1550 Laser Diode Driver Kirdy

Features

- 307.2 mA max output current, 20-bit resolution
- Low noise current source, 300 pA/rtHz @ 1 kHz
- Modulation input with DC-18 MHz bandwidth
- Monitor photodiode and LD protection
- Temperature controller with sub-mK stability
- Full digital control over Ethernet
- Bias-tee for RF modulation input

Figure 1: Kirdy card photo

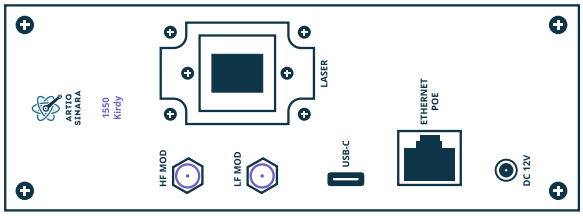

Figure 2: Kirdy front panel

Applications

- Spectroscopy
- Laser cooling
- Atomic clocks
- Suitable for use with adapter and preinstalled laser assembly or with external laser heads

General Description

The 1550 Laser Diode Driver Kirdy is an 8hp EEM module, part of the Sinara open hardware family. It serves as a precision laser diode driver, featuring a low-noise current source, low- and high-frequency modulation inputs, and full digital control over Ethernet. Soft start, laser power monitoring with a user-defined trip point, overtemperature protection, and a protection relay minimize the risk of damage to the laser diode.

1550 Kirdy supports both low-frequency modulation, suitable for laser locks and linewidth reduction, as well as RF modulation injected directly into the diode, typically to add sidebands to the optical output and implement stabilization schemes such as Pound-Drever-Hall and modulation transfer spectroscopy.

Source

1550 Laser Diode Driver Kirdy, like all the Sinara hardware family, is open-source hardware, and design files (schematics, PCB layouts, BOMs) can be found in detail at the repository https://git.m-labs.hk/sinara-hw/kirdy. The associated adapter can be found at the repository https://git.m-labs.hk/sinara-hw/kirdyAdapter/src/branch/master.

Electrical Specifications

These specifications are based upon various information from the Sinara hardware repository[1].

Table 1: Recommended Operating Conditions

Parameter	Min.	Typ.	Max.	Unit	Conditions
Input power					
Voltage		12		V	
Current			2.0	A	
LF modulation input†					
Voltage	-1		1	V	
Bandwidth (-3 dB)		18		MHz	
Impedance		50 / 43.3k		Ω	Termination switch on/off

1550 Kirdy supports Power-over-Ethernet, PoE+ (802.3at) and PoE (802.3af) standards. Alternatively, power can be provided via input in front panel. When using PoE, TEC output current should be limited to ±2A.

Table 2: Electrical Specifications

Parameter	Min.	Typ.	Max.	Unit	Conditions
Photodiode†					
Photocurrent range	0		3.0	mA	
Photocurrent resolution		0.8		µA	
Bandwidth (-3 dB)		500		Hz	
Laser diode current driver					
Resolution		0.292		µA	
Control range			307.2	mA	
Current limit		319		mA	
Compliance	4.928			V	
Current noise @ 1 kHz			300	pA/rtHz	300 mA DC bias, 10 Ω load
RMS noise @ 10 Hz-1 MHz			300	nA	300 mA DC bias, 10 Ω load
Temp. coefficient	-1		+1	ppm/°C	50 mA DC bias, tested 43-56 °C

†Circuit may be damaged if photodiode input current exceeds 3.0 mA. It is possible to modify the circuit and reprogram the photodiode current monitor range in the Kirdy driver.

[1] https://git.m-labs.hk/sinara-hw/kirdy/

Table 3: Electrical Specifications, cont.

