ColorDRIVE one

1ch laser diode driver with integrated TEC driver

Datasheet
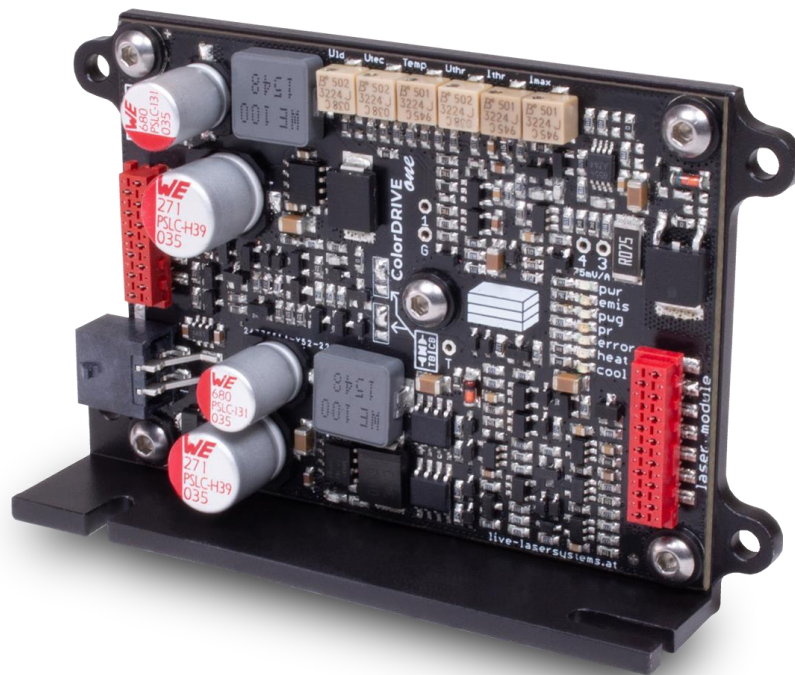
5A Laser Driver, with DC-DC converters and 5A TEC driver

Features

- 6V to 28V operating voltage
- 1V to 23V laser diode compliance Voltage
- Very high efficiency of up to 95,5%(1) due to integrated step-down converters for the laser and TEC driver
- Up to 230W output power in a tiny form factor of only 91x60x19mm
- 1,2Mhz -3db modulation frequency (2)
- 600ns rise 500ns fall time (2)
- Capable of driving multiple diodes in series. For example: 5 blue NDB7Y75 laser diodes or 10 single-mode red laser diodes
- Integrated TEC driver with heating and cooling capabilities
- Standard NTC 10k Beta: 3977 compatible
- 3,3-23,5V @ 5A TEC drive capability per driver
- Power reduction feature reduces laser output at excessive and subnormal temperatures
- fully ColorBUS compatible
- Dual Voltage Technology (DVT)
- TEC booster compatible (240W/48V @ 5A per booster)

(1) Measured at 12V input , 9V ULD (2x NDB7Y75) with 2A diode current.
(2) Measured with square wave at 0,5A Ithr and 3,5A Imax with NDB7Y75 as load.

Applications

- LIVE Lasersystems Sparrow OEM laser module series
- Laser display systems
- Industrial positioning systems
- DNA sequencing
- Optogenetics
- Other laser applications

Description

ColorDRIVE one is designed to be efficient and versatile.
It supports a high operation voltage and offers stable and fast current regulation in a small, easy to integrate form factor.
ColorDRIVE one offers 115W maximum output power for laser diodes and 115W for TECs. The TEC power can be extended to 1100W with the use of LIVE Lasersystems TecBOOSTER technology.
TecBOOSTERs enable to drive up to 48V @ 4x 5A TECs with minimal cost and maximum efficiency.
A temperature good output (power reduction) enables an easy integration of the driver in any system. It offers the possibility to check if the TEC driver has reached the desired temperature e.g., if everything is working as it should. The driver also features a NTC sensor error detection.
The drivers are fully compatible with LIVE Lasersystems' ColorBUS system.
ColorBUS makes it possible to connect everything in a tidy way and furthermore uses the power reduction (PR) output (temp ok) to command a reduced drive current from ColorDRIVEs to protect the laser diodes if a TEC should fail.

