



ColorDRIVE 6

V2.2

3 x 2ch laser diode driver and TEC driver with heating and cooling capability

Manual



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Features

- Up to 48V operating voltage
- Up to 960W output power in a tiny form factor of only 111,5x50x18mm
- Very high efficiency of up to 97.5% due to integrated step-down converters for each laser channel and the TEC driver
- 2,2Mhz -3db modulation frequency (1)
- 350ns rise 500ns fall time (1)
- 3 modulation channels
- each offer configurable output channels - 5A or 2x 2,5A
- Up to 10 green laser diodes per channel e.g., capable of powering a 60W green module
- Integrated TEC driver with heating and cooling
- Standard NTC 10k Beta: 3977 compatible
- 5-48V @ 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 with square wave and 2 parallel output channels with 1A I_{thr} and 5A I_{max} with NUBM-44 as load.

Applications

- Laser show display systems
- Industrial positioning systems
- DNA sequencing
- Optogenetics
- Other laser applications

Description

ColorDRIVE 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 offers 720W maximum output power for laser diodes and 240W for TECs. The TEC power can be extended to 1200W with the use of our TEC booster technology. TEC boosters enable to drive up to 48V @ 25A TECs with minimal cost and maximum efficiency.

A temperature good output (power reduction) enables an easy integration of the driver in any system. It gives you 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 our 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 our ColorDRIVES to protect the laser diodes if a TEC should fail.

Information

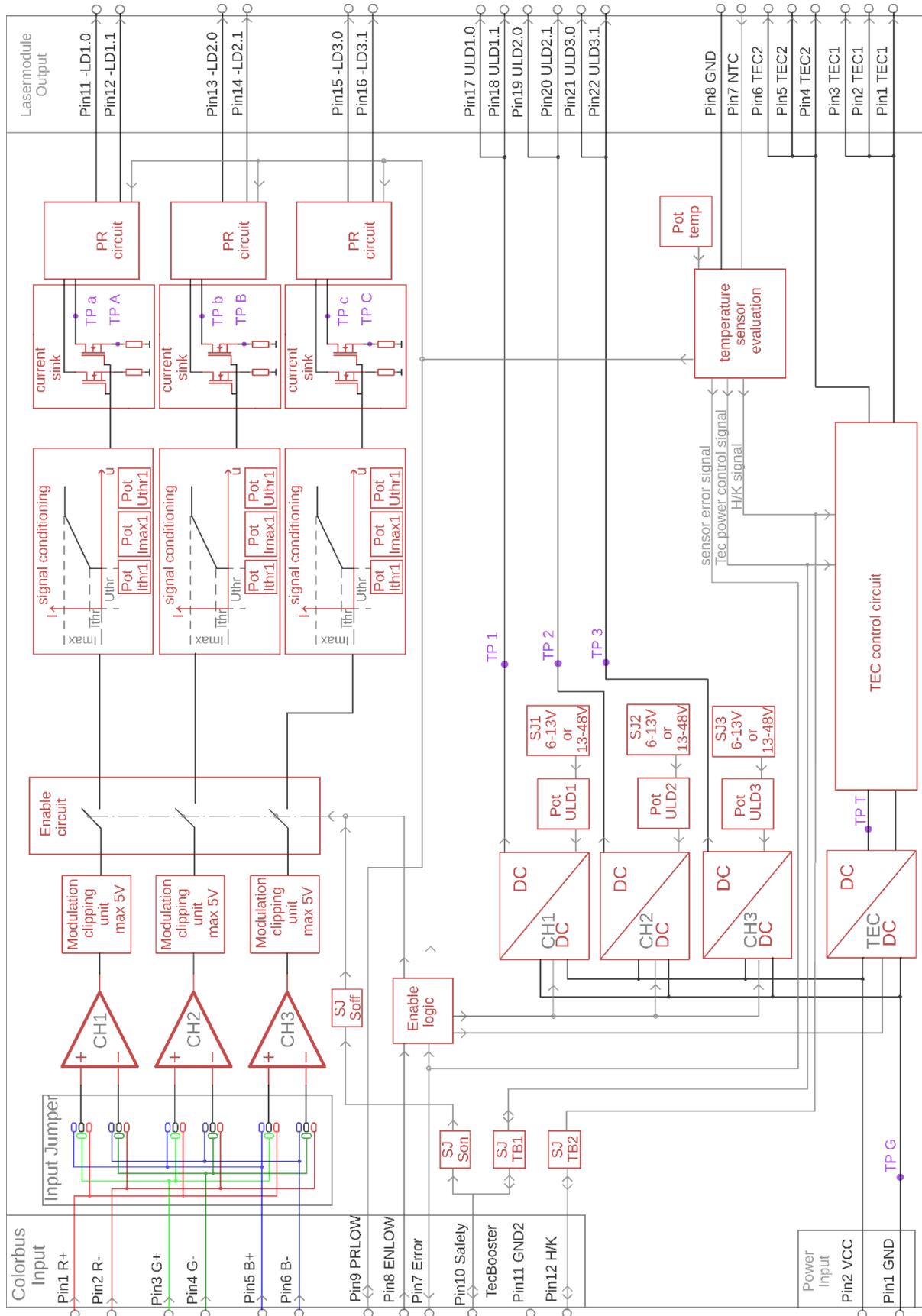
LIVE Lasersystems designs and manufactures every driver in Austria to meet high standards.

Drivers are shipped ready to use. ColorDRIVE comes with all needed connectors.

For more information, please contact LIVE Lasersystems.

