damage to connected equipment. The SIS is designed to satisfy typical laser interlock requirements.

The first element of the SIS is the Access Control lock that restricts use of the SLICE-DLC to authorized operators. The provided Operator keys should only be given to operators who have read this manual and have a working knowledge of laser safety. If a key is removed at any point during operation, the SIS system will be engaged.

The second element of the SIS is the Remote Interlock port that allows the user to install a remote interlock system. If a remote interlock system is not required, install the provided 50 Ω BNC terminator on the port. To operate the SLICE-DLC, the inner and outer conductors of the port must be electrically connected. If this connection is broken, the SIS will be engaged. Proper use of the Remote Interlock requires that the circuit does *not* connect to ground as this may also engage the SIS.

The SLICE-DLC shuts off current to both lasers when the SIS is engaged. Both Operation Mode buttons flash red and their text changes to 'INTERLOCK' to indicate that the SLICE-DLC has entered Interlock mode.

To exit Interlock mode, the cause of the interlock must first be resolved. Then the operator can tap on either Operation Mode button to return to normal operation. If a channel was in Current On mode when the SIS was engaged it will enter Standby mode upon exiting Interlock mode.

5.2.2 Open Circuit/Over Voltage Error

In Current On mode, the current driver attempts to match the setpoint current. If the output voltage required to drive the setpoint current exceeds the capabilities of the SLICE-DLC, then an Open Circuit/Over Voltage error is triggered. This generally occurs when the Current Output port is open.

During an Open Circuit/Over Voltage error, the SLICE-DLC shuts off current to the affected channel. The affected channel's Operation Mode button flashes red and the display text alternates between 'Open Circuit' and 'Voltage Error'.

To exit Open Circuit/Over Voltage mode, tap the flashing Operation Mode button to return the channel to Standby mode. Before continuing check the circuit connected to Current Output for continuity.

5.2.3 Power Limit/Exceeded Error

If the output power exceeds the limits of the SLICE-DLC while in Current On mode, then a Power Limit warning is triggered. Current is shut off to both lasers. Both Operation Mode buttons flash red and their display text alternates between 'Power Limit' and 'Exceeded'.

To exit Power Limit/Exceeded mode, tap on either Operation mode button. A message window appears that displays the approximate power, current, and voltage at the time of the error. Dismissing the window with the OK button will resume normal operation. Before continuing check your system for possible issues.

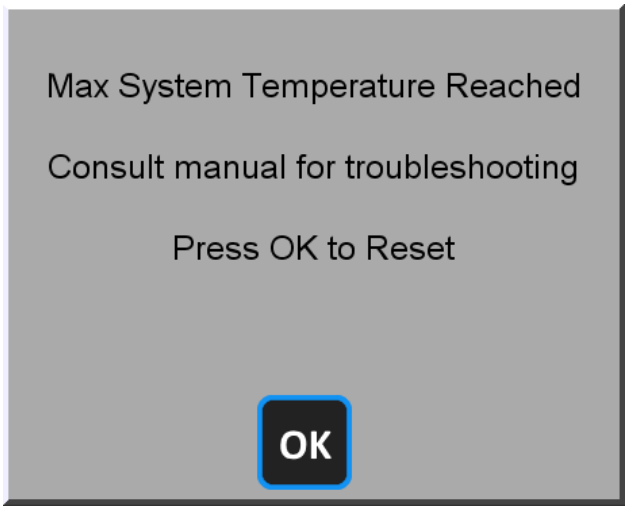
5.2.4 Hardware Temperature/Exceeded Error

If the temperature of the SLICE-DLC exceeds suitable limits (~100 C), then a Hardware Temperature warning is triggered. Current is shut off to the affected laser.

Safely and quickly shut off the SLICE-DLC. If applicable, remove the SLICE-DLC from an extreme temperature environment.

5.2.5 Maximum System Temperature

If the Maximum System Temperature is reached, all channels will return to Current Off mode, and a warning message will display on the touchscreen. The warning will read:



Ensure the SLICE-DLC is properly ventilated, the fan is operating, and the ambient temperature is below 30°C. If applicable, remove the SLICE-DLC from an extreme temperature environment.

6 Remote Operation

This section describes how to set up a remote connection.

6.1 Setting up a Remote Connection

Start by connecting the SLICE-DLC to a computer with a USB-A to USB-B cable. Plug the USB-B connector into the USB port on the SLICE-DLC and the USB-A connector to a free port on the computer.

In Windows systems, the SLICE-DLC will appear as a COM Port. In UNIX-like systems (Linux, MacOS), it will appear as a serial port in the /dev/ folder.

Using a serial terminal application, such as Tera Term or Putty, connect to the SLICE-DLC with the following parameters:

- Speed: 115200
- Data Length: 8-bit
- Parity: None
- Stop Bits: 1
- New Line Receive: AUTO
- New Line Transmit: CR

Test your connection by sending a command, such as "***IDN?"**

You should see a response like: **Vescent,SLICE-DLC-200,065535,S-V1.237,DC-V1.37,QTC-V2.68**

You are now ready to control the SLICE-DLC via serial API commands. For a complete list of commands, see the SLICE-DLC Serial API Guide.