Information

LIVE Lasersystems designs and manufactures every driver in Austria to meet its high standards.
Drivers are shipped ready to use.
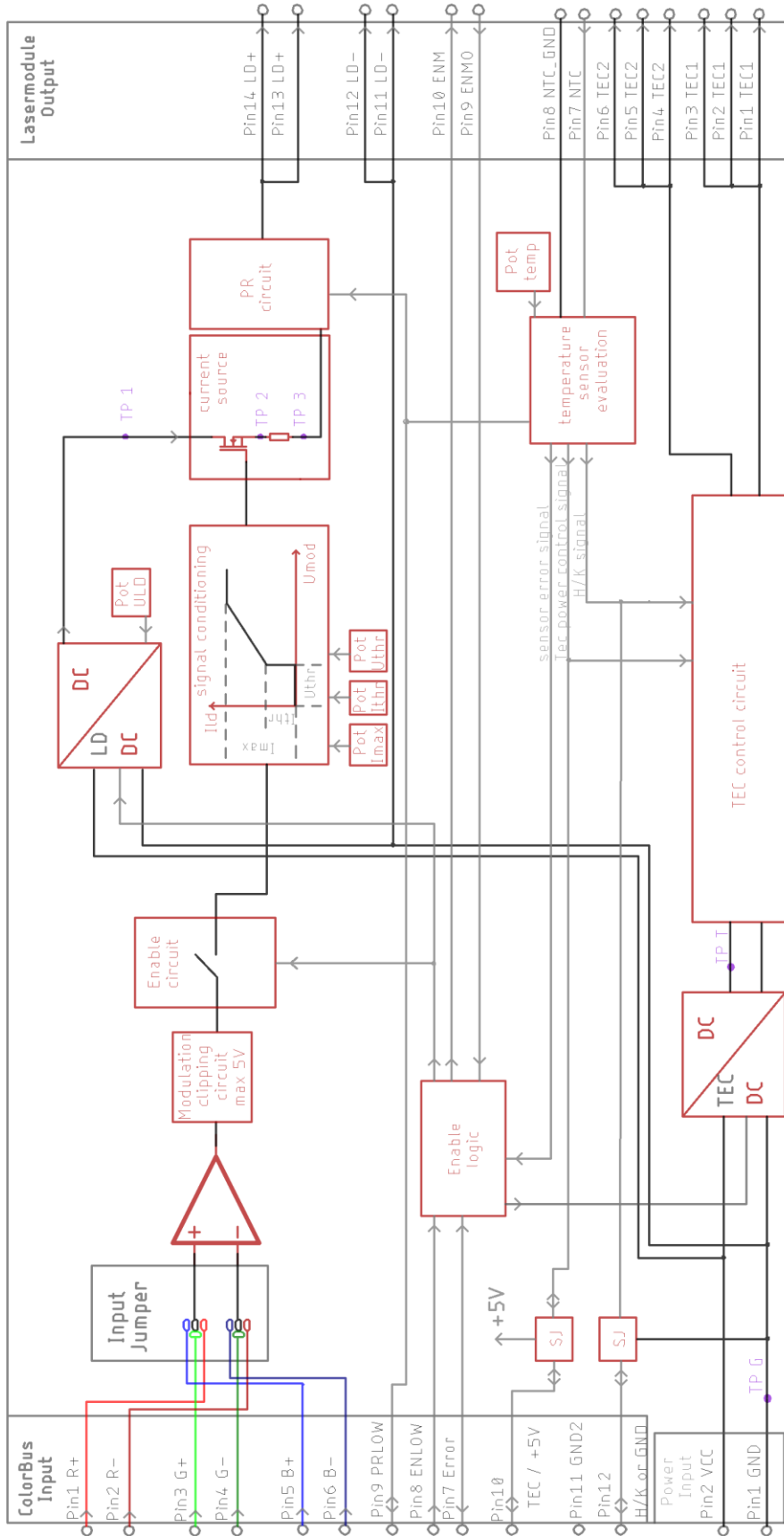ColorDRIVE comes with all needed connectors.
Breakout boards for input and output are available separately.
Plug and play: Works with LIVE Lasersystems laser modules.
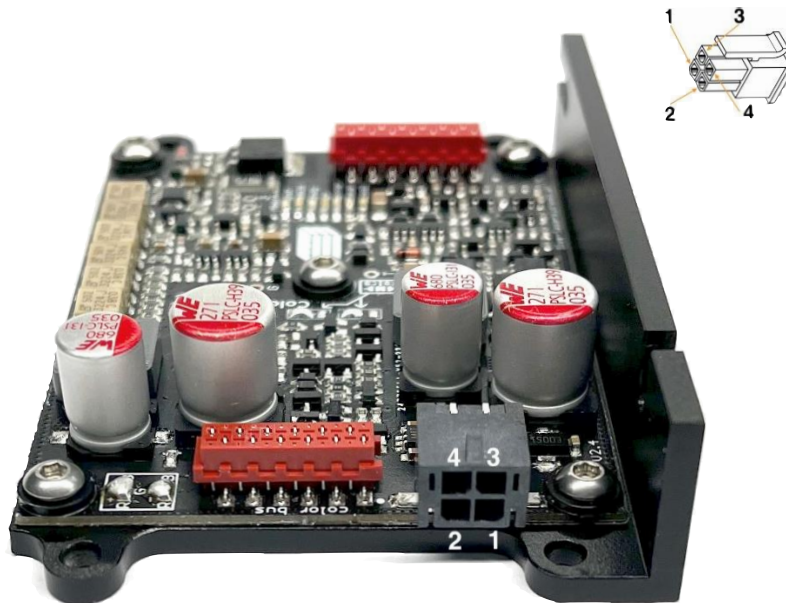For more information, please contact LIVE Lasersystems.

Functional Block Diagram

Lasermodule Output

Pin14 LD+
Pin13 LD+
Pin12 LD-
Pin11 LD-
Pin10 ENM
Pin9 ENM0
Pin8 NTC_GND
Pin7 NTC
Pin6 TEC2
Pin5 TEC2
Pin4 TEC2
Pin3 TEC1
Pin2 TEC1
Pin1 TEC1

PR circuit

current source

TP 1
TP 2
TP 3

Pot temp

temperature sensor evaluation

Pot ULD

DC LD DC

Ild signal conditioning

Umod

Pot Uthr
Uthr
Pot Ithr
Ithr
Pot Imax
Imax

sensor error signal
Tec power control signal
H/K signal

TEC control circuit

Enable circuit

TP T

Modulation clipping circuit max 5V

DC TEC DC

Enable logic

+5V

Input Jumper

SJ
SJ

TP G

ColorBus Input

Pin1 R+
Pin2 R-
Pin3 G+
Pin4 G-
Pin5 B+
Pin6 B-
Pin9 PRLOW
Pin8 ENLOW
Pin7 Error
Pin10
TEC / +5V
Pin11 GND2
Pin12
H/K or GND

Power Input
Pin2 VCC
Pin1 GND

Power Input Connector

Pin		I/O	Description
No.	Name		
1	GND (-)	I	Negative supply voltage, 0.25 - 0.5mm² / 20 - 30 AWG conductors
2	GND (-)	I	Negative supply voltage, 0.25 - 0.5mm² / 20 - 30 AWG conductors
3	VCC (+)	I	Positive supply voltage, 0.25 - 0.5mm² / 20 - 30 AWG conductors
4	VCC (+)	I	Positive supply voltage, 0.25 - 0.5mm² / 20 - 30 AWG conductors

Power Input Considerations

The power supply input connector uses 4 Pin WR-MPC3 dual row connectors. Use both connector rows if the input current exceeds 5A total.