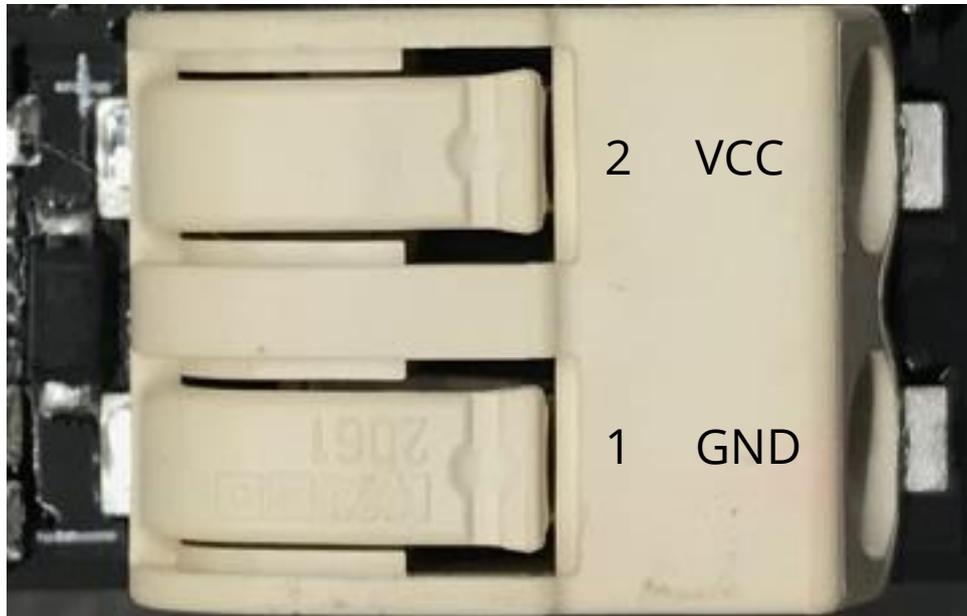


Functional block diagram





Power input connector



Power input connector

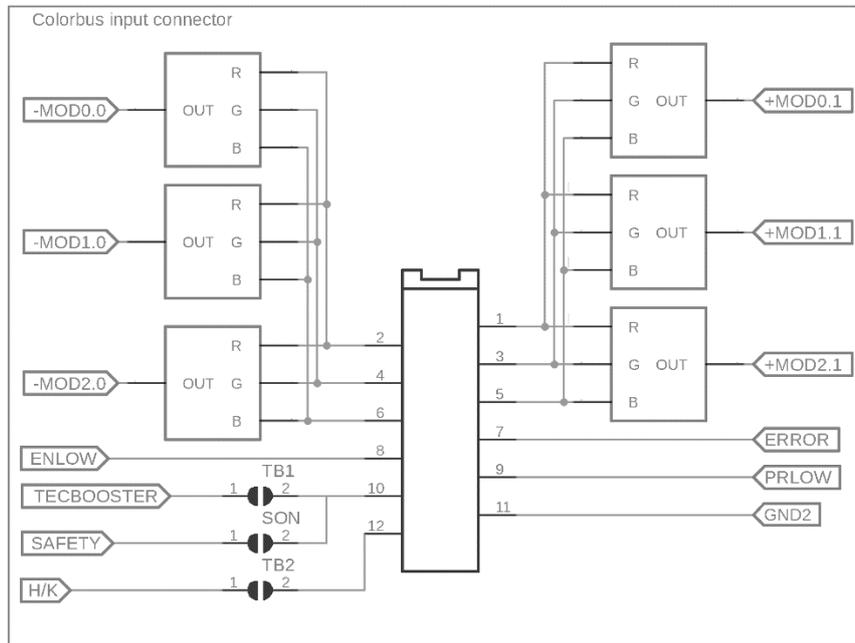
Pin		I/O	Description
No.	Name		
1	GND (-)	I	Negative supply voltage, 0.5 - 1.5mm ² / 20 - 16 AWG conductors
2	VCC (+)	I	Positive supply voltage, 0.5 - 1.5mm ² / 20 - 16 AWG conductors

Power input considerations

The power supply input connector uses spring loaded clamping mechanism. Make sure to strip the wires 7 - 10mm / 0.28 - 0.39 inch before inserting them into the connector. To release the conductor, push down the lever on the corresponding terminal and pull out the wire. The PCB has markings for negative and positive connections. You need to use low impedance connections e.g., using short wires that can withstand the current your application needs. 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.



