DRIVER BOARD EBD11200

Product Specification Document

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1 SCOPE

1.1 PURPOSE

The purpose of this document is to describe the set of functional features, the performance and the user interfaces of the 4-channel EXALOS' analog driver board EBD11200 for combined SLED modules (Super-Luminescent Emitting Diodes), including RGB engines.

1.2 BOARD REVISION

This product specification is based on the EBD11200 production series, revision V1.

1.3 RESPONSIBILITY

EXALOS is responsible for establishing, implementing and maintaining this specification. The quality representative shall ensure that a timely Engineering Change Notice (ECN) is issued in accordance with EXALOS' procedure for any changes.

2 PRODUCT DESCRIPTION

2.1 ARCHITECTURE

The EBD11200 is a high-performance driver board that consists of a multi-layer PCB board on which the 14-pin butterfly (BTF) module is soldered. The multi-layer PCB design with shielding ground layers allows for the co-existence of a highly efficient switched-mode temperature controller (TEC) with four independent low-noise linear SLED drive current controllers in a compact form.

A low-power microcontroller is used to control and monitor the operating conditions of the device and provide a comprehensive user interface that can be used for system integration.

Furthermore, the multi-layer PCB design features a sophisticated heat-spreading thermal design that reduces hot spots, which is the basis for stable operation at high ambient temperatures.

2.2 FEATURES

The main characteristics of the EBD11200 are:

- High-efficiency switched-mode TEC supporting high-power SLEDs at high ambient temperatures
- Generation of ultra-stable and ultra-low noise drive currents for InP-based, GaAs-based or GaN-based SLEDs with high compliance voltages up to ~3.0 V
- Individual adjustment of the SLED drive currents (and thus power levels) either through an external analog control voltage (0-2.5V) or through the USB interface
- Enabling the optical output either through a mechanical code switch, an electrical TTL signal or through the USB interface
- High-speed digital on-off modulation with TTL signals for each SLED individually up to 300 kHz
- One monitor photodiode (MPD) signal
- Noise and spike filter network and brown-out detector for input supply voltage
- Low-power, high-performance microcontroller with USB (serial) interface

The EBD11200 features a stabilization feedback loop for the SLED drive currents (automatic current control, ACC). Automatic power control (APC) can be supported through the microcontroller that would monitor and adjust the output power based on the MPD reading.

2.3 OPERATING RANGE

The EBD11200 has been designed for operation over a wide temperature range. Only industrial-grade components have been selected that are qualified for operating temperatures from -40 °C to +85 °C. The standard temperature operating range of the EBD11200 is 0 °C to +50 °C, though. Wider operating temperature ranges are available upon request.

The EBD11200 is designed to ensure proper operation in environments with electro-magnetic interference (EMI) by using a star-like ground concept and various levels of analog grounds throughout the design.

The EBD11200 supports a wide power supply range between +12 V and +24 V. Supply voltages outside this range may result in improper operation or elevated power dissipation of the electronics. Spiky and unstable supply voltages may activate the on-board spike and brown-out detector, resulting in a controlled shut-off followed by a ramp-up of the SLED currents. The required supply current is composed

of the sum of the SLED drive currents and of the Peltier current. The maximum supply current is 3 A for a maximum SLED drive current of 600 mA and a maximum Peltier current of 2400 mA at low supply voltages of 12V. Typical supply current under operation might be significantly lower, depending on the supply voltage, and depending on the SLED and ambient temperature.

2.4 ROHS COMPLIANCE

All components and fabrication or assembly processes used for the EBD11200 are compliant to the Restriction of Hazardous Substances directive 2011/65/EU (RoHS 2).

