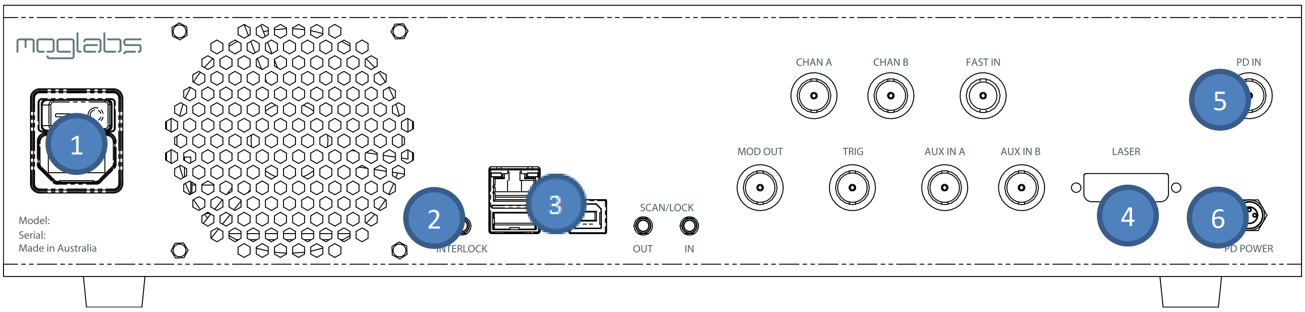
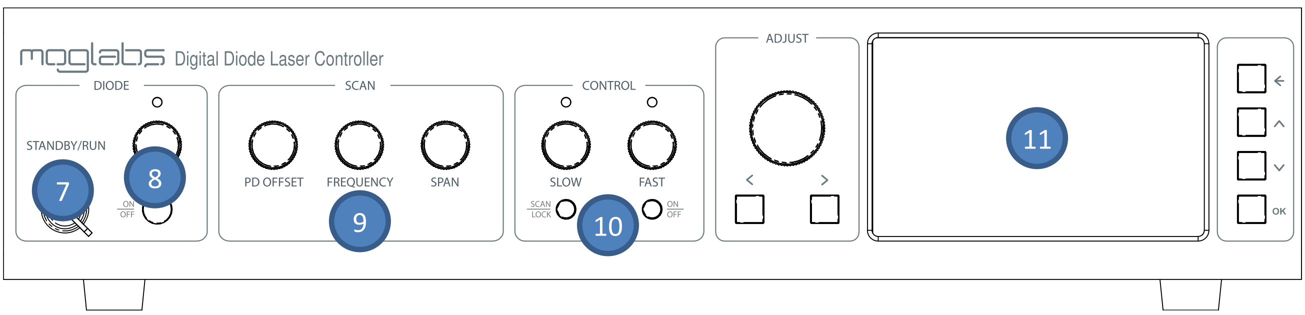
Digital DLC (dDLC) getting started guide

Hardware connections

The rear-panel connectors of the device are shown below. Ensure that the side vents and rear case fan vent are unobstructed at all times.



1. IEC connector to mains power and primary power switch 90 – 250 Vac.
2. Interlock connection. Must be externally **shorted** to enable laser emission per safety requirements. **Do not supply any voltage to this input; use a relay if necessary.**
3. RJ45 Ethernet receptacle and USB 2.0 type-B (printer style) receptacle for PC communication. Do not use the USB type-A connector (beneath the ethernet port); it is reserved for future use.
4. DVI receptacle for connecting to the MOGLabs laser head. **Ensure that the dDLC is powered off when connecting or disconnecting this cable. Do not hotplug the laser.**
5. BNC photodetector input used for locking the laser. Nominally for connection to a MOGLabs PDA003 or PDA030 photodetector. The dDLC is not compatible with legacy MOGLabs PDD photodetectors.
6. M8 connector for powering an external photodetector with ±15V. Pin-compatible with Thorlabs PDA photodetectors.



7. Safety keyswitch and multicolour indicator LED. Must be set to the RUN position to permit laser operation, including remote operation. Turning the key to STANDBY will immediately power-down the laser and piezo driver, however temperature control will continue. When the key is at STANDBY, it cannot be overridden remotely. See Appendix 1 for colour indications.
8. Laser emission control, status LED indicator and current adjustment encoder. Pressing the ON/OFF button toggles the laser emission, as indicated by the LED. See Appendix 1 for colour indications.
9. Encoders to adjust the laser sweep and photodetector offset; all are inactive when laser is locked.