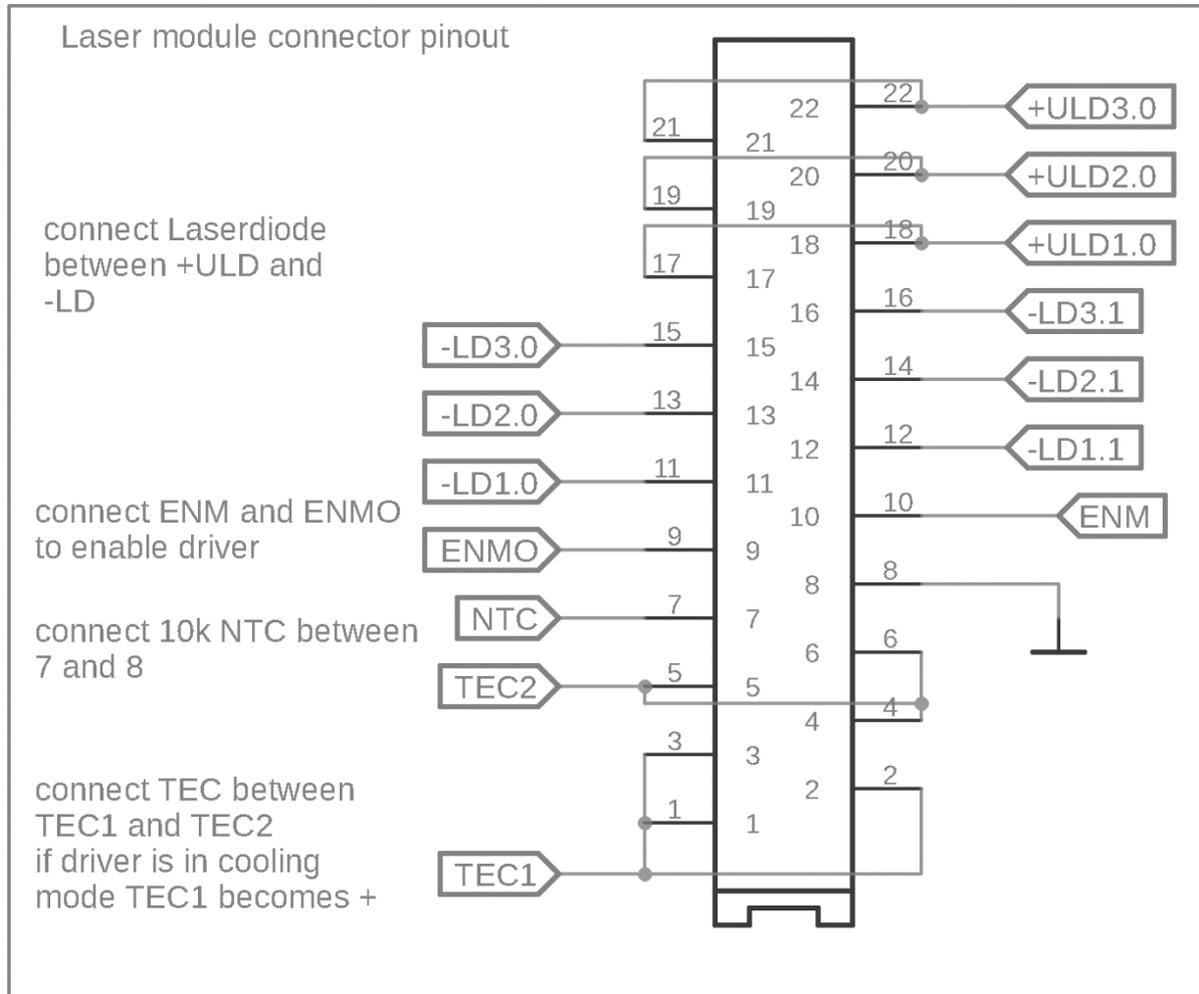
Modulation input connector configuration and function



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	Powerreduction pin, if the driver detects a temperature problem with the module, this pin gets internally connected to GND2.
10	Safety/ TecBooster	I/O	Configurable as safety or TEC booster pin If you configure the pin as safety, you need to connect it to GND2. If you don't pull it low, the driver shuts off the laser current. If TEC boosters are connected, you must configure the pin as TEC booster. 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	H/K	O	Output pin for TEC boosters: high if the driver is in cooling mode, low if the driver is in heating mode.



Driver output connector pinout





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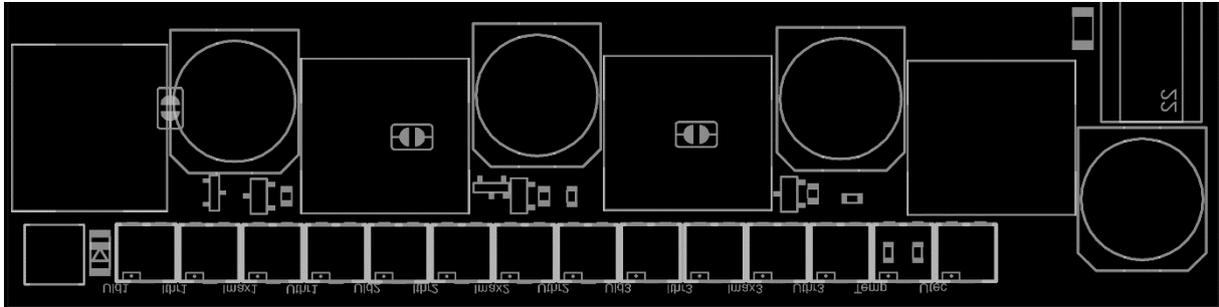
Service

Rental

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	GND	-	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 1.0	I	Current sink for 1.0 laser driver channel. Use voltage from ULD 1.
12	-LD 1.1	I	Current sink for 1.1 laser driver channel. Use voltage from ULD 1.
13	-LD 2.0	I	Current sink for 2.0 laser driver channel. Use voltage from ULD 2.
14	-LD 2.1	I	Current sink for 2.1 laser driver channel. Use voltage from ULD 2.
15	-LD 3.0	I	Current sink for 3.0 laser driver channel. Use voltage from ULD 3.
16	-LD 3.1	I	Current sink for 3.1 laser driver channel. Use voltage from ULD 3.
17	+ULD 1	O	Laser diode supply voltage 1, use both pin 17 and 18 if you need more than 2,5A.
18	+ULD 1	O	Laser diode supply voltage 1, use both pin 17 and 18 if you need more than 2,5A.
19	+ULD 2	O	Laser diode supply voltage 2, use both pin 19 and 20 if you need more than 2,5A.
20	+ULD 2	O	Laser diode supply voltage 2, use both pin 19 and 20 if you need more than 2,5A.
21	+ULD 3	O	Laser diode supply voltage 3, use both pin 21 and 22 if you need more than 2,5A.
22	+ULD 3	O	Laserdiode supply voltage 3, use both pin 21 and 22 if you need more than 2,5A.