Every ColorDRIVE one ships with pre-crimped cables that feature black VCC and black GND wires. These wires are 0.5mm² / 20 AWG with a length of 25cm.

LIVE Lasersystems also offers raw terminals and receptacles for applications that need custom wire harnesses. If you need different wire lengths, LIVE Lasersystems is happy to customize the length according to your needs.

To release the connector, push down the black plastic lever on the receptacle and pull it out. The PCB has markings for negative and positive connections. You need to use low impedance connections e.g., short wires that can withstand the current of your application. The driver has limited reverse polarity and surge protection. The voltage surge protection is only useful against transients, so please make sure you use power supplies of
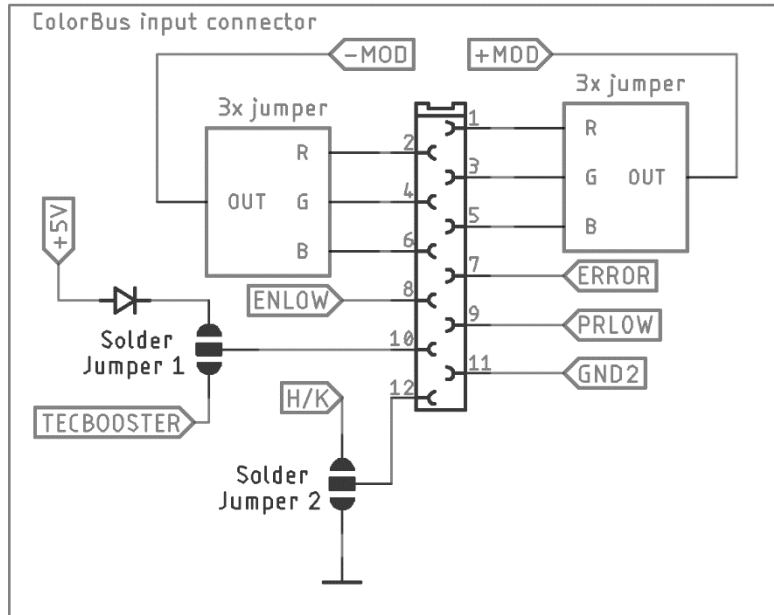
good quality from a reputable brand only. You can also contact LIVE Lasersystems for advice on choosing the right power supply for your application.

Modulation Input Connector Pinout and Function

| Pin		I/O	Description
No.	Name		
1	R+	I	Positive modulation input red channel
2	R-	I	Negative modulation input red channel
3	G+	I	Positive modulation input green channel
4	G-	I	Negative modulation input green channel
5	B+	I	Positive modulation input blue channel
6	B-	I	Negative modulation input blue channel
7	Error	O	Will be pulled to GND2 if NTC is shorted or open and driver will be deactivated
8	EnLow	I	Enable input, connect to GND2 to enable laser driver
9	PrLow	I/O	Power reduction pin, if the driver detects a temperature problem within the module, this pin gets internally connected to GND2.
10	+5V or TecBooster	I/O	Configurable as +5V or TEC booster pin If ControlBOX is connected, you must configure the pin as +5V. If TecBOOSTERs are connected, you must configure the pin as TecBOOSTER. The master driver sends the control power needed to reach the set temperature over this pin, -5V if 100% power needed, 5V if 0% power is needed.
11	GND2	-	Return pin for all control signals. Do not connect to GND!
12	GND or H/K	O	Configurable as GND or TEC booster pin If ControlBOX is connected, you must configure the pin as GND. If TecBOOSTERs are connected, you must configure this pin as H/K output pin. Gets internally set to high if the driver is in cooling mode, low if the driver is in heating mode.

Driver Output Connector Pinout
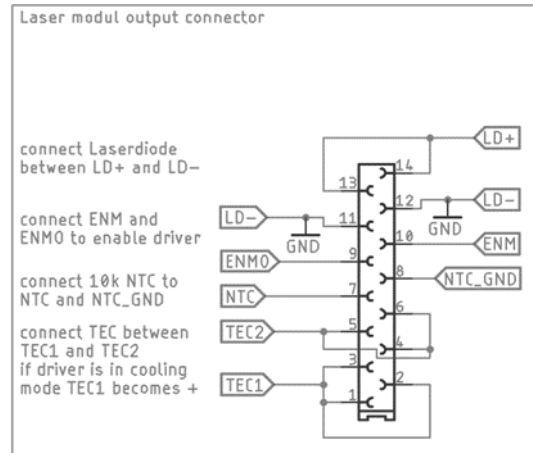
Pin		I/O	Description
No.	Name		
1	TEC1	O	Output pin for TEC, if the driver is in cooling mode, this becomes positive.
2	TEC1	O	Output pin for TEC, if the driver is in cooling mode, this becomes positive.
3	TEC1	O	Output pin for TEC, if the driver is in cooling mode, this becomes positive.
4	TEC2	O	Output pin for TEC, if the driver is in cooling mode, this becomes negative.
5	TEC2	O	Output pin for TEC, if the driver is in cooling mode, this becomes negative.
6	TEC2	O	Output pin for TEC, if the driver is in cooling mode, this becomes negative.
7	NTC	I	Temperature sense pin Connect one lead from NTC to this pin. Do not connect anything else.
8	NTC_GND	-	NTC_GND pin Connect one lead from the NTC to this pin. Do not connect anything else.
9	EnMo	I	Enable input. This pin is used to detect a connected laser module. The module connects EnMo and EnM.
10	EnM	O	Enable output. This pin is at +4,5V if the driver is enabled through the modulation input connector.
11	LD-	I	Negative connection for laser diode. Current sink. Use in parallel with pin 12.
12	LD-	I	Negative connection for laser diode. Current sink. Use in parallel with pin 11.
13	LD+	I	Positive connection for laser diode. Current source. Use in parallel with pin 14.
14	LD+	I	Positive connection for laser diode. Current source. Use in parallel with pin 13.

