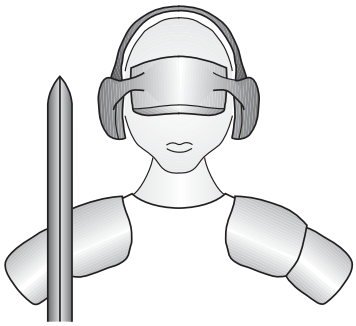
LED-Warrior04

Intelligent 4 channel LED driver with bus interfaces



Code Mercenaries

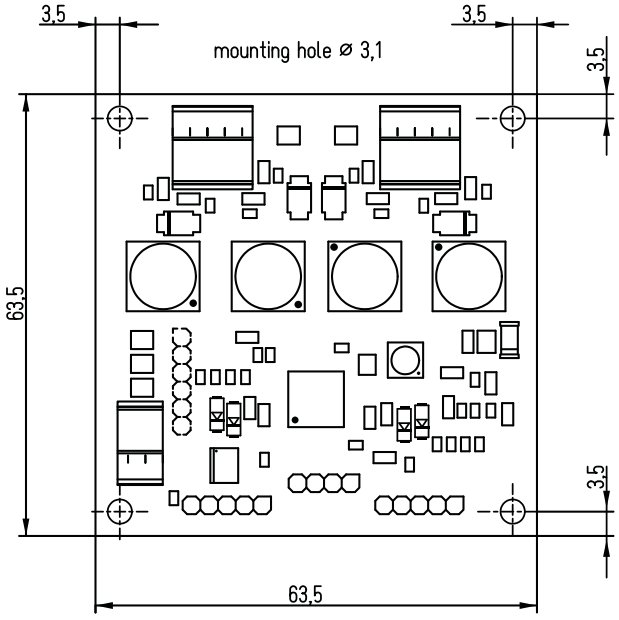
1. Features

- Four channel HB LED driver
- Input voltage 7 - 32V
- Constant current output 80mA to 1000mA
- Current programmable per channel
- Internal 12 bit PWM for each channel
- Maximum output power: 25W per channel
- Up to 94% efficiency
- I2C control and programming interface
- DMX512 control
- DALI (bus interface on add on module)
- Wireless add on module (compatible with Bluetooth 4.0)
- Autonomous operation, configurable via I2C
- Programmable dynamic light scenarios

2. Functional overview

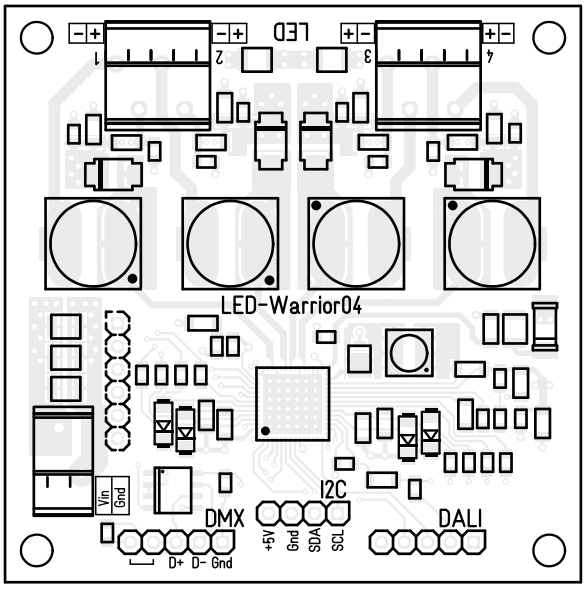
LED-Warrior04 is a point-of-load regulator for LED lighting applications. It offers multiple options for lighting control. Direct control of the four channels via I2C, DALI, DMX512, or wireless is possible as well as autonomous operation with settings preprogrammed via I2C, including dynamic light scenarios.

3. Mechanical dimensions



Dimensions in mm
Height at thickest point: tbd
Tolerances:
Outer contour: ±0.2mm

3.1 Pin Description



Vin
Supply voltage input. Apply a DC voltage of 7V to 32V here. The input is protected with a fuse.

GND
Ground reference.

DMX+/DMX-
RS485 DMX connection, connect direct to the DMX bus. Close jumper for bus termination.

I2C
SDA, SCL lines of the I2C interface.
+5V can supply power to add on modules like the wireless module. Do not connect an external power supply here!

DALI
The DALI physical bus interface module can be placed on this header

Ch1, Ch2, Ch3, Ch4
Outputs to the LED strings. The negative pins are not identical with ground. Do not connect pins of two outputs together!

4. Connecting the LEDs
The maximum number of LEDs that can be driven by LED-Warrior04 depends on the supply voltage and the combined forward voltage of the LEDs.
Input voltage needs to be about 2.5V higher than the total forward voltage of the LED string for proper operation.
Connect the LED strings between the + and - outputs for each channel.

4.1 EMC
LED-Warrior04 has been designed to produce a minimal level of RF emissions.
As a component LED-Warrior04 can not be EMC approved but the EMC tests in a typical configuration were completely unproblematic. Test results are available on request.