Potentiometer configuration and function



Potentiometer (Left to right on connector side)		Min	Max	Unit
Uld1	Voltage for 1.0 and 1.1 current sink	5	48	V
Ithr1	Threshold current for 1.0 and 1.1 current sink	0	50 %	Imax
Imax1	Highest current possible for current sink 1.0 and 1.1	0	2.5	A
Uthr1	Threshold current cut off voltage for 1.0 and 1.1	0	0.5	V
Uld2	Voltage for 2.0 and 2.1 current sink	5	48	V
Ithr2	Threshold current for 2.0 and 2.1 current sink	0	50 %	Imax
Imax2	Highest current possible for 2.0 and 2.1	0	2.5	A
Uthr2	Threshold current cut off voltage for 2.0 and 2.1	0	0.5	V
Uld3	Voltage for 3.0 and 3.1 current sink	5	48	V
Ithr3	Threshold current for 3.0 and 3.1 current sink	0	50 %	Imax
Imax3	Highest current possible for 3.0 and 3.1	0	2.5	A
Uthr3	Threshold current cut off voltage for 3.0 and 3.1	0	0.5	V
TEMP	Set temperature	-15	+30	°C
UTEC	Voltage for TEC	3	48	V

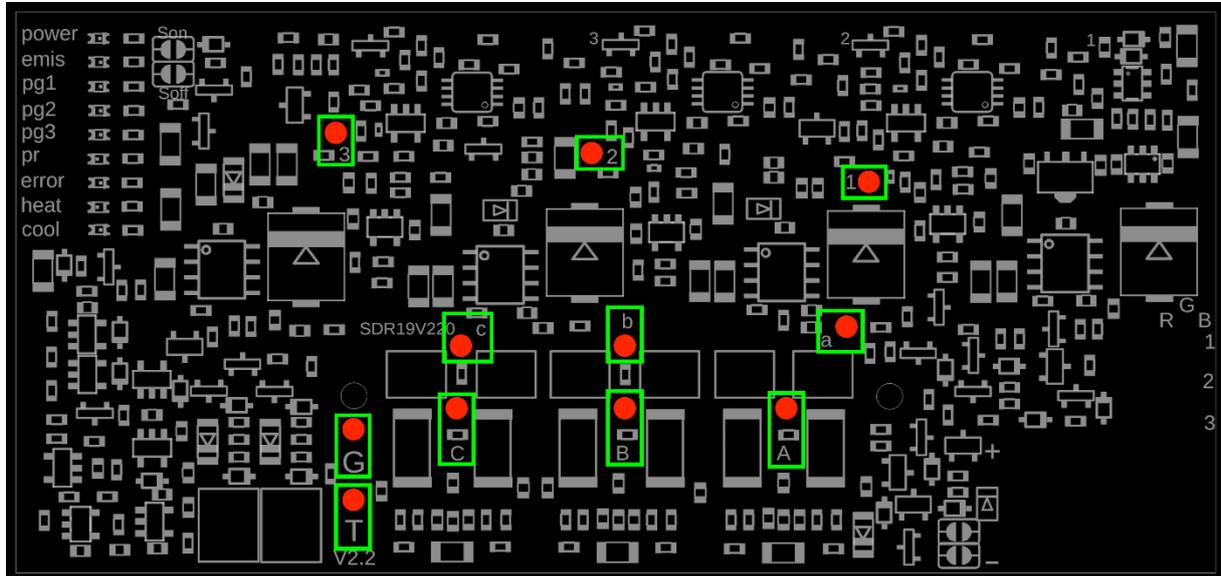
Potentiometer considerations

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

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



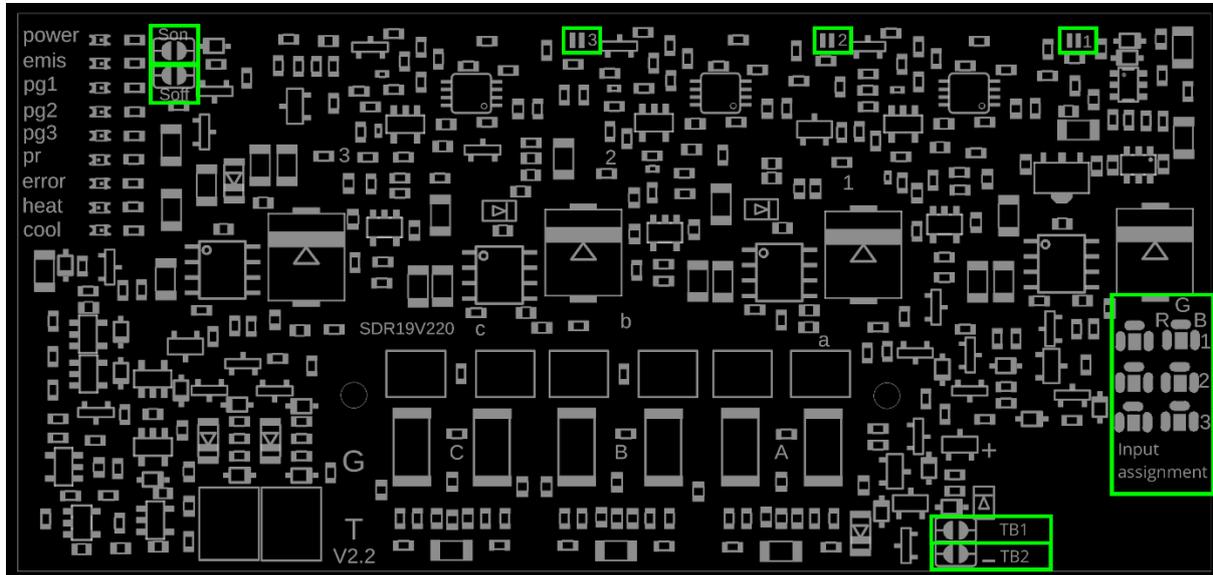
Measurement Point		Min	Max	Unit
G	GND	0	0	V
T	T-G supply voltage TEC	3	48	V
1	1-G supply voltage +ULD 1	5	48	V
2	2-G supply voltage +ULD 2	5	48	V
3	3-G supply voltage +ULD 3	5	48	V
a	a-A voltage over output stage FET 1.1			V
	a-1 compliance voltage over laserdiode LD 1.1	2	46	V
A	A-G Laserdiode Current 75mV / A	0	187.5	mV
b	b-B voltage over output stage FET 2.1			V
	a-2 compliance voltage over laserdiode LD 2.1	2	46	V
B	B-G Laserdiode Current 75mV / A	0	187.5	mV
c	c-C voltage over output stage FET 3.1			V
	c-3 compliance voltage over laserdiode LD 3.1	2	46	V
C	C-G Laserdiode Current 75mV / A	0	187.5	mV