Potentiometer Configuration and Function
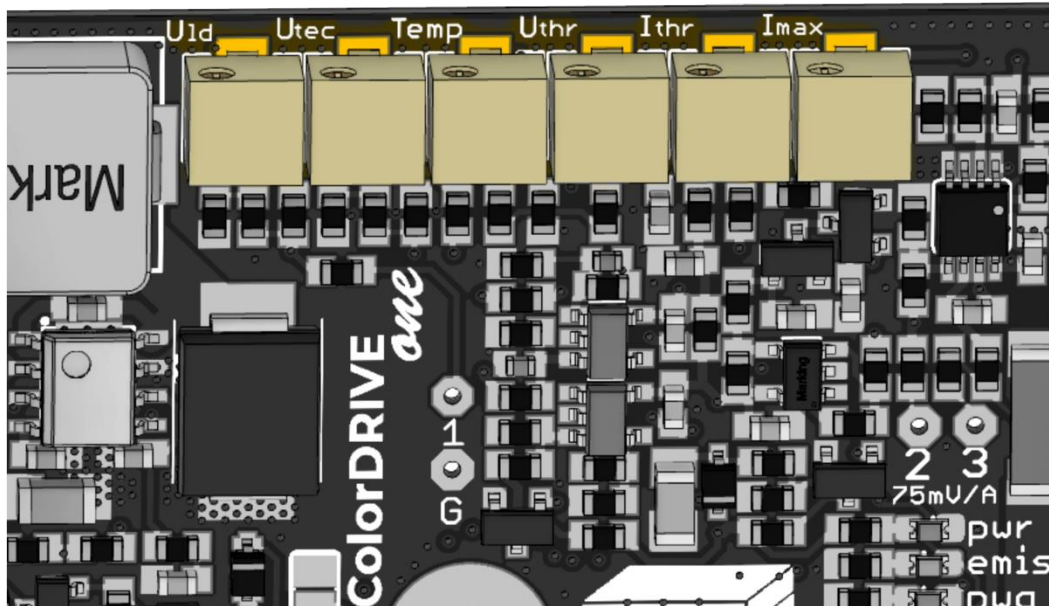
| Potentiometer (left to right on connector side)		Min	Max	Unit
U_{ld}	Compliance Voltage adjustment voltage laserdiode	2,5	24	V
U_{tec}	Voltage for TEC	3,3	23,5	V
Temp	Set temperature	-15	+30	°C
U_{thr}	Threshold current cut off voltage	0	0,625	V
I_{thr}	Threshold current for laserdiode	0	50 %	Imax
I_{max}	Maximum modulation current for laserdiode	0	5	A

Potentiometer Considerations

Each potentiometer increases the value CW and decreases the value CCW.

Please be careful with your adjustment tool. The potentiometers are easy to break away from the PCB. Do not use excessive force!

Probe Point Configuration and Function
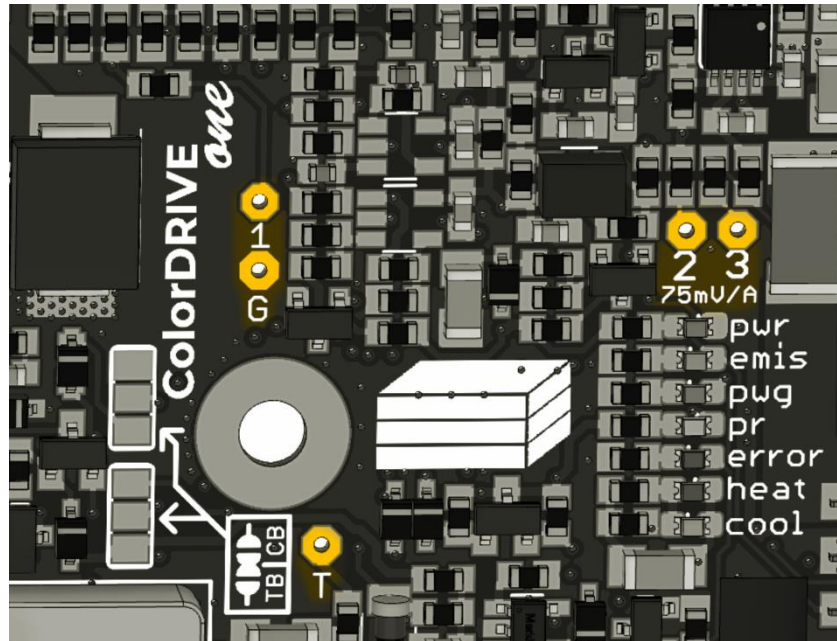
Measurement Point	Measurement Direction	Min	Max	Unit
G	GND	0	0	V
T	T-G supply voltage TEC	3,3	23,5	V
1	1-G supply voltage U_{ld}	2,5	24	V
2	2-3 Laserdiode Current 75mV / A	0	375	mV
3	3-G Laserdiode forward voltage	2	22	V
	3-1 Output stage voltage drop (at 5A output current)	0,5	2,5	V

Probe Points

The probe points are labeled on the PCB. Use a V meter for all measurements. Make sure the meter has a high input impedance. Otherwise, the measurements will be inaccurate. Every probe point is protected against short circuits.