Parameter	Min.	Typ.	Max.	Unit	Conditions
PID temperature controller					
Stability		1		mK	with Kirdy adapter, copper plate; subject to operating conditions
TEC output					
Resolution		22.9		µA	
Control range	-3.0		3.0	A	12 V power, active cooling
	-2.0		2.0	A	with PoE (802.3af)
Compliance		4.3		V	
Voltage reading resolution		3.22		mV	
Current reading resolution		2.9		mA	
TEC limits					
Voltage limit range	0		4.3	V	
Voltage limit resolution		3.14		mV	
Current limit range	-3.0		3.0	A	
Current limit resolution		1.57		mA	
NTC thermistor sensor					
Resolution		0.01		mK	10 kΩ, B-constant 3950K, T_0 25°C
Sampling rate		16.67	>1000	Hz	Subject to operating conditions

Modulation inputs

1550 Kirdy supports two additional modulation inputs via SMA in the front panel, respectively `HF MOD` for high-frequency and `LF MOD` for low-frequency. LF modulation input can accept DC input to impose a DC offset on the output current. HF modulation input is AC-coupled and acts as a bias-tee.

The relationship of modulation input to output current is governed by the following equation:

$$I_L = max(I_D + U_{in} \cdot G_{mod}, 0)$$

where I_L is the laser diode current, I_D is the laser diode driver output current, U_{in} is the input voltage, and G_{mod} is the modulation gain. Care should be taken that I_L always remains under the current limit. Otherwise, overcurrent protection may be triggered.

Modulation gain is adjustable by DIP switch in top right of board. *Exactly one* DIP switch should be enabled at all times. Enabling zero DIP switches may cause serious damage to the laser diode. Other configurations (multiple switches enabled) are invalid, but will not cause damage.

Switch	Setting
1	25 mA/V
2	2.5 mA/V
3	0.25 mA/V

Table 4: DIP switch settings

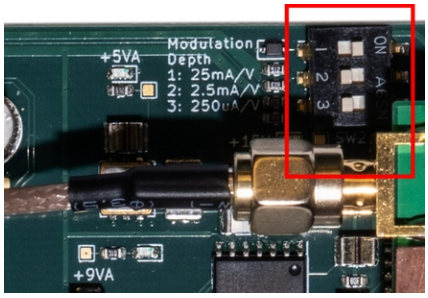

Figure 3: Position of DIP switch

Configuring termination

LF modulation input termination must be configured by setting a physical switch on the board. The termination DIP switch is found at the upper left part of the board, behind the front panel. Turning this switch on adds a 50 Ω termination to the LF modulation input. Without the switch, the input impedance is approximately 43.4k Ω.

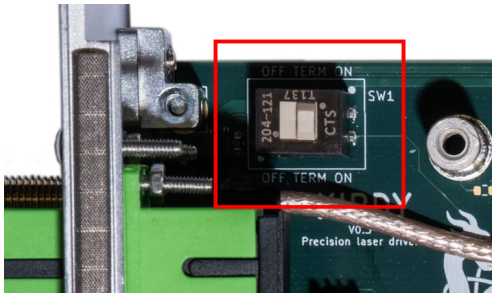

Figure 4: Position of DIP switch

Adapter and Laser Options

An optional adapter allows compact lasers in butterfly packages to be mounted directly onto 1550 Kirdy, with a fibre-optic output in the front panel. Multiple single-frequency narrow-linewidth lasers are currently available as preinstalled options for order.

Alternatively, Kirdy accepts laser signals broken out to the front panel and is suitable for use in driving external laser heads, including commercial or custom ECDLs (with additional piezo driver not included with Kirdy) or injection-locked Fabry-Perot diodes.

Firmware and driver

1550 Kirdy features front panel Ethernet and USB-C. Either DFU or OpenOCD can be used to flash firmware; OpenOCD however requires a JTAG adapter.

Using M-Labs firmware, communication with a host system is performed over Ethernet/TCP in the form of pre-defined JSON objects. A Python driver implementing these can be found in the Kirdy firmware repo, hosted at `https://git.m-labs.hk/M-Labs/kirdy/`, under `pykirdy`. See inline documentation for descriptions of particular functions and implemented capabilities.

This driver may be used directly or through the Kirdy GUI, hosted in the same repo. To start the GUI, run the file `pykirdy/pykirdy/kirdy_qt.py`, or install it using `pykirdy/pyproject.toml`. Users familiar with the Nix package manager through ARTIQ or for other reasons may note that the root of the repository includes a `flake.nix` with an appropriate development shell (e.g. `nix develop`) including all dependencies.

Examples in the `pykirdy` folder further demonstrate the use of the Kirdy driver, as well as the PID autotune temperature regulation feature.