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.



Jumper



Solder Jumpers

The solder jumpers (SJ) are needed to configure the driver to your specific application. SJ1/2/3 selects the respective ULD potentiometer range. Bridged: 5-13V Open: 13-48V

Son and Soff are used for activating the safety input.

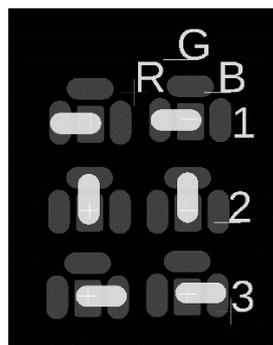
TB1 and TB2 need to be bridged if you want to use a TEC booster with this driver. If both are bridged, the connected TEC booster receives the temperature data from the main driver and regulates accordingly.

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

Input Assignment

All channels can be mapped on to the ColorBUS as desired. The input assignment jumpers are located above the supply voltage connector.

A picture of an example configuration for a RGB module can be found below. In this example, the R input channel is mapped to the first output channel. G is mapped to the second output channel and B to the third. It is possible to map two or three output channels to one input channel. You cannot map two input channels to one output, though.





Absolut Maximum Ratings

	Min	Max	Unit
Supply voltage (VCC)	-0,3	50	V
Input common-mode voltage range (Vcm)	-50	50	V
Output transistor power dissipation		6	W
Storage temperature range (non condensing) ²	-40	100	°C
Operating temperature range (measured on mounting bracket) (non condensing) ²	-10	65	°C
TEC output current		5.5	A
Diode output current (each double channel)		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		12	48	V
Standby power draw		1.3	2	W
Undervoltage lockout	Driver will be disabled below	10.5	11.8	V
EnLow				
Current source	One driver enabled	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	K
Rin +	Input resistance positive terminal	68.2	68.4	K
Rin -	Input resistance negative terminal	56.2	56.2	K
Output				
Rise			360	ns
Fall			550	ns
THD	20khz at 1A Ithr with 2,5A I _{max} with NUBM-44	0.04		%
I _{max}	I _{max} per channel, 2 channels can be paralled		2.5	A
I _{thr}	I _{thr} range depends on I _{max}	0	50	%
Softstart	Time from enable to full output current	60	70	ms
Compliance voltage	Maximum laser diode (string) forward voltage		VCC - 3V	
VG-a / VG-b / VG-c	Voltage across output stage for proper regulation	(I _{diode} *0.15)+0.65V=VG-a		



Status LEDs

LED Label	Color	Function	Status if lit	Status if off	Problem/Solution
Power	Green	Shows power status of the driver	Driver is connected to VCC	Input voltage to low	Check VCC
				Driver faulty	Contact LIVE Lasersystems
emis	Yellow	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 or temperature of module out of range
Pg1	Green	Power good signal for channel 1	DCDC converter of channel 1 working	Driver not enabled	Check emis
				DCDC converter faulty	Contact LIVE Lasersystems
Pg2	Green	Power good signal for channel 2	DCDC converter of channel 2 working	Driver not enabled	Check emis
				DCDC converter faulty	Contact LIVE Lasersystems
Pg3	Green	Power good signal for channel 3	DCDC converter of channel 3 working	Driver not enabled	Check emis
				DCDC converter faulty	Contact LIVE Lasersystems
Pr	Orange	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. Module gets too hot.
Error	Red	Shows NTC error	NTC short/open or current temperature out of range (-10°C - 60°C)	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 48V to drive many laser diodes in series and do not need to change the modulation signal. Every other function except the TEC booster is DVT compatible.

ColorBUS

ColorBUS gives you the possibility to connect two or more laser drivers and TEC drivers/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 a 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 a bad temperature condition, then this signal gets sent. Each ColorDRIVE responds with a 50% reduced diode drive current to protect them.

This signal gets distributed across the ColorBUS to all connected drivers, even if you connect one to -24V and GND and the other driver to GND and +24V.