3 EBD11200 DRIVER BOARD

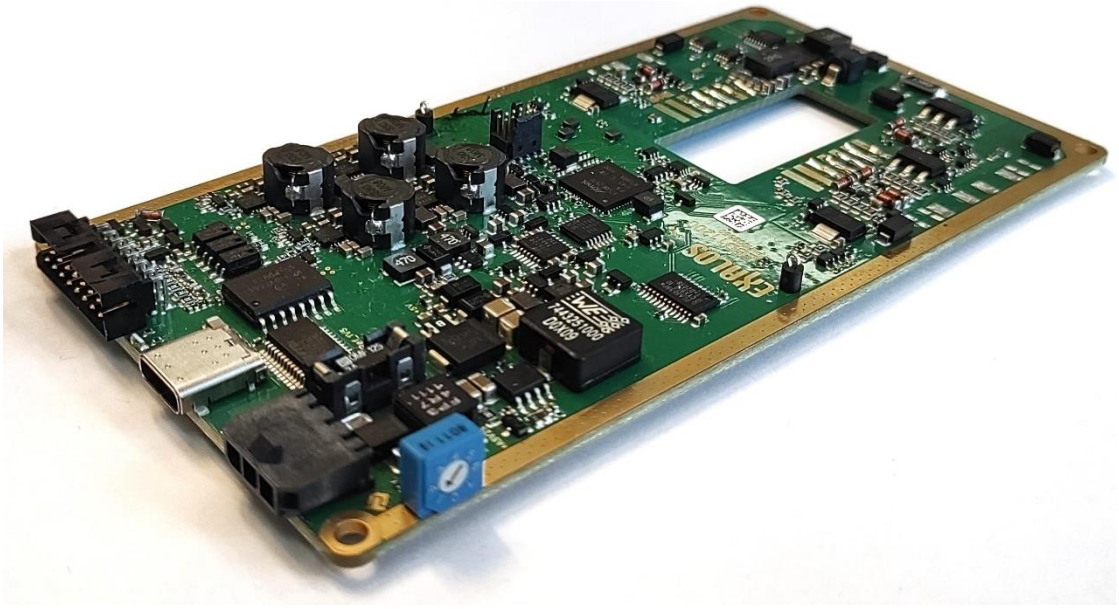

Fig 1: EBD11200 driver board (front view)

3.1 PRINTED CIRCUIT BOARD (PCB)

The EBD1200 board has a size of 132 mm (L) x 69 mm (W). Figure 2 shows pictures of the top view of the EBD11200 board. Figure 3 shows the front side of the board and the names of connectors, switches and LED indicators.

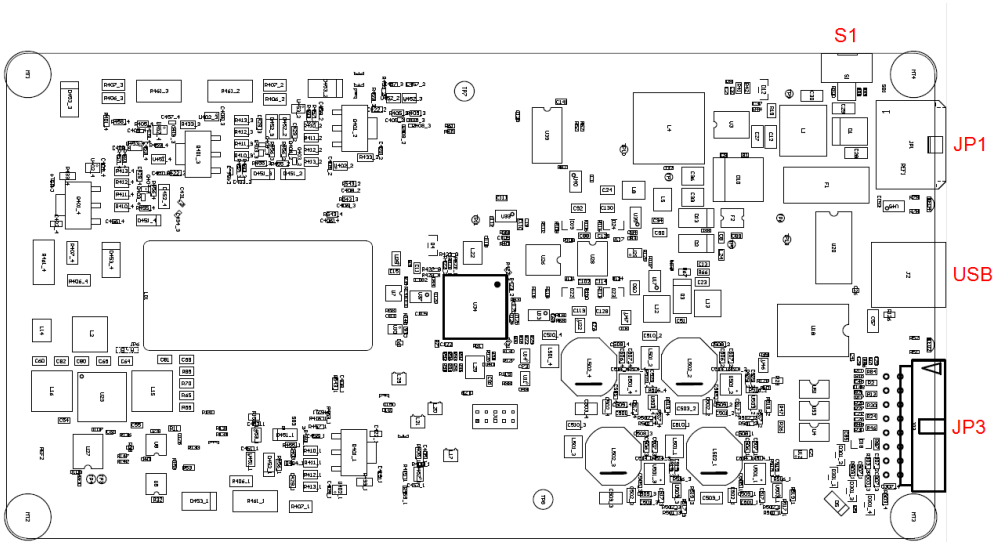

Fig 2: Top view of the EBD11200 indicating the user interfaces

3.2 ELECTRICAL USER INTERFACES

When the EBD11200 is, together with an SLED module, assembled into a metal case only the connectors JP1 and JP3 as well as the USB interface are accessible from the outside. In addition to the electrical interfaces, there are tree LED indicators, LED 5, LED1 and LED4, visible on the outside of the enclosure. Hidden inside the metal case and hence not accessible from the outside is the code switch S1, which allows for the selection of various operating modes, and two other LED indicators. Table 1 provides a list of all electrical connectors that belong to the user interface.

Name	Connector on EBD11200 board	Function	Mating connector for cable assembly
JP1	MOLEX "Micro-Fit 3.0"; 43650-0300 Header (male)	+24V power supply, GND, PE	MOLEX "Micro-Fit 3.0"; 43645-0300 Receptacle (female)
JP3	MOLEX "Milli-Grid"; 87833-1620 Header (male)	SLED enable & on-off modulation, analog and digital input & output signals	MOLEX "Milli-Grid"; 51110-1651 Crimp Housing
USB	Type-C USB connector	USB/serial configuration interface between microcontroller and host	Male USB Type-C

Table 1 List of on-board user interface elements including electrical connectors

Fig. 3 shows the front view of the connector JP1 and JP3. The corresponding pinout information is listed in Table 2 and Table 3, respectively.