User Configurable Solder Jumpers
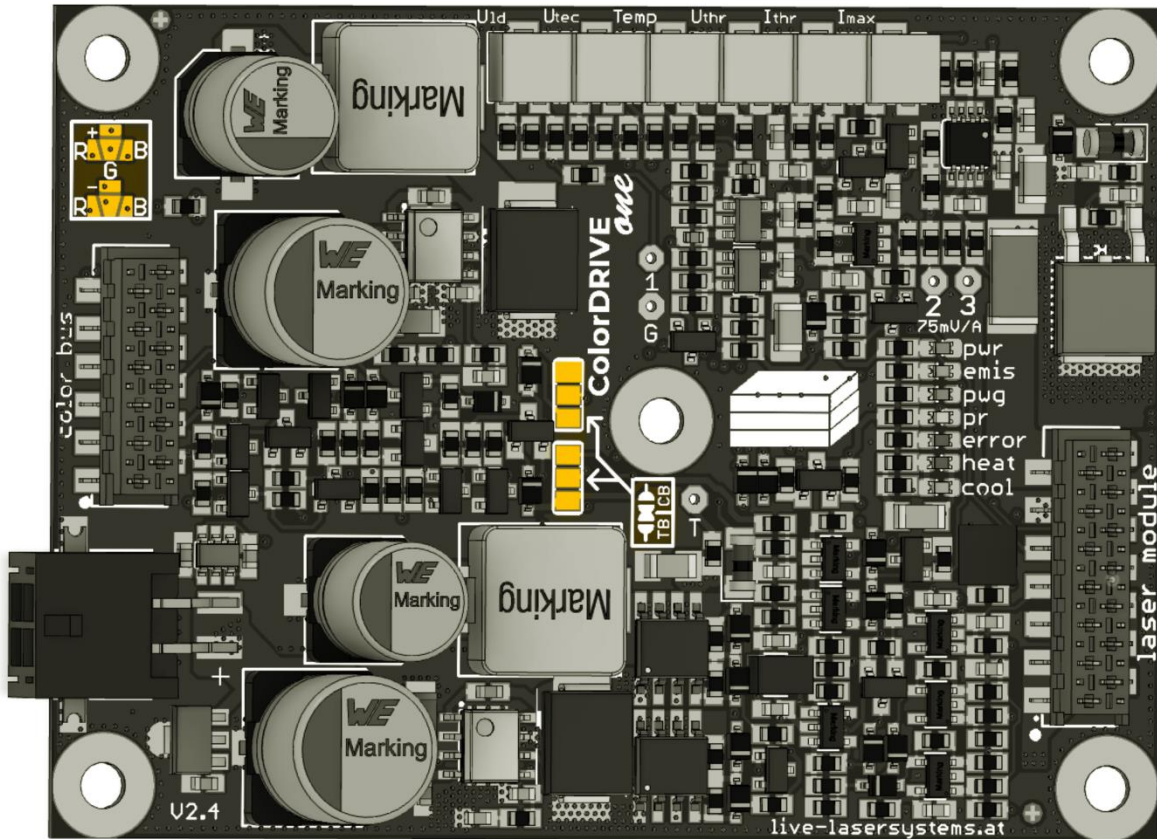
Solder Jumpers

The solder jumpers are needed to configure the driver to your specific application.

If TecBOOSTERs are connected, both jumpers need to be soldered to the bottom position.

This connects the TecBOOSTER control signals to the ColorBUS.

The connected TecBOOSTER receives the temperature data from the main driver and regulates accordingly.

If a ControlBOX is connected or if the application requires a low current 5V output (max 50mA), both jumpers need to be placed in the CB position.

You can find more information on the jumpers in the ColorBUS section of this document.

Input Assignment

ColorBUS carries three independent modulation signals. Each driver can be set to use one of these signals. To select a signal, both the positive and negative jumper need to be bridged to the desired channel.

The input assignment jumpers are located above the ColorBUS connector.

You cannot map two input channels to one output.

Absolute Maximum Ratings

	Min	Max	Unit
Supply voltage (VCC)	-0,3	28	V
Input common-mode voltage range (Vcm) without phase reversal	-50	50	V
Output transistor power dissapation	0	12	W
Storage temperature range[2]	-40	80	°C
Operating temperature range (measured on mounting bracket)[2]	-10	65	°C
TEC output current	0	5.5	A
Diode output current	0	5	A

([2]) Only to be used in a non condensing environment. Stress beyond those limits may cause damage to the driver.
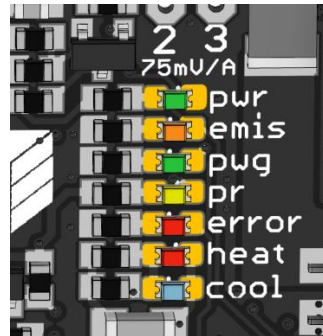
Electrical Characteristics

		Min	Max	Unit
VCC				
Input supply voltage		6	28	V
Standby power draw	Supply voltage dependent. 6-28V	0,2	0,85	W
Overvoltage lockout	Driver will be disabled above	28.5	29	V
EnLow				
Current source	Single driver on ColorBus	49.5	50.5	uA
Enable threshold	Voltage needs to be lower than this value compared to GND2	1	2	V
Color Input				
Vcm	Common mode input range	-31	31	V
Vdm	Differential mode input range	0	5	V
Rin diff	Differential input resistance	112.2	112.6	Kohm
Rin +	Input resistance positive terminal	68.2	68.4	Kohm
Rin -	Input resistance negative terminal	56.2	56.2	Kohm
Output				
Rise			600	ns
Fall			500	ns
THD	20khz at 1A Ithr with 2,5A Imax with NUBM-44	0.04		%
Imax	Imax per channel		5	A
Ithr	Ithr range depends on Imax	0	50	%
Softstart	Time from enable to full output current	60	70	ms
Compliance voltage	Maximum laser diode forward voltage at 5A (set by Uld)	0	VCC - 3V	
Voltage between TP 1-3	Voltage across output stage for proper regulation	$(I_{diode}*0.2)+0.5V$		