EnLow

The EnLow 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 an error occurs, for example, a broken output stage, it would still disable the current into the diode.

Safety (only without TEC booster)

Pin 10 can be configured to act as a safety pin or to control a TEC booster.

If you want to switch the output current for the laser diodes on/off in a fast way, then you need to use the safety pin. Therefore you need to bridge the Son SJ, open the Soff SJ and TB1/2 SJ.

This configures pin 10 at the ColorBUS connector as a safety input.

If you pull the pin to GND2, the driver activates. If you leave the pin floating or connect it to VCC, the driver becomes disabled.

TEC booster

If you want to use a TEC booster to get more power for your TECs then you need to connect SJ TB1 and TB2. This configures the ColorDRIVE as a bus master. The bus master sends the thermal information to other connected TEC boosters. All slave TEC boosters need to be connected to the same GND. The VCC voltage can be different. You can use up to 4 TEC boosters 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.



Connecting Laser Diodes

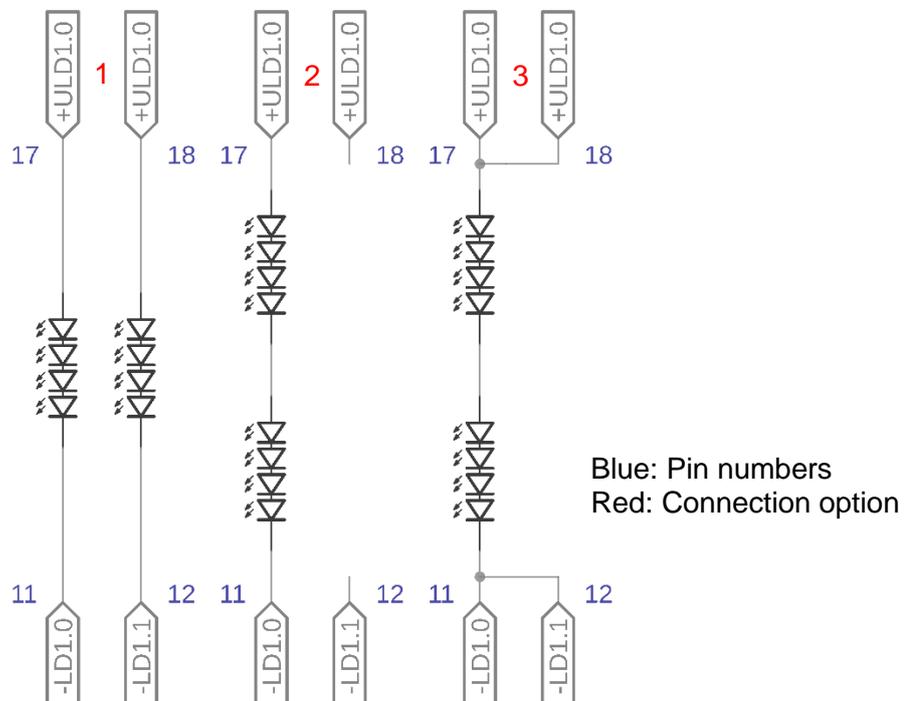
Laser diode connection planning needs to be done carefully to maximize efficiency.

If you want to connect laser diodes that need more than 2.5A, it is necessary to use two output channels from one input channel in conjunction. Paralleling two output channels gives you 5A total drive current. You can only parallel two output channels that share a modulation channel e.g. -LD1.0 and -LD1.1 or -LD2.0 and -LD2.1 or -LD3.0 and -LD3.1. You can not parallel -LD1.x with -LD2.x.

If you only need 2.5A or below, the driver makes it possible to drive two strings per modulation channel.

Example: 8x 2A 5.5V laser diode

There are multiple ways to connect the diodes, but only one way is most efficient and should, therefore, be used.



Option 1 uses both channels to drive eight diodes. Because of the four diodes per string arrangement, the driver only needs $(5V \cdot 4) + 3V = 23V$ VCC min. The disadvantages are increased overall current, resulting in less efficient operation.

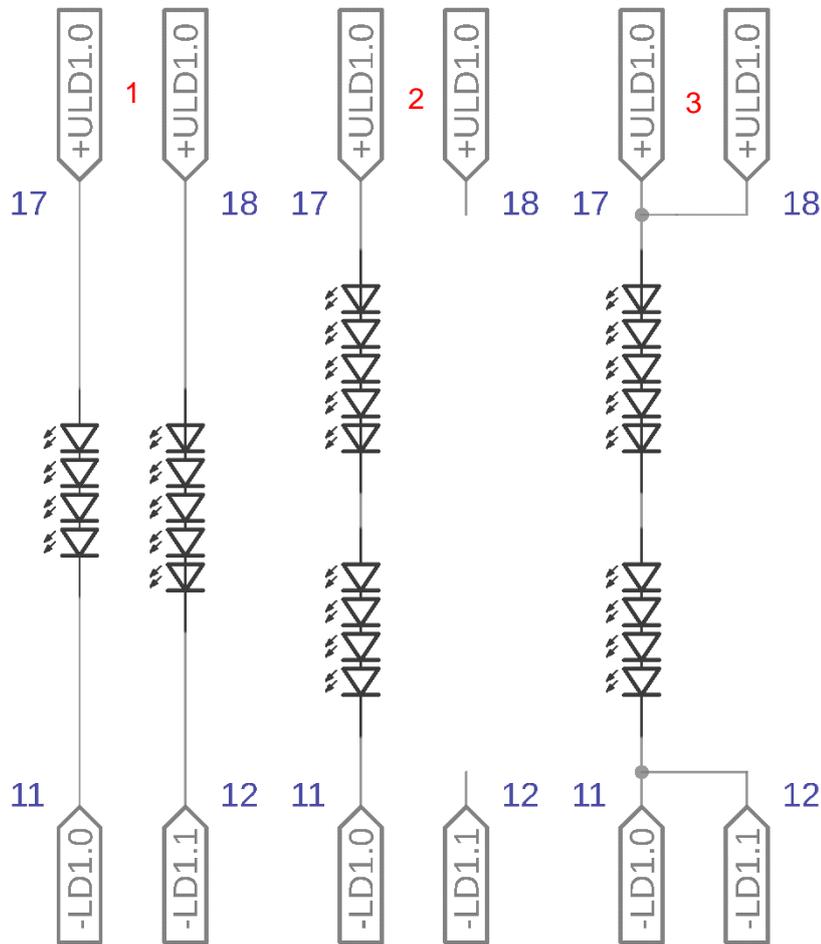
Option 2 uses one channel to drive eight diodes. Because of the eight diodes per string arrangement, the driver needs $(5V \cdot 8) + 3V = 44V$ VCC min. The disadvantages are, that the laser diode current is only sunk by one output transistor, resulting in more voltage drop across the shunt resistor and transistor, thus less efficient operation.