10. Controls and indicators related to laser stabilisation. The dDLC has two servo controllers (SLOW and FAST) which can be operated independently or together. The encoder controls the gain of the associated servo. See Appendix 1 for colour indications.
11. LCD display permitting local operation of the device through a menu system without requiring a computer. Any error messages will be shown on the display.

Booting the device

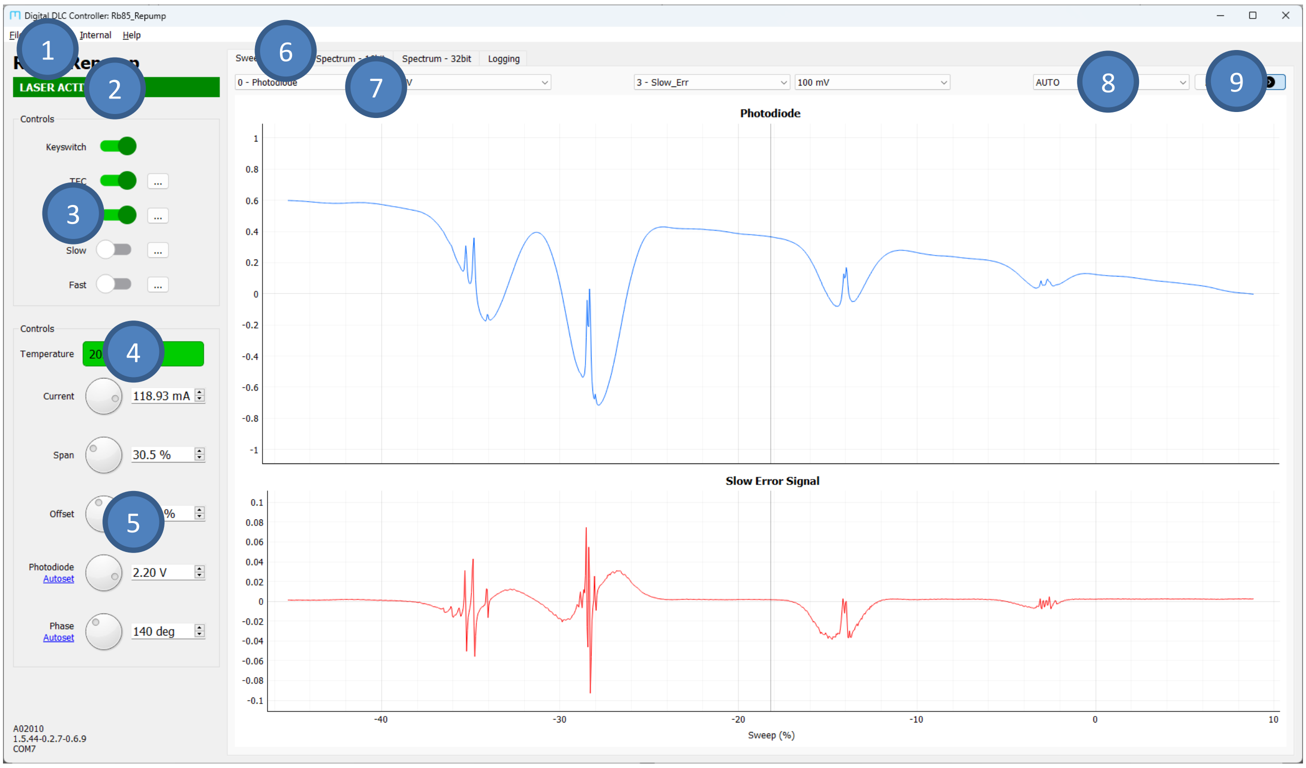
1. Ensure all hardware connections are made as described above. **Do not connect or disconnect the DVI cable to the laser while the device is powered.**
2. Turn on the power switch on the rear of the unit.
3. The LCD display will show that the device boot sequence is in progress.
4. Once the boot is complete, the menu system will be shown on the display and the device will now accept connection from a PC.
5. Set and/or verify both the laser current limit (in the *Laser* submenu) and the TEC setpoint temperature as necessary to **prevent accidentally damaging the laser**.
6. Turn the keyswitch to RUN.
7. Verify that the measured laser temperature starts converging towards the setpoint temperature.
8. Set the laser diode current as desired.
9. Press the ON/OFF button to activate the laser diode.
10. Control the laser as required either using the PC interface, or the menu system (described below).

PC application

The dDLC is designed for remote operation from a PC, either from the provided standalone Windows application or by integration into custom lab control software using a simple command interface. The command language is defined in the product manual.