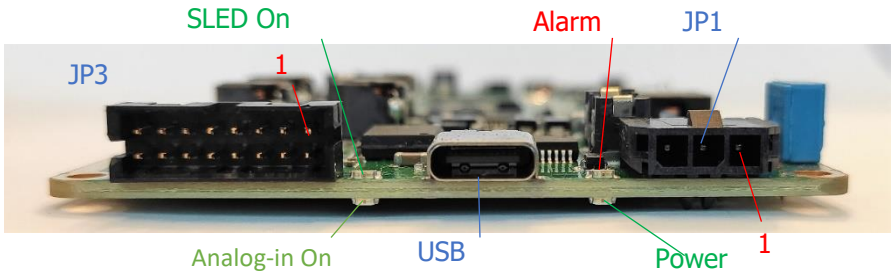

Fig 3: Front view of header JP3 and JP1 with pin indication, USB connector and LED indicators for Power, Alarm and SLED On.

Pin	Name	Function	Description /Comment
1	PE	Input	Protective Earth, to ground the metal case
2	GND	Input	External electrical Ground (3A)
3	+24Vext	Input	External power supply (12-24 V, 3A)

Table 2 Pinout of connector JP1

Pin	Name	Function	Description / Comment
1	AIN_enable	Input	Enable SLED current control through analog input (AIN) signals on pin 13, pin14, pin15 and pin16
2	+5V	Output	5V supply voltage from JP1, for configuration purposes only, e.g., enable the SLED through short to pin3. 100mA max.
3	SLED_enable	Input	LV TTL digital signal to enable/disable all SLED channels
4	GND_ext	Output	GND reference for all input and output channels, i.e., for digital modulation or SLED-enable input signals or for analog control input signals AIN, or for digital or analog output signals
5	Modulation_1	Input	LV TTL digital modulation signal for SLED 1
6	Modulation_2	Input	LV TTL digital modulation signal for SLED 2
7	Modulation_3	Input	LV TTL digital modulation signal for SLED 3
8	Modulation_4	Input	LV TTL digital modulation signal for SLED 4
9	SLED_enabled	Output	Digital output indicating that SLED is on
10	Alarm	Output	Digital output indicating any active alarm state
11	AOUT	Output	Multi-Purpose analog output (0…+2.5 V)
12	AIN_enabled	Output	Digital output indicating that SLED currents are controlled through analog input signals on pin13 to pin16
13	AIN_1	Input	Analog input voltage (0-2.5V) to control the current for SLED channel 1
14	AIN_2	Input	Analog input voltage (0-2.5V) to control the current for SLED channel 2
15	AIN_3	Input	Analog input voltage (0-2.5V) to control the current for SLED channel 3
16	AIN_4	Input	Analog input voltage (0-2.5V) to control the current for SLED channel 4

Table 3 Pinout of connector JP3

Pin8 to pin10 of connector JP3 contain digital alarm or status signals that are decoupled from the rest of the electronics through opto-couplers. They are open-collector outputs with a common ground "GND_ext" that is on pin4 of JP3. These status signals are also logically connected to the LED1, LED4 and LED2 that are found on the board, which are listed in Table 4.

LED	Name	Description / Comment
LED1	SLED On (green)	Indicating that at least one SLED is on
LED4	Alarm (red)	Indicating that any kind of alarm was detected by the firmware
LED5	Power (green)	Indicating supply voltage with correct polarity, measured after fuse and brown-out / spike detector
LED2	AIN enabled (orange)	Indicating that the drive current is controlled by the analog input voltage applied to pin13 to pin15 of JP3

Table 4 Configuration of LED indicators

The alarm signal on pin10 is a general alarm indicator that might be enabled for one of the following reasons:

- the board is unable to hold the target temperature of the SLED
- the supply voltage is not within specifications
- an unexpected behavior of one of the SLEDs was detected (e.g., excessive MPD signal).

Other alarm reasons are conceivable and may be added later. Specific information about the alarm at hand is available over the USB interface.

The output signal "AOUT" on pin11 of JP3 is a general-purpose analog output that can be configured over USB. The output voltage of the pin will be between 0 and +2.5V and proportional to the selected output parameter. By default, the output will be configured to the MPD voltage.