Status LEDs

LED Label	Color	Function	Status if lit	Status if off	Problem/ Solution
pwr	green	Shows power status of the driver	Driver is connected to VCC	Input voltage to low	Check VCC
				Driver faulty	Contact LIVE Lasersystems
emis	orange	Indicates readiness of laser output Caution if lit, laser output possible	Driver is enabled and no error condition is detected	ENM and ENMO pins on output connector not connected	Enable driver by connecting the appropriate pins on input/output connector
				ENLOW and GND2 pins on input connector not connected	
				Error condition detected	NTC shorted/open
pwg	green	Laserdiode voltage power good indicator	DCDC converter working as expected	Driver not enabled	Check emis
				DCDC converter faulty	Contact LIVE Lasersystems
pr	yellow	Lights up to signal current NTC temperature not near set temperatur.	Laser driver in power reduction mode, output current halved to protect laser diodes from over/under temperature	OK	Check TEC voltage/power/ set temperature and module mounting.
error	red	Shows NTC error	NTC short/open	OK	Check NTC wiring and module temperature
heat	red	Indicates heating power applied	Driver delivers power to TEC to heat module	No power applied	Does not light up if temperature is correct
cool	blue	Indicates cooling power applied	Driver delivers power to TEC to cool module	No power applied	

Dual Voltage Technology

ColorDRIVE makes it easy to use symmetrical power supplies (+-24V with GND) commonly found in show laser systems.

The color input (e.g., +-R/G/B) supports a high CMIR. High CMIR enables you to power the driver with +24V and -24V in conjunction with ground-based modulation signals.

You can use the both 24V rails to drive laser diodes and don't need to used extra power supplies for your ColorDRIVE one.

ColorBUS

ColorBUS gives you the possibility to connect multiple ColorDRIVEs and TecDRIVEs/BOOSTERs together. It shares all control and fault signals between drivers and boosters. ColorBUS makes it easy to expand the power capabilities of the drivers to drive even more diodes and TECs. ColorBUS also reduces the amount of wiring needed. You can use one long ribbon cable with multiple connectors crimped on to get all control signals wired between the drivers.

Power Reduction

The PR signal is used to protect the diodes in an over/under temperature condition.

If a TEC driver (also the integrated one in ColorDRIVE) detects an abnormal temperature condition, then the power reduction signal gets sent. Each ColorDRIVE responds with a 50% reduced diode drive current to protect the connected diodes.

This signal gets distributed across the ColorBUS to all connected drivers.

EnLow

The EnableLow signal is an interlock signal. This signal needs to be pulled to GND2. Every driver connected to the ColorBUS checks this pin. If not connected to GND2, the driver responds with disabled DCDC converters. It also disables the modulation signal flow. It is thus providing a safe way to disable the laser current entirely. If a fault occurs, for example a broken output stage, it would still disable the current into the diode.

ControlBOX accessory (only without TecBOOSTER)

Pin 10 and 12 can be configured to act as a power supply pin for the LIVE Lasersystems ControlBOX accessory or to control a TecBOOSTER. If a ControlBOX is connected, the ColorDRIVE can't be used with TecBOOSTERs.

Reference the "Solder Jumper" section of this document for information on setting the jumpers.

TecBOOSTER

If you want to use a TecBOOSTER to get more drive power for your TECs then you need to connect the solder jumpers in TB mode. This configures the ColorDRIVE as a bus master. The bus master sends the thermal information to connected TecBOOSTERs.

This enables the slave TecBOOSTERs to drive additional TECs cooling/heating the same thermal load.

All slave TecBOOSTERs need to be connected to the same GND. The VCC voltage can be different. You can use up to 4 TecBOOSTERs with one master driver.

If you want to have more than one master driver on the ColorBUS then you need to break pin 10 and pin 12 between the master drivers.

Tuning the Driver

Please make sure you read and understand the whole section completely before attempting to tune the driver!

Driver tuning needs several steps. The first step is tuning the TEC temperature regulation.
Even if it is not intended to use a TEC, the TEC driver needs to be set up.

Close the interlock loop on the output connector to enable the driver.
The input connector does not need a closed interlock loop to tune the TEC.
If you don't want to use temperature regulation or protection you can connect a 10k resistor to the NTC input. Otherwise, an NTC with 10k at 25°C and a beta of 3977 should be used.
The NTC needs to be thermally connected with the heatsink of the laser diodes that you want to heat/cool with a TEC or just protect.

After all connections are made, the driver can be powered up.
If the error LED lights up, the NTC or resistor is not connected properly or has a short.

Next, you need to tune the TEC voltage and the set temperature with the U_{tec} and Temp pot.
First, the TEC voltage needs to be tuned. Measure the voltage on test points T-G.
Use the Temp pot to get the driver in full TEC output power state by turning it counter clockwise until the PR LED lights up. Now it's time to set the TEC voltage by turning the U_{tec} pot.
After the TEC voltage is set the temperature can be set with the Temp pot.

If you don't use a TEC, set the TEC voltage to a minimum and turn the Temp pot until the drivers heating, cooling and PR LEDs are off.

The second step is tuning the laser diode driver.
Connect a voltage source that is capable to be adjusted between 0-5V to the modulation input and set it to 5V.
Connect the laser diodes to the driver.
Close the input connector interlock loop to activate the laser diode driver.
Calculate the needed compliance voltage of the connected laser diodes, use the typical voltage provided in your diode's datasheet. If multiple laser diodes are connected in series, just add their voltage together. Also add 1V for proper regulation.
If you are unsure about your diode's compliance voltage, you need to be very careful. You cannot use the steps provided below to adjust the driver. You can still adjust the driver but you need to read the next section "Compliance Voltage".

If all connections are made properly, the driver can be power up.

Now you need to adjust the compliance voltage with the U_{ld} pot.
Measure the voltage at test points G-1.

After the compliance voltage is set the drive current can be adjusted.

Measure 2-3 voltage, this voltage equals the current that's flowing through the diodes.
Tune the I_{max} pot to reach the desired current, be careful to adjust the right current but don't overshoot.