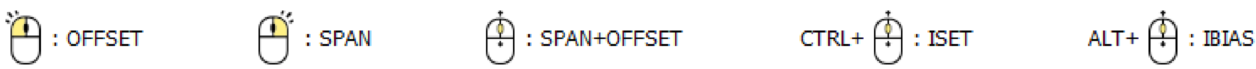
The dDLC app is available from https://www.moglabs.com/products/laser-electronics. Install and start the app, which should then show the *Device discoverer* (see below) which searches for dDLC devices accessible over USB or the local network. **It is strongly recommended to use the Ethernet interface** rather than the USB interface, where possible. Select the intended device and click *Connect*. When multiple dDLCs are available, be sure to double-check the name and/or serial number of the device when connecting.

The application provides control of the device features, as well as an integrated oscilloscope for adjusting the laser scan parameters and operating the feedback servos. The oscilloscope displays the measured photodetector voltage and the error signal against time, for identifying and locking to features of interest. The oscilloscope shows one duration of the laser sweep by default, although different timebases and diagnostic channels can be selected.



1. Device identification – the serial number by default, but can be assigned by double-clicking.
2. System status indicator, e.g. whether the laser is active or if a problem has been detected.
3. Primary function controls, permitting enabling or disabling of core functionality. Click the "…" button adjacent to each switch to bring up the associated additional settings dialog box.
4. Laser temperature indicator. Red indicates the temperature is greater than 1°C from the setpoint, and green when it is within 0.1°C.
5. Virtual encoders provide a mechanism for smoothly adjusting parameters. Click and drag the dials to adjust the values with fine control, or type a number in the associated box. Some parameters have an *autoset* option.
6. Tabs for accessing different application functionality, such as spectrum analysis or logging.
7. Drop-down boxes for selecting the channels shown in the oscilloscope feature.
8. Timebase for the oscilloscope feature. Setting to AUTO will display one sweep of the scan.
9. Oscilloscope mode controls. The arrow button controls the acquisition, alternating between *active* and *paused*.

The oscilloscope supports mouse interactions and gestures. Clicking and dragging adjusts the *OFFSET* and *SPAN* of the sweep depending on the mouse button.



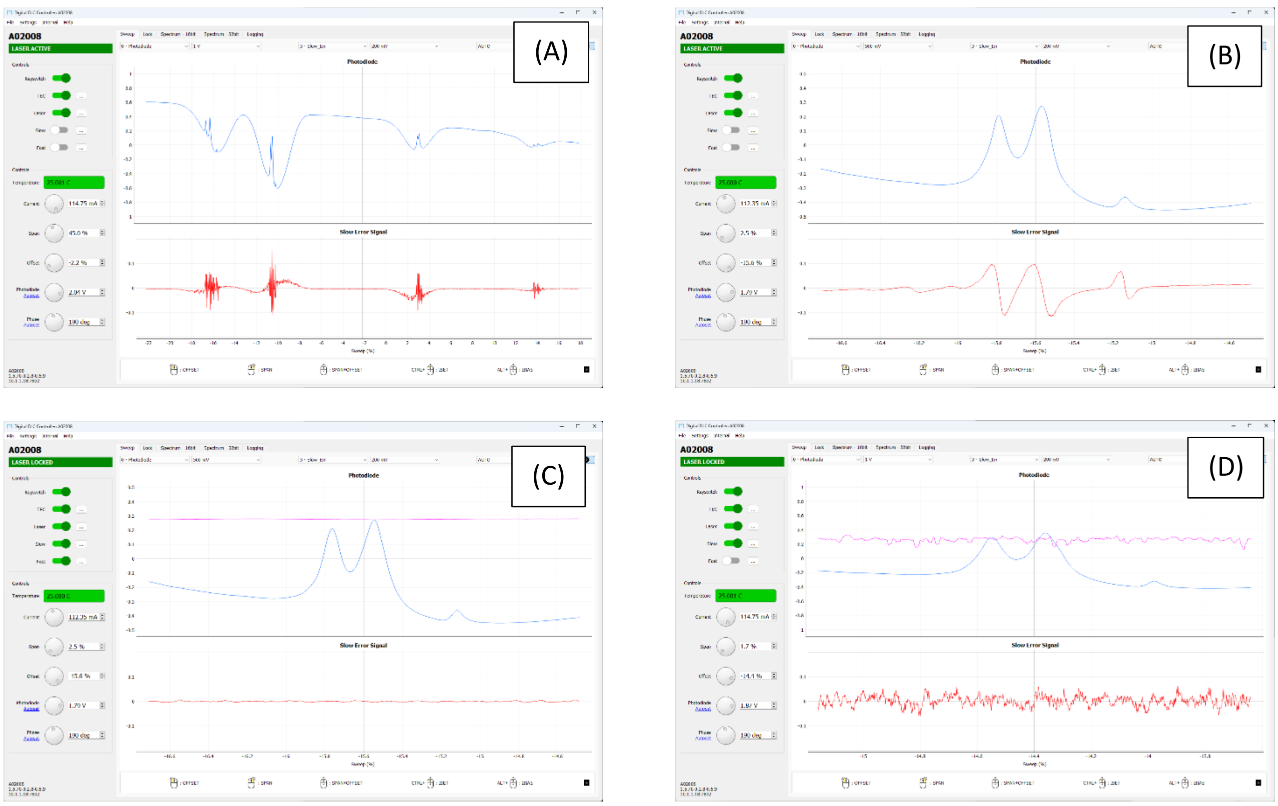
Similarly, using the mouse wheel adjusts both simultaneously to zoom in or zoom out from the position of the mouse cursor. Combining the mouse wheel with the CTRL or ALT keys allows directly adjusting the setpoint current or scan bias while looking at the sweep.