Pin5 to pin8 are digital modulation signals controlling each SLED individually. The "SLED_enable" pin3 acts as a master control and must be pulled to +5 V to enable any SLED.

The left half of connector JP3 contains pins for analog control of the SLEDs' drive currents and hence of the optical output power. The analog input pins shall be handled with care as they are not decoupled through opto-couplers, which may, in cases of false connectivity, result in unwanted GND loops. Pin 13 to 16 allow for applying an analog control voltage (0 to +2.5V) in order to control the drive currents of the SLEDs. The analog control input voltage is fed into an instrumentation amplifier of high accuracy, low offset voltage and low drift. Each SLED is controlled individually.

3.3 OPERATING CONDITIONS

Table 5 shows the typical, minimum and maximum operating conditions of the EBD11200 driver board.

Parameter	Min.	Typ.	Max.
Supply Voltage	11.2 V	24 V	28.8 V
Supply current when SLEDs are disabled but TEC is enabled (1)	0.25 A (@ 28.8V)	0.30 A (@ 24.0V)	0.80 A (@ 11.2V)
Supply current when SLEDs are enabled and TEC is enabled (2)		1.0 A	3.0 A
Ambient operating temperature (3)	0 °C		+50 °C
Ambient storage temperature	-40 °C		+85 °C

(1): Typical values at room temperature. Larger than typical supply currents can occur during power-up of the board or at extreme ambient temperatures.
(2): Typical values at room temperature and SLEDs up to 300 mA. Larger than typical supply currents can occur during power-up of the board or at extreme ambient temperatures, or for SLEDs requiring higher drive currents.
(3): Extended temperature range from -40°C to +85°C available upon request.

Table 5 Operating conditions of the EBD11200

3.4 PERFORMANCE CHARACTERISTICS

Table 6 shows the typical performance of an EBD11200 driver board when operated with a short-wavelength SLED module from EXALOS. The current stability and current noise performance of the EBD11200 will be similar to the performance of the EBD5x00 driver board family as the architecture of the current driver stage is very similar on both types of boards. Detailed performance measurements of the EBD11200 driver board for full validation still have to be carried out, though.

Parameter (ptp=peak-to-peak, rms=root mean square)	**Typical**	**Maximum Rating**	**Conditions/Comments**
Drive current		800 mA	
Compliance voltage		7.5 V	
TEC current		2.4 A	Extended TEC currents up to 3.0 A upon request
TEC temperature stability ptp 24h	±0.002 °C		Equivalent to ±100 ppm @ 20 °C
TEC temperature drift 1000h	±0.07 ppm/h		Linear interpolation over 1000 h
Current stability ptp 24h	±75 ppm		Ambient temperature constant within ±0.5 °C
Current stability rms 24h	±20 ppm		Ambient temperature constant within ±0.5 °C
Current stability ptp 1h	±75 ppm		Ambient temperature constant within ±0.5 °C
Current stability rms 1h	±20 ppm		Ambient temperature constant within ±0.5 °C
Mid-term current drift 24h	±9 ppm/h		1h sliding window
Long-term current drift 1000h	±0.5 ppm/h		Linear interpolation over 1000 h
Temperature-related current change (1)	±10 μA/°C		Average value, not including warm-up
Current noise	1.3 μA_{rms}		Extracted from spectral noise measurements (1 kHz – 10 MHz)
Turn-on delay to enable SLEDs (2)	500 ms		
Turn-off delay to disable SLEDs	<1 ms		
Turn-on delay on-off modulation (2,3)	100 ms		In 'slow' modulation mode
10:90 rise time on-off modulation (2,3)	250 ms		In 'slow' modulation mode
90:10 fall time on-off modulation (2,3)	<100 ns		In 'slow' modulation mode
Max. on-off modulation frequency (3,4)		1 kHz	In 'slow' modulation mode
Turn-on delay on-off modulation (2,3)	<10 ms		In 'fast' modulation mode
10:90 rise time on-off modulation (2,3)	25 μs		In 'fast' modulation mode
90:10 fall time on-off modulation (2,3)	<100 ns		In 'fast' modulation mode
Max. on-off modulation frequency (3,4)		300 kHz	In 'fast' modulation mode
Max. analog modulation frequency (3)	3 Hz		For all analog inputs

(1): Typically, a change of 1.0 mA or less in drive current is expected over temperature range from -40°C to +85°C.

(2): The EBD11200 features a built-in safety circuitry that powers down the electronic driver stage of the SLEDs whenever the SLEDs are disabled. This guarantees that under no circumstances the driver board can generate any light output from the SLEDs as long as the SLEDs are disabled. Furthermore, this turn-on delay also guarantees a controlled power-up behavior of the board in case the supply voltage is cycled while the SLEDs are enabled.