Option 3 uses two channels to drive eight diodes. Because of the eight diodes per string arrangement, the driver needs $(5V \cdot 8) + 3V = 44V$ VCC min. There are no disadvantages: The laser diode current is sunk by two output transistors, resulting in a reduced voltage drop across the shunt resistor and transistor. Thus the highest efficiency possible is achieved.

Be careful. **Be Careful:** if you use both output stages in parallel, the current you are measuring is half of the actual output current.



Example two: 9x laser diodes 250mA 3V



Option 1 uses both channels to drive nine diodes. Because of the four/five diodes per string arrangement, the driver only needs $(3V \cdot 5) + 3V = 18V$ VCC min. The different amount of laser diodes also causes trouble; each diode uses $3V \cdot 0.25A$, thus using $0.75W$. The voltage difference of each string produces extra heat at the output stage ($12V$ vs. $15V @ 0.25A$). This example works because the extra $0.75W$ in stage 1.1 does not exceed the capability of $7W$ maximum power dissipation but reduces the efficiency significantly. Connect the higher laser diode count to the higher channel e.g. 1.1 instead of 1.0.

Therefore: you can drive different amounts of laser diodes per string, but you need to respect the maximum dissipation of the output stage.

Option 2 uses one channel to drive 9 diodes. Because of the 9 diodes per string arrangement, the driver needs $(3V \cdot 9) + 3V = 30V$ VCC min. The disadvantages are, that the laser diode current is only sunk by one output transistor, resulting in more voltage drop across the shunt resistor and transistor, thus less efficient operation.

Option 3 uses two channels to drive eight diodes. Because of the eight diodes per string arrangement, the driver needs $(5V \cdot 9) + 3V = 30V$ VCC min. There are no disadvantages: The laser diode current is sunk by two output transistors, resulting in a reduced voltage drop across the shunt resistor and transistor. Thus the highest efficiency possible is achieved. Be careful. If you use both output stages in parallel, the current you are measuring is half of the actual output current.



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 thermal mass that should be controlled or protected.

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 UTEC 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 clockwise until the PR LED lights up. Now it's time to set the TEC voltage by turning the UTEC 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. This manual only describes the procedure to set up channel one, the following steps need to be executed for each channel in use. Be careful to use the right pots to tune the other channels.

Connect a voltage source that is capable to be adjusted between 0-5V to the modulation input and set it to 5V.

After determining the right laser diode connection scheme (see the previous page), you can connect the 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 you are unsure about your diode's compliance voltage, you need to be very careful. You can not use the steps provided below to adjust the driver. However, 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 ULD1 pot. Measure the voltage at test points G-1.

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



Measure G-A voltage, this voltage equals the current that's flowing through the diodes. Tune the I_{max1} pot to reach the desired current, be careful to adjust the right current and don't overshoot it. If you are using two channels in parallel to drive more than 2,5A you need to divide the needed current by two!

If you can not reach the desired current your diodes need more compliance voltage than currently set with ULD1. 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_{max1} 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 a-A. This voltage multiplied by the drive current can not exceed 6W or the driver will get damaged. If you use both channels in parallel, the channels share the power dissipation. The measured voltage needs to be set with the ULD1 pot to a calculated value. Use the following equation to calculate the voltage.

$$LD_{current} * 0,2 + 0,5V = V_{testpoint}$$

$LD_{current}$ is the maximum laser diode drive current and $V_{testpoint}$ is the voltage measured at test points a-A.

I_{max} and ULD1 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 change in threshold current does not influence I_{max} or ULD, 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 diodes current shuts off.

Repeat the steps for each channel. ColorDRIVE is now adjusted perfectly.



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Compliance Voltage

The compliance 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 ULD1 set to the lowest voltage possible.

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 (A-G).

After that increase the compliance voltage (1-G) with the ULD1 pot by 1V.

Repeat this until you reach your desired drive current.

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

If you are using different laser diodes or different numbers of diodes on one channel e.g.

Two diodes on 1.0 and three diodes on 1.1 then you need to work with the higher compliance voltage. However, calculate the power dissipation of the output stage beforehand and make sure you don't exceed it.

All other steps remain the same.