If you cannot reach the desired current, your diodes need more compliance voltage than currently set with U_{ld}.
To fix this, turn the current down with I_{max} until the current drops, increase the compliance voltage by 1V, and start to tune I_{max} again.

Now you need to adjust the compliance voltage again for maximum efficiency.
Measure the voltage drop across the outputs stage with the measurement points 1-3.
Be careful: This voltage multiplied by the drive current cannot exceed 14W or the driver will get damaged.

The measured voltage needs to be set with the U_{ld} pot to a calculated value.
Use the following equation to calculate the voltage.

$$V_{testpoint} = (LD_{current} * 0{,}2) + V_{head}$$

$LD_{current}$ is the maximum laser diode drive current and $V_{testpoint}$ is the voltage measured at test points 1-3.
V_{head} is the headroom voltage for proper regulation.
This voltage needs to be 0,25V if the driver should be tuned for maximum efficiency.
0,25V are recommended for show laser use.

You can use 1V for faster rise and fall times, with the tradeoff of higher power dissipation.

I_{max} and U_{ld} are now set correctly and don't need to be changed anymore.

Step 3 includes setting the modulation curve.
ColorDRIVE includes stand-by beam suppression and threshold current.
Any changes in threshold current do not influence I_{max} or U_{ld}, it can be set fully independently.

To set the threshold current, reduce the modulation voltage to a lower value like 0,15V.
Tune the I_{thr} pot to a desired laser diode brightness and or current.
To adjust the stand-by beam suppression you need to use the U_{thr} pot to adjust the modulation voltage below the driver cuts the current completely.
Set 0,14V modulation voltage and turn the U_{thr} pot until the diode's current shuts off.

ColorDRIVE is now adjusted perfectly.

Compliance Voltage

The U_{ld} supply voltage further known as laser diode forward voltage needs to be set precisely. If you don't know the value you need to start tuning the driver with U_{ld}, set to the lowest voltage possible.

You can also start with an estimate of the forward voltage by laser diode wavelength. Values below:

Infrared	Red	Green	Blue	UV
2,2V	2,8V	5V	4,2V	5V

You can try to increase the laser diode current, if the current cannot be adjusted to your desired value, you need to turn the I_{max} pot down until the current decreases (2-3).

After that, increase the compliance voltage (1-G) with the U_{ld} pot by 1V.

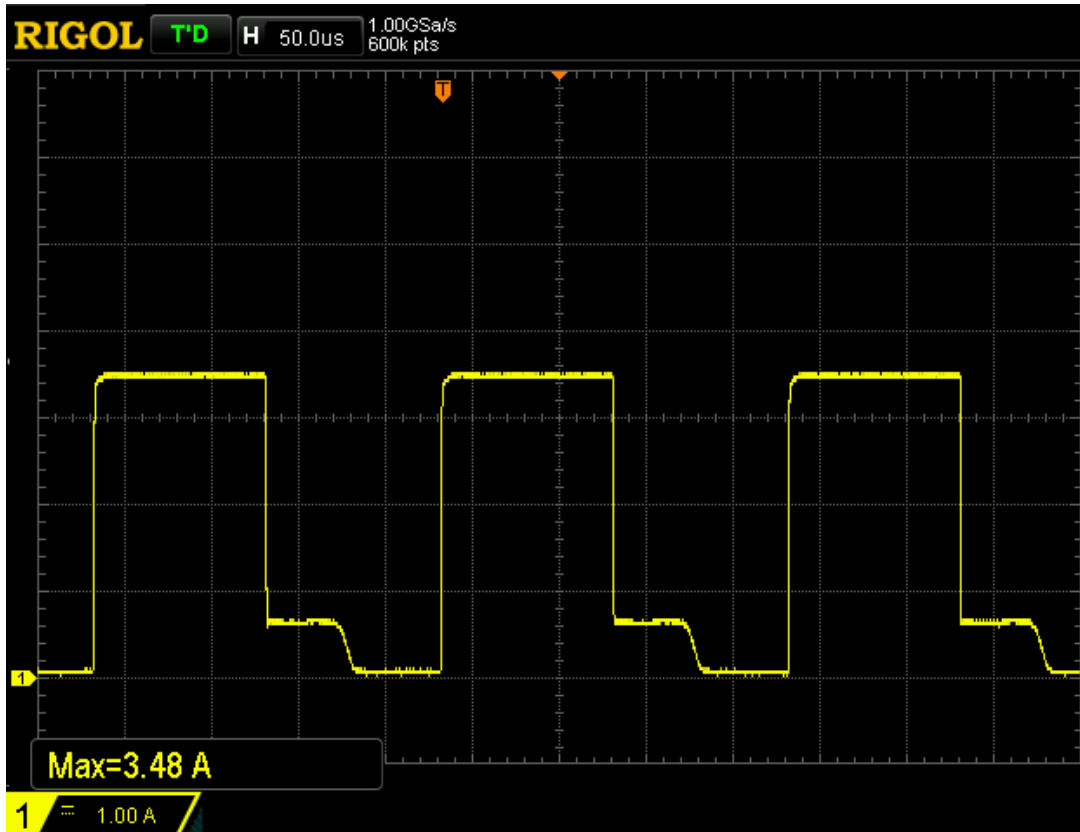Repeat this until you reach your desired drive current.

Now tune the voltage drop across the output stage like previously mentioned.

All other steps remain the same.