(3): The default configuration of the EBD11200 board is optimized for lowest possible noise performance with modulation rates of a few Hertz. The board can be configured for modulation mode using the USB interface which allows on-off modulation frequencies up to 1 kHz.

(4): Upon request, customized versions of the EBD11200 can be realized that support faster modulation rates up to 300 kHz, possibly at the expense of higher current noise or inferior pulse shape.

Table 6 Typical performance characteristics of the EBD11200

4 PACKAGED SLED DRIVER MODULE

The EBD11200 was designed as an OEM board to be used in various system environments. The EBD11200 is only available as a packaged module with an aluminium metal case, in which the driver board and the combined SLED module are assembled. The bottom part of the aluminium case will act as a heat sink for the optical SLED module. Furthermore, the metal case was designed to be mounted on a base plate of the corresponding system to improved thermal dissipation through heat conduction.

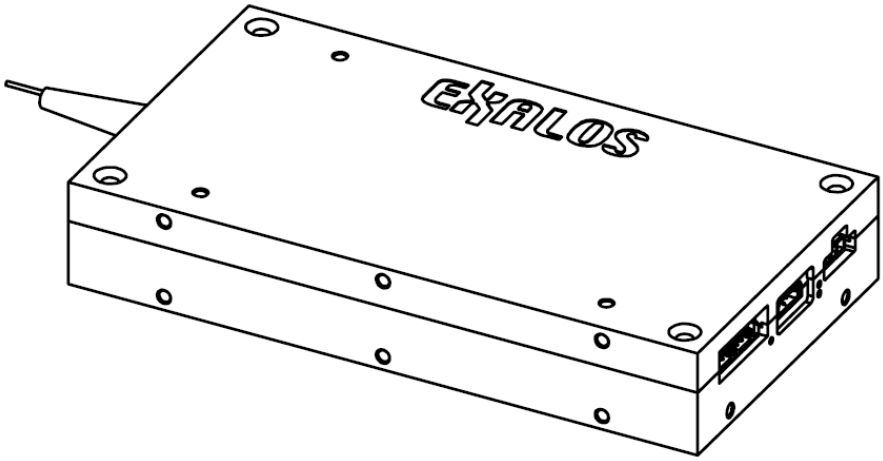

Fig 4: Rendering of the EBD11200 enclosure with the optional fiber snout.

Fig. 4, Fig. 5 and Fig. 6 show the metal case for the EBD11200 driver board assembly. The outer dimensions of this assembly without the optional snout are 138 mm (L) x 75 mm (H) x 23 mm (W). As shown in Fig 5: , the optical window is placed slightly decentered at a height of 15.1 mm measured from the base.

The enclosure supports both free-space and fiber-coupled optical modules. In the case of a free-space module, the exit pupil of the beam is at the same position as the fiber snout.

The side of the metal case provides access to the connectors JP1 and JP3 as well as to the USB connector and the three side-facing status LEDs.