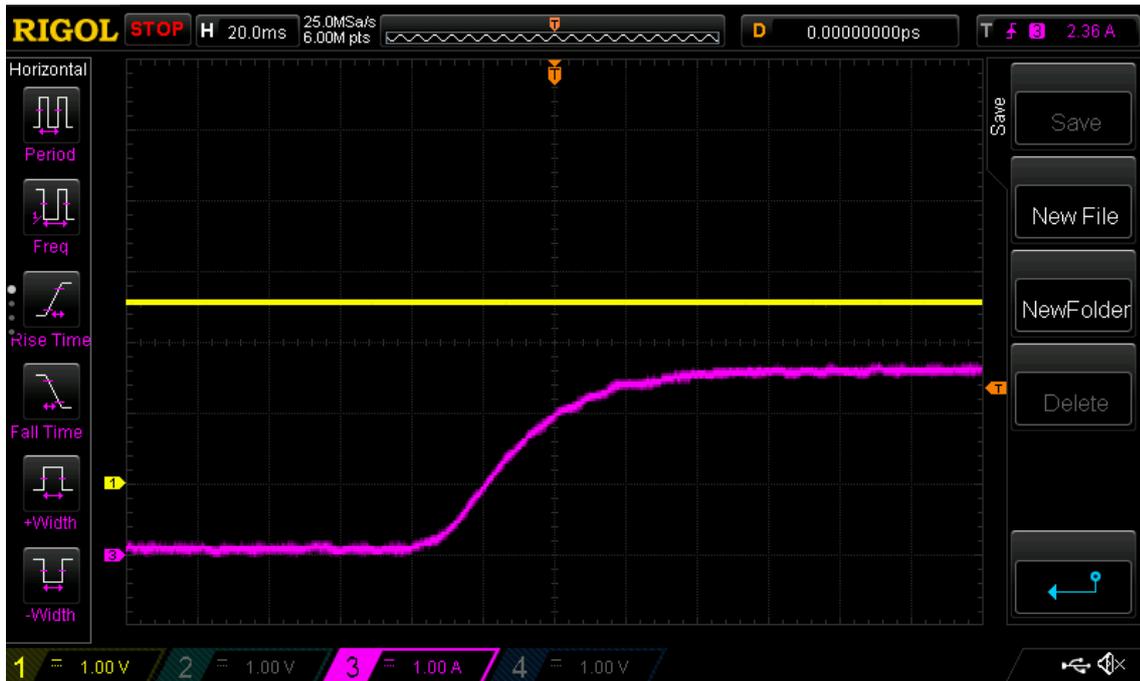


Waveforms

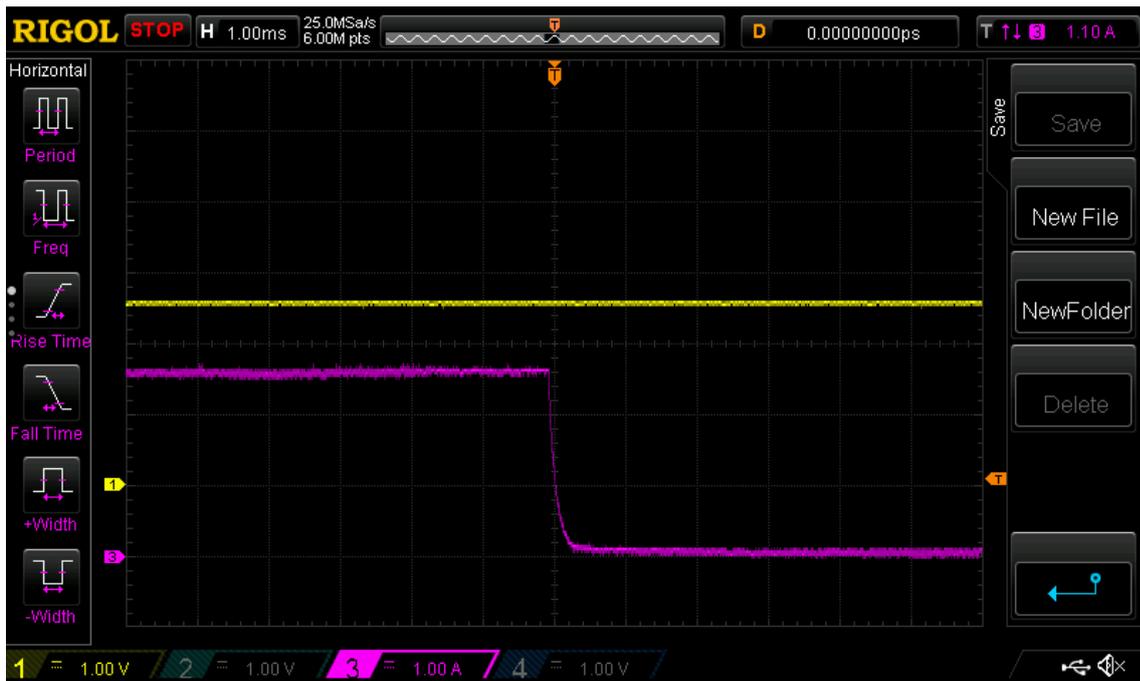
All Waveforms recorded with Rigol DS1104

Yellow: Modulation Input

Violett: Current Output



Turn on event e.g. connecting 48V to tuned driver with modulation signal already in place with 2.5V modulation signal and I_{max} tuned to 5A.
No overshoot and 65ms softstart time



Turn off event e.g. disconnecting the power supply with 2.5V modulation signal and I_{max} tuned to 5A.



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Development

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Square wave 2App



Sine wave 2,2Mhz 1,5App



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Notes