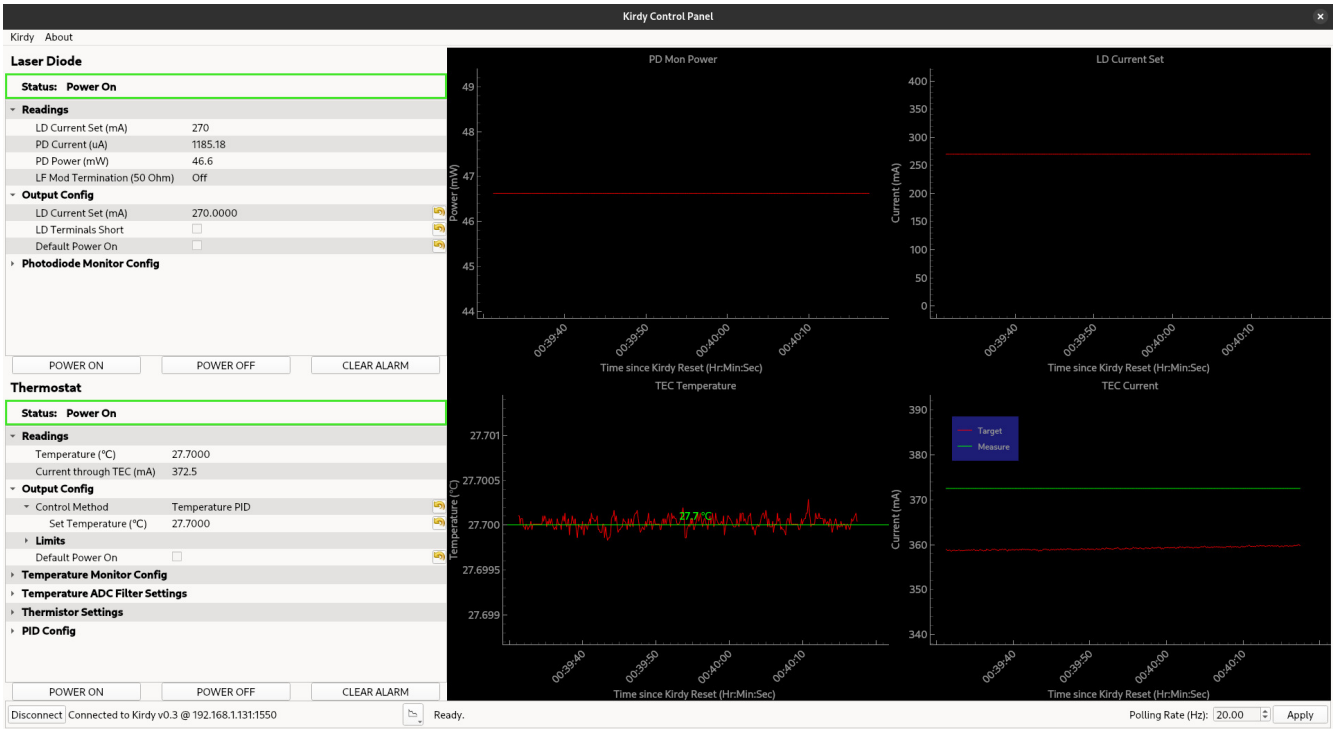

Figure 5: Kirdy driver GUI

To first connect to Kirdy, use the "Connect" button in the lower right corner and the IP address and port number assigned to Kirdy. By default, these are `192.168.1.128` and `1550` respectively. They can also be changed using commands supplied by the Python driver.

Ordering Information

To order, please visit `https://m-labs.hk` and choose 1550 Laser Diode Driver Kirdy in the ARTIQ/Sinara hardware selection tool. Cards can be ordered as part of a fully-featured ARTIQ/Sinara crate or standalone through the 'Spare cards' option. Otherwise, orders can also be made by writing directly to `mailto:sales@m-labs.hk`.

Kirdy can ship with a single-frequency narrow-linewidth laser pre-mounted and configured. Current wavelength options include 1270-1610 nm and 633-1064 nm. See the M-Labs hardware selection tool or contact M-Labs for prices and details.

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