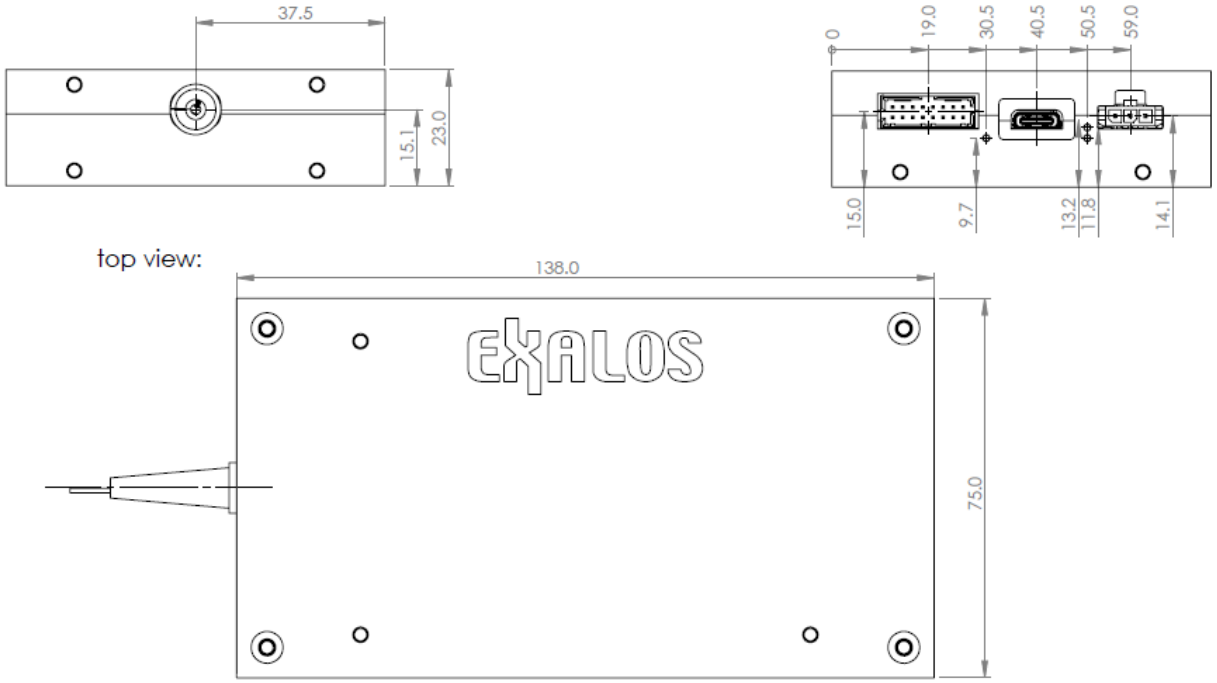

Fig 5: Mechanical drawing of the metal enclosure including the optional fiber snout.

The enclosure provides M3 mounting holes on each side that can be used to the assembly to a fixture or device of choice. The bottom side of the enclosure is used for heat dissipation and must be mounted on a heatsink or heat-conductive fixture. On request, EXALOS can provide the assembly with heatsink or several types of mounting adapters (e.g. for 25mm or 1" breadboards).

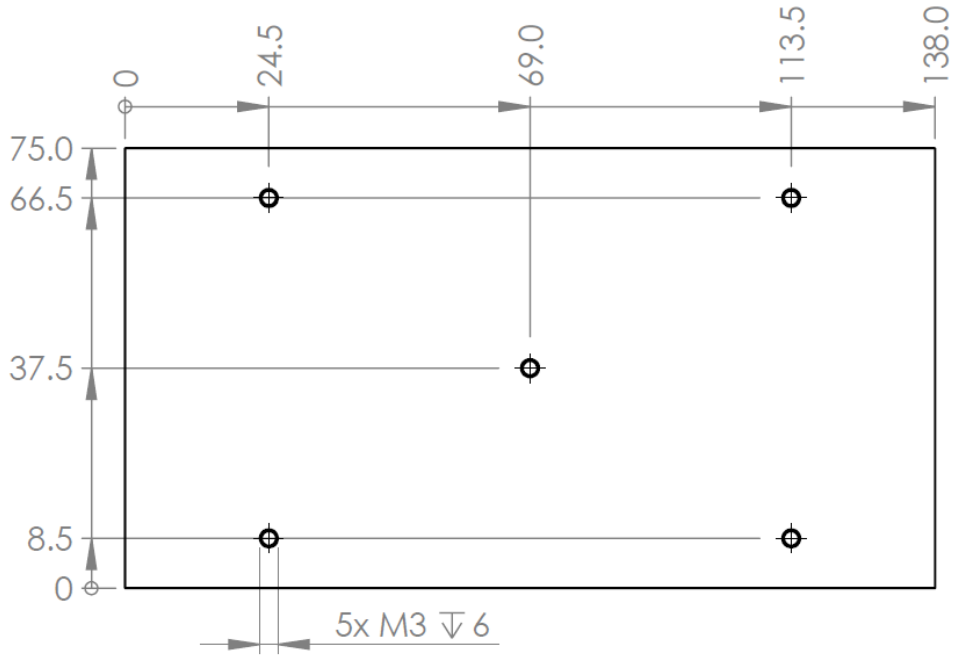

Fig 6: Mechanical drawing of the bottom side of the EBD11200 enclosure with the mounting holes for the heat sink or custom mounting adapters

In order to provide a shield against electro-magnetic interference (EMI), pin1 of the power supply connector JP1 shall be connected to PE through a short cable. Having a short contact to PE is essential to provide high-frequency shielding of the driver board and the mounted SLEDs. Alternative to pin1 of JP3, a PE cable can be directly connected to the metal case using one of the M3 mounting holes. The non-conductive electroplated surface finish is scratched by the mounting screw, for example by using a toothed washer in between the screw and the metal case.

5 OPERATING INSTRUCTIONS

5.1 AMBIENT TEMPERATURE

Make sure the ambient operating temperature is within 0 °C to +50 °C, unless specified differently by EXALOS.