Double-clicking within the oscilloscope display will toggle whether the laser is locked. Double-clicking to activate the lock will engage the lock at the mouse position, allowing a transition of interest to be selected.

Locking using the PC app

The following is a rough guide for frequency stabilising (locking) the laser using AC-locking to a saturated absorption spectroscopy cell ("sat-abs") as an example. See your laser manual for information about adjusting the bias current to achieve a wide modehop-free scan-range.

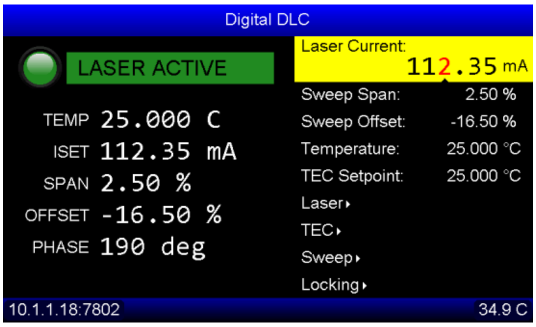
a) Adjust diode current to achieve required optical power
b) Increase the SPAN (e.g. to 25%) to see spectral features of interest, adjusting current to achieve continuous scans without mode-hops
c) Reduce SPAN to zoom in on the desired locking feature
d) Adjust master gain so that error signal amplitude is about 100mV
e) Adjust phase to optimise error signal for largest negative slope at the locking point
f) Adjust the error offset to adjust the zero-crossing (if required)
g) Press SLOW to lock. The unlocked photodetector signal trace (blue) maintains the last photodetector trace before the piezo is set to the lock point, enabling comparison against the locked photodetector signal (magenta). If the DC value does not match the intended setpoint, try inverting the slow polarity and/or decreasing the slow master gain.
h) Increase the slow gain *Kp* until the amplitude of error signal starts increasing, then reduce by 10%.
i) Engage the FAST lock and verify the DC photodetector signal (magenta) does not jump. If it changes significantly, try inverting the fast polarity and/or fast master gain.
j) Increase the fast gain *Kp* until the onset of oscillation, then reduce by 10%
k) If required, further optimisation can be achieved using the spectrum analyser mode



Typical satabs spectra at wide span (A) and narrow span (B) with optimised phase. Engaging the lock stabilises to the peak (C) and increasing the gain too far yields oscillation (D).

Front panel controls

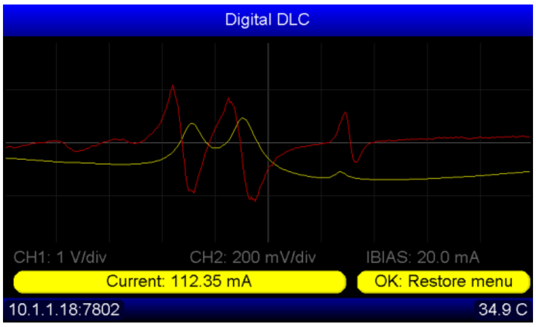
The dDLC can operate as a standalone device using the front panel display for intuitive control of the laser and controller functions. The left-hand side of the display shows a readout of the current device status and the right-hand side provides an interactive menu system.

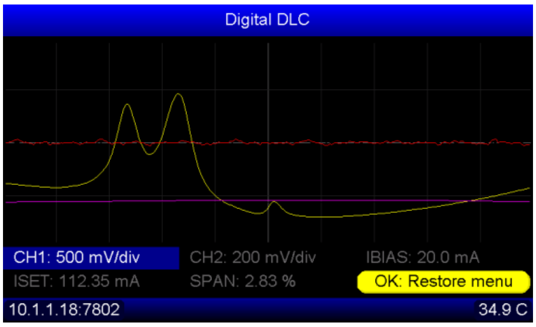


The up/down buttons select between menu items, OK enters a submenu and ← returns to the parent menu. Turning the ADJUST knob modifies the selected value, and the left/right buttons change the digit to be adjusted (shown in red).