Waveforms

All Waveforms recorded with Rigol DS1104.
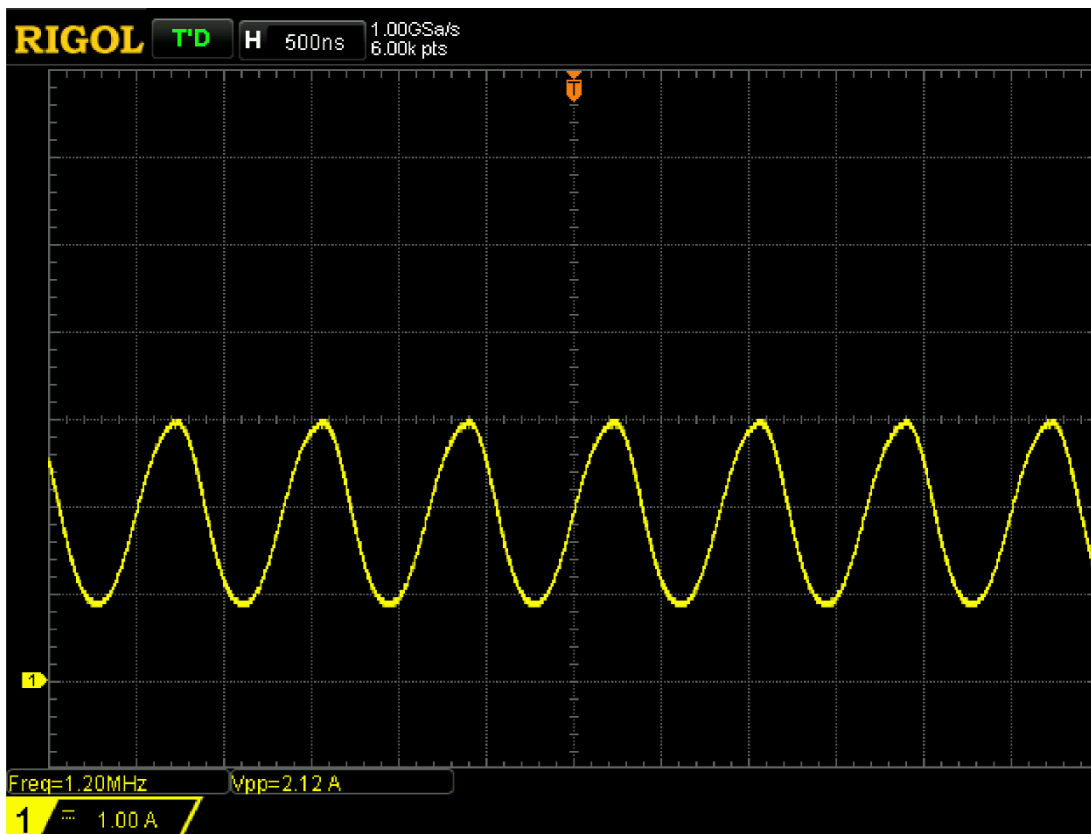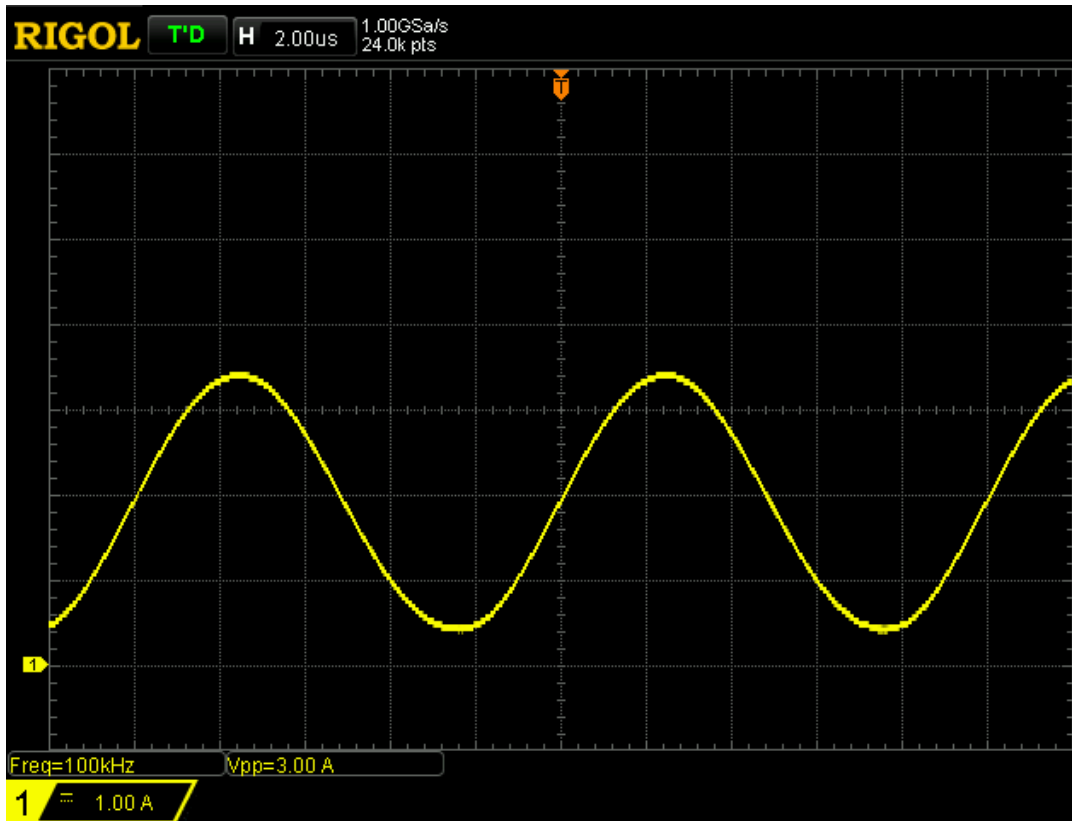

Threshold current suppression example.

RIGOL   T'D   H 2.00us   1.00GSa/s   24.0k pts

Freq=100kHz   Vpp=3.00 A

1   1.00 A

RIGOL   T'D   H 500ns   1.00GSa/s   6.00k pts

Freq=1.20MHz   Vpp=2.12 A

1   1.00 A

1,3Mhz -3db example 3App setting