5.2 SUPPLY VOLTAGE

Make sure a stable supply voltage within 12 V to 24 V is applied with the correct polarity. Polarity inversion will not harm the optical module but might eventually result in damage of the on-board supply voltage filter network. For first testing, it might be useful to set the current limit to 1.5-2.0 A. The on-board 3A fuse has a current- and temperature-dependent pre-arcing time, i.e. lower current limits will result in longer pre-arcing times and hence more time for the user to react to accidental polarity inversion. The EBD11200 is not sensitive to noise of the supply voltage as it features various filter networks and ground decoupling stages as well as a spike and brown-out detector.

5.3 PROTECTIVE EARTH (PE)

Make sure to provide a low-impedance connection to protective earth in order to avoid unwanted and uncontrolled electro-static discharges (ESD). A PE connection can either be realized through a short cable connection at the power supply connector JP1 (pin 1) or through direct connection to the metal case. For the latter, a toothed washer could be used to remove locally the anodization and to realize a conductive connection to the PE of the surrounding system.

5.4 TEMPERATURE CONTROLLER (TEC)

The TEC is working as soon as a supply voltage is applied to the board. The TEC is a high-performance switched-mode controller that is working at an internal frequency of 1 MHz. Depending on the ambient temperature, it may take a few seconds after turn-on of the board for the TEC to stabilize the module temperature. During this stabilization period, the TEC may operate the Peltier element at a maximum current of 2.4 A, resulting in a high supply current. It is recommended to enable the optical module only when the TEC is in a stable condition, indicated through the alarm (LED4 and pin10 of JP3) being off.

5.5 ENABLING THE SLEDS

The SLEDs inside the optical module are enabled and the optical power is turned on either by applying a 5V signal to pin3 of JP3 (active-HIGH). When using an electronic enable signal, e.g., a 5V TTL signal from an external host or external controller, make sure that the voltage is relative to the GND_ext on pin4 of JP3. Enabling the SLEDs will first power up all OpAmps of the driver stages before the optical power is turned on after a built-in time delay. The turn-on sequence guarantees proper operation of the driver board even when the power supply is hot-plugged though the optical module was enabled. This means that the optical module can be enabled with the drive current being set to the maximum level, i.e. it is not necessary to ramp up the drive current manually. Furthermore, the driver board generates a current ramp of several milliseconds at turn-on to avoid optical power overshoots.

5.6 ADJUSTING THE DRIVE CURRENT

The SLED current levels can be either manually adjusted through the USB interface or through an analog control signal (AIN, 0 to +2.5V) applied to pin13, pin14 or pin15 of JP3. When adjusting the current level electronically, make sure that the analog control is enabled (AIN_enable, pin1 of JP3). When using a signal for AIN_enable, e.g., 5V TTL, make sure that the voltage is relative to the GND_ext on pin4 of JP3.

The analog input voltage is limited to 2.5V on the board to ensure safe operation. AIN voltages larger than 2.5V are clipped and an alarm signal is enabled (LED4 and pin10 of JP3). The generated SLED drive current is linearly proportional to the analog input voltage, resulting in a typical "L-I-curve" characteristics, as shown in Fig. 7. At the maximum input voltage, the EBD driver board generates the maximum drive current that is factory pre-set individually for each SLED product.

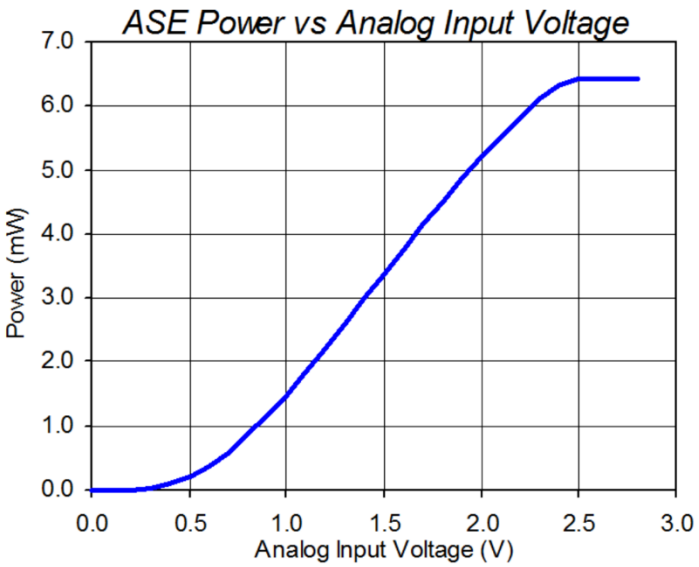

Fig 7: "L-I-curve" of an EBD11200 assembly where the light output is increasing proportional to the analog input voltage at JP3 up to 2.5V.