Front-panel *Oscilloscope* mode

The front panel includes a simple integrated oscilloscope function similar to the Windows app. Pressing the ← button from the menu system root page will display the oscilloscope. The photodetector signal is shown in yellow and the error signal in red. When the laser is locked the last scan (yellow trace) is frozen and the active capture is shown in magenta for comparing against the expected lock point.





Several parameters can be adjusted while in oscilloscope mode without needing to re-enter the menu system. Press the < or > buttons to select a parameter (highlighted with a blue background), and then turn the ADJUST knob to change it. Turning any of the other front-panel knobs will display a yellow popup showing the value of the modified parameter.

Spectrum analysis using the PC app

The PC application includes a spectral noise analysis tool for optimising the performance of feedback servos. The goal of the servos is to suppress noise in the error signal, which is a measure of the laser frequency stability. In general, increasing the gain of the controllers suppresses noise at low frequencies at the expense of increasing noise at high frequencies. Increasing the gain too far will destabilise the controller, which can be detected as a rising peak (known as a "Bode bump") in the noise spectrum.

The above screenshot shows the desired behaviour with the SLOW servo activated at low gain (blue). Increasing the SLOW *Kp* suppresses noise up to a few kHz (green). Subsequently engaging the fast controller and also optimising FAST *Kp* further suppresses noise at low frequencies (red). Frequency noise increases at the Bode bump, indicating the approximate servo bandwidth of the combination of frequency discriminator, controller, and control actuator, in this case around 20 kHz.

Note that changing the master gain affects the error signal used for the spectrum analysis, which should be kept constant while considering the spectrum. In most cases *Ki* can be left at the default value; adjusting it is recommended only for advanced users familiar with PID optimisation.

Appendix 1: Status Indicators

Keyswitch Standy/Run

SYSTEM INDICATOR	MEANING
GREEN	Keyswitch is set to RUN and no error has been detected
YELLOW	Device is booting, keyswitch is set to STANDBY
RED	System error – check display for an error message
CYAN	Keyswitch has been remotely disabled
BLUE	System is disabled, such as during firmware update

Laser diode

LASER INDICATOR	MEANING
OFF	Laser is disabled in hardware (e.g. by keyswitch or interlock)
GREEN	Laser is active and appropriate precautions should be taken
YELLOW	Laser is inactive, but ready to be enabled
RED	An issue with has been detected with the laser – check display
BLUE	System is disabled

Frequency Locking

LOCK INDICATOR	MEANING
OFF	Servo is inactive
GREEN	Servo is actively locked
YELLOW	Servo exhibited anomalous behaviour
RED	Servo has unlocked
BLUE	Servo has unlocked and is in the process of relocking

Appendix 2: Troubleshooting/FAQ

1. **Measured temperature is always shown as "6 C"**
   Indicates a problem measuring the thermistor on the laser head. Power-off the dDLC and reconnect the DVI cable. If the issue persists, verify the thermistor connection to the laser headboard.
2. **Laser is "disabled by interlock" or display shows red "INTERLOCK" message**
   Confirm that the rear-panel interlock connector is **shorted** and the laser headboard interlock is not accidentally open-circuit.
3. **Keyswitch indicator is red and display shows "STANDBY" despite being set to "RUN"**
   The keyswitch must be toggled at boot, and to clear certain error states. Either physically toggle the keyswitch or click the button in the PC app to override and reset it.

4. **Laser does not emit light despite being turned on**
   Check the measured laser current matches the setpoint current, and that the measured laser voltage in nonzero (from the *Laser* menu/dialog). Confirm the interlock status and whether the laser has dropped out of flash, or accidentally killed by not setting I_{LIM}.
5. **TEC does not control temperature**
   Check TEC polarity – if the TEC is heating instead of cooling, try inverting the TEC polarity. Confirm that thermistor is well-seated in the laser head.
6. **Device does not work over Ethernet**
   The dDLC attempts to automatically obtain an IP address via DHCP. If this fails, please verify any requirements with your network administrator. If required, a static IP can be allocated using the menu system via System → Ethernet. Ensure to select *Restart Ethernet* and press OK once appropriate settings have been configured.
7. **Application states "Device is busy with another connection"**
   At this stage the dDLC only supports an active connection with the application from one PC. Please close the application on the other PC.
8. **Display shows an error message**
   Please take a photo of the display and email it to support@moglabs.com for further assistance