7 Troubleshooting

The following table describes typical issues that may be encountered while using the SLICE-DLC and recommended actions to solve the problems.

Problem	Recommended Actions
Numeric field does not increase when right rotary knob is turned clockwise -or- Numeric field does not decrease when right rotary knob is turned counterclockwise.	Value likely exceeds a software or user-defined limit. For user-defined limits, adjust the limit to increase the parameter range.
SLICE-DLC does not react to Trigger input signal.	Check the polarity of the Trigger input signal.
While in Servo mode, Actual Temperature oscillates around Setpoint Temperature.	Decrease the proportional gain value.
Temperature servo rate is slower than expected.	1. Review PID parameters for the temperature plant 2. Check the Slew Rate Limit. Turn off if appropriate. 3. Check the Load Limit. If appropriate, increase the current and/or power limit.
Temperature oscillates in Servo mode.	Turn down the proportional gain for the temperature plant. Consider performing a PID Auto Tune.
Unable to exit Interlock Error mode.	1. Check the Remote Interlock circuit continuity and the Access Control Lock state. 2. Ensure the Remote Interlock does not have a path to ground. 3. An Operator Key inserted into the Access Control Lock is grounded. Ensure the key does not conduct to the Remote Interlock port.

Unable to switch from STANDBY to CURRENT ON mode.	1. Go to the Home screen and open the Channel Detail window. Check that the Temperature Control Mode matches use case. 2. Check that temperature controller channels are stable to within the Locked Range value (i.e. temperature indicators are green). If not, consider increasing the value of Locked Range (Section 3.4.2).

A Specifications

A.1 Current Driver Performance

Parameter	DLC-200 Value	DLC-500 Value	Units	Comments
Current Channels per Unit	2			
Current Capacity per Channel	200	500	mA	
Minimum Deliverable Current	0		mA	
Polarity	Cathode ground only			
Current Noise Density	≤100	≤200	pA/√Hz	At > 1 kHz
Current Noise	≤50	≤100	nA, rms	Integrated from 10 Hz to 100 kHz
	≤100	≤150		Integrated from 10 Hz to 1 MHz
	≤300	≤500		Integrated from 10 Hz to 10 MHz
Current Setpoint Resolution	≤0.0002	≤0.0005	mA	
Temperature Drift	≤1		µA/°C	
Compliance Voltage	≥6		V	At max current
Servo Input Bandwidth	≥10		MHz	
RF Input Modulation Bandwidth	1		GHz	
LIV Acquisition Range	0 to I_{max}		mA	
LIV Acquisition Time	1 to 100		s	

A.2 Temperature Controller Performance

Parameter	Value	Units	Comments
Total Temp. Channels	4		2 per current channel
Compatible Transducer	TEC or resistive heater		
Compatible Sensor	NTC thermistor		
Temperature Stability	±0.2	mK	w/ properly designed temperature plant
Precision	±0.2	mK	
Control Capacity	20	W	per channel
	40	W	total
Current Capacity	5	A	per temperature plant
Compliance Voltage	≤18	V	automatically adjusted

A.3 Front Panel Connections

Parameter	Value	Units	Comments
Input Impedance	50, 1M	Ω	Configurable
Input Voltage Limit	±10	V	
Output Voltage Range	±10	V	

A.4 Input Voltage

Parameter	Value	Units
Overvoltage Category	2	
Input Line Voltage	100 - 240	VAC
Mains Supply Voltage Fluctuations	±10	%
Frequency	50 - 60	Hz
Phase	1 phase	
Maximum Input Current	2	A
User-Serviceable Fuse	HBC 2.0 A 250 V	

A.5 Environmental

Parameter	Min. Value	Max. Value	Units	Comments
Indoor or Outdoor Use	Indoor Use Only			Dry Location Only
Pollution Degree of Environment		2		
Operating Altitude		10000 (3048)	ft (m)	
Operating Temperature	15	30	°C	
Operating Relative Humidity	20	60	%	Non-condensing
Dew Point		15	°C	

A.6 Model Designation

SLICE-DLC-(AMP)	
AMP	Maximum current in mA per channel

B Additional Resources

QR Code	Details
	Vescent Home vescent.com Additional resources are available at vescent.com

C Service & Maintenance

The SLICE-DLC is designed to be maintenance free. No user-serviceable parts are inside the unit. No further calibrations are necessary for the SLICE-DLC to meet its accuracy specifications over the lifetime of the product. Opening the instrument case voids the warranty and exposes the user to hazardous voltages that are present inside the instrument case.

Cleaning instructions: Do *not* clean outside surfaces of any Vescent products with solvents such as acetone. Front panels on electronics modules may be cleaned with a mild soap and water solution.

For service or repairs:

1. Contact Vescent customer service via telephone at (+1) 303-296-6766, online at vescent.com/support, or via email at info@vescent.com. Customer service will determine if the equipment requires service, repair, calibration, or replacement. Factory office hours are 9:00 am - 5:00 pm MST.