5.7 ON-OFF MODULATION

The current of the SLEDs can be turned on and off with a TTL modulation signal through pin5, pin6 and pin7 of JP3 (see Table 3). The logic is inverted, i.e. an open connection at any of these modulation pins or 0V (LOW) leaves the SLEDs on (optical power is HIGH) while 5V (HIGH) turns the SLED off (optical power is LOW). When using an active modulation signal, e.g., 5V TTL, make sure that the voltage is relative to the GNDext on pin4 of JP3.

The maximum modulation frequency is specified in Table 6.

Faster modulation frequencies may be realized upon request. However, faster current rise times can, in principle, lead to unwanted optical power transients if the rise time of the drive current is below the thermalization time of the SLEDs, which is typically in the range of 10 μs. Therefore, EXALOS offers faster modulation rates only based on customer requests. Typical optical rise and fall times that can be achieved using the on-off modulation inputs are shown in Table 7.

There is no intentional time delay or current ramp for the turn-on of the SLED under on-off modulation, different to the procedure of enabling any of the SLEDs. Turning off the any SLED through pin5, pin 6 or pin7 of JP3 will also not power down the OpAmps of the driver stage.

	Modulation speed = slow (default)	**Modulation speed = fast**
10:90 rise time	250 ms	25 µs
90:10 fall time	<100 ns	<100 ns

Table 7 Optical rise and fall time of on-off modulation modes

5.8 ANALOG CURRENT MODULATION

The SLED current level and hence the optical power can be varied or slowly modulated through pin13, pin14, pin15 and pin16 of JP3. The maximum modulation frequency is specified in Table 6. Faster modulation frequencies may be realized upon request.

5.9 OPEN-COLLECTOR OUTPUTS

Status and alarm indicators at JP3 are realized as open-collector outputs that are decoupled from the GND potentials of the EBD11200 driver board. According to Table 3, these digital outputs are "SLED_enabled" (pin), "AIN_enabled" (pin9) and "Alarm" (pin10). In order, for example, to illuminate an external LED in the presence of an alarm, a minimum load has to be considered to limit the current through the open-collector opto-couplers on the EBD11200 board, as shown in Fig. 8. Positive external voltages (+U) in the range of 3V to 28V are acceptable as long as the current does not exceed 20 mA. For example, for a voltage +U=5V a minimum load R of 250 Ohms would be required. The external voltage +U shall be relative to GND_ext at pin4 of JP3.

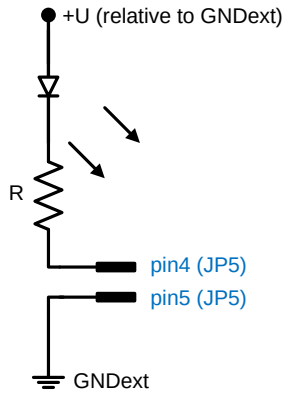

Fig 8: Example of using an open-collector alarm output of JP3 to illuminate an external LED. The load R limits the current to max. 20 mA.

5.10 DISABLING THE SLEDS

In order to disable the SLEDs and hence the optical output, apply 0V to pin3 of JP3 (active-HIGH). When the SLEDs are disabled all OpAmps of the SLED driver stages are powered down as an additional safety feature. In case of loss of supply voltage before disabling it, the SLEDs are automatically and safely powered down.

5.11 HOT-PLUGGING THE SUPPLY VOLTAGE

As mentioned earlier the supply voltage of the EBD11200 can be hot-plugged while the SLEDs are enabled without harming the SLED. The SLEDs are safely powered up or powered down when the supply voltage is hot-plugged.

5.12 WARM-UP TIME

As any other electronics the EBD11200 has a warm-up time until, for example, the current drift during the turn-on phase is minimized. Typical warm-up time at 20 °C ambient temperature is 20 minutes.

5.13 TEMPERATURE ALARM

In case of a permanent temperature alarm for more than 30 seconds, the drive current is automatically disabled in order to protect the SLEDs. This may happen if the heat sinking of the optical module is insufficient or if the ambient temperature is exceeding the specified operating range, or if otherwise the TEC is unable to control the temperature of the SLEDs.

6 REVISION HISTORY

Revision History				
Rev.	**Description**	**ECN Number**	**Date (ECN)**	**Released**
0.1	First release (preliminary)	-	-	27-Oct-2022

Appendix I – Mechanical Adapters