2. If the unit must be returned to Vescent, ask for a Return Merchandise Authorization (RMA) from customer service. **Never send any unit back to Vescent without a completed Return Merchandise Authorization (RMA).**

3. Pack the unit in its original shipping material (if possible) with at least 1 inch of compressible packing material on all sides. Be sure to include an ownership tag and enter a description on the RMA form fully detailing the defect and the conditions under which it was observed.

4. Return the unit, postage prepaid, to Vescent. Do not forget to return a hard copy of the completed RMA form with the unit and write the RMA number on the shipping label. Vescent will refuse and return any package that does not bear an RMA.

5. After repair, the equipment will be returned with a repair report. If the equipment is out of warranty but operates within specifications, a test set-up fee will be charged to the customer. If the equipment is not under warranty, the customer will be invoiced for the cost appearing on the repair report.

6. Vescent is responsible for shipping the unit back to the customer if the unit is under warranty. **Shipping damage is not covered by this warranty,** and shipping insurance, which Vescent recommends, is at the customer's expense.

D Warranty

Vescent hereby warrants to Buyer, that during the applicable Warranty Period (as defined below) the Products will conform to Vescent's published specifications and will be free of defects in materials or workmanship when used, installed and maintained in accordance with Vescent's published specifications. Vescent's sole liability and Buyer's sole and exclusive remedy for breach of warranty shall be limited to, at Vescent's option, either repairing or replacing the defective components of the Product or crediting Buyer for the amount Buyer has paid to Vescent for the applicable Product. Vescent's liability shall apply only to Products which are returned to the factory or authorized repair point, with shipping charges prepaid by Buyer, and which are, after examination, determined to Vescent's satisfaction to be defective due to defects in materials or workmanship. Vescent will only accept returns authorized by a Vescent customer service representative and with a valid RMA number. This warranty does not apply to Products which are designated by Vescent as "Pre-Production Products", e.g. Alpha, Beta or Prototypes or are Products which have been repaired or modified without Vescent's written approval, or subjected to unusual physical, thermal, optical or electrical stress, improper installation or cleaning, misuse, abuse, accident or negligence in use, storage, transportation or handling. The "Warranty Period" during which this warranty applies varies with Product type as follows:

a. For standard Vescent lasers in which a counter is incorporated (i.e. lasers with counters for which Vescent has published a datasheet and which have not been obsoleted by the time of order placement): one (1) year after the date of original shipment or 3,000 hours of use, whichever occurs first;

b. For standard Vescent products other than lasers with counters, (i.e. products for which Vescent has published a datasheet and which have not been obsoleted by the time of order placement): one (1) year after the original shipment;

c. For any other Product including, without limitation, all product types as set forth in sections a. and b. of this clause 5 which are in any way customized, build-to-order, otherwise non-standard and/or are subject of a blanket purchase order: one (1) year after the date of original shipment unless otherwise agreed to in writing on a case by case basis. If, in relation to any Product Vescent offers as an additional purchase option, a warranty period over and above that which is set out in sections b. and c. of this clause 5 ("Extended Warranty") and Buyer exercises such option then the Warranty Period shall be the duration as specified on such Extended Warranty commencing on the date of original shipment. Any Extended Warranty option is only available at the time of and on the same order as the original Product purchase.

d. For any non-warranty Product that has been repaired, Vescent will extend the applicable Warranty Period by sixty (60) calendar days for the specific characteristic of the Product that is repaired by Vescent. Other characteristics of the non-warranty Product will remain uncovered by any warranty.

e. For Products that are discontinued, Vescent's liability shall terminate at the end of the applicable Warranty Period or one (1) year from the date of discontinuity, whichever occurs first.

f. Except for the warranty stated herein and to the extent permitted by applicable law Vescent specifically disclaims any and all warranties, express or implied, including, but not limited to, any warranties of merchantability, fitness for a particular purpose, or noninfringement.

EU Declaration of Conformity

In accordance with EN ISO/IEC 17050-1:2010

This declaration is issued under the sole responsibility of the manufacturer.

Manufacturers Name:	**Vescent Technologies, Inc.**
Manufacturers Address:	14998 W. 6th Ave., Suite 700 Golden, Colorado 80401 U.S.A.
Product:	**SLICE Dual Laser Controller**
Product Model Name:	**SLICE-DLC**

The object of the declaration described above is in conformity with the relevant Union harmonization Legislation:

Application of Council Directives:

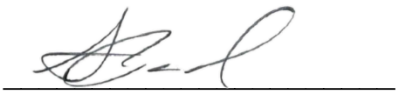
Low Voltage Directive	2014/35/EU
EMC	2014/30/EU
RoHS	2011/65/EU, 2015/853/EU

Standards:

Product Safety	EN 61010-1:2010/A1:2019/AC:2019-04
EMC	BS EN IEC 61326-1:2021 -Immunity BS EN IEC 55011:2016+A2:2021 - Emissions
RoHS2 Technical Documentation	BS EN IEC 63000:2018

We, the undersigned, hereby declare that the equipment specified above conforms to the above Directives and Standards.

Location: Golden, Colorado
Date: 05/01/2025

Signature: 
Full Name: Scott Rommel
Title: COO