5. Controlling the LW04
LED-Warrior04 is designed to be controlled via I2C, DMX-512, or DALI. It can also be programmed for autonomous sequence operation.

5.1 I2C control
The primary configuration and control interface for the LED-Warrior04 is the I2C interface. It allows to set all parameters of the LW04, change the DMX address, set channel currents for DALI mode, and to program it for autonomous operation.

5.1.1 I2C addressing
The factory defaul I2C address is xx
The LW04 I2C address can be programmed to any valid I2C address by sending a broadcast command (address 0) followed by the register number $04 and the new I2C address.
To change the address LW04 has to be the only device connected to the I2C.

5.1.2 I2C Registers
I2C communication with the LW04 is done via registers. The first byte of a write transaction contains the register number.
A read transaction always reads from the last accessed register. Reading multiple registers in a single transaction is possible by reading the appropriate number of bytes (i.e. reading 4 bytes from register 2 returns the current settings for all four channels).
The register address is not changed by a read command, i.e. if the last register accessed was register 6 any subsequent read access will go to that register until the register number is changed by a write transaction.

Reg#	Bytes	R/W	Description
1	9	R	Device Descriptor
2	1	R/W	Current Channel 1
3	1	R/W	Current Channel 2
4	1	R/W	Current Channel 3
5	1	R/W	Current Channel 4
6	2	R/W	PWM Channel 0 (12 bit)
7	2	R/W	PWM Channel 1 (12 bit)
8	2	R/W	PWM Channel 2 (12 bit)
9	2	R/W	PWM Channel 3 (12 bit)
10	1	R	LED Status
11	1	R/W	Controller Mode 1
12	1	R/W	Controller Mode 2
13	2	R/W	DMX512 Start Slot
14	1	W	Flash Write / Reset
15	2 / 9	R/W	Sequence Mode Table

All multi byte values are in little endian format (first byte contains least significant bits).

5.1.3 Register 1: Device Descriptor (read only)
Byte 1: Length Byte
Length of register 1 including the length byte itself. (Future versions may append additional data)
Byte 2-5: Serial Number
A unique 32-bit serial number, factory programmed, LSB first
Byte 6-7: Version
The 16-bit value is composed of the following halfbytes (LSB first):
<Major-Version>.<Minor-Version>.<Major-Release>.<Minor-Release>
Byte 8-9: Model
$0004 for standard LED-Warrior04, LSB first.

5.1.4 Register 2 - 5: Channel X Current
The average output current for channel 1/2/3/4 in milliampere divided by five (i.e. decimal 100 equals 500 mA drive current). Values from 16 to 200 are valid, out of range values will be clipped.
Writing to the channel current registers must be enabled by setting the enable bit in register 11. Any write to registers 2-5 are ignored unless bit 7 in register 11 has been set.

5.1.5 Register 6 - 9: Channel X PWM
A 12-bit little endian value to fade channel 1/2/3/4. Changes to these registers will only take effect if I2C is set as dimming input in controller mode 0 register (register 11). LSB first

5.1.6 Register 10: LED Status (read only)
Values are valid only after performing a check command (register 12, bit 7)
Bit 0 - Channel 1 status 0
Bit 1 - Channel 1 status 1
Bit 2 - Channel 2 status 0
Bit 3 - Channel 2 status 1
Bit 4 - Channel 3 status 0
Bit 5 - Channel 3 status 1
Bit 6 - Channel 4 status 0
Bit 7 - Channel 4 status 1

The two bits contain the status for a channel:
0b00 - normal function
0b01 - open circuit or undervoltage
0b10 - unused, may be used for future function
0b11 - unable to test, the channel was switched off (see register 11)

5.1.7 Register 11: Controller Mode 1
Bit 0 - Activate channel 1 driver (1 = active)
Bit 1 - Activate channel 2 driver (1 = active)
Bit 2 - Activate channel 3 driver (1 = active)
Bit 3 - Activate channel 4 driver (1 = active)
Bit 4 - Dimming source 0
Bit 5 - Dimming source 1
Bit 6 - Activate sync mode
Bit 7 - Enable current setting

Dimming source selects which bus is active or if an autonomous sequence controls the channels:
0b00 - I2C
0b01 - DMX512
0b10 - DALI
0b11 - Sequence Mode
Activate sync mode selects synchronized dimming mode when set to 1. If sync mode is enabled any values written to registers 6…9 are used after receiving a broadcast $0A I2C command. This allows to switch multiple LED-Warrior04 to new brightness values simultaneously to avoid a wave effect that would occur with sequential writing.
Enable current setting has to be set to "1" prior to any writes to registers 2-5. This is intended to prevent accidentially setting current values that may damage the connected LEDs. Writing to any other register than a channel current register does reset this bit.

5.1.8 Register 12: Controller Mode 2
Bit 0 - unused, always write as 0
Bit 1 - unused, always write as 0
Bit 2 - unused, always write as 0
Bit 3 - unused, always write as 0
Bit 4 - unused, always write as 0
Bit 5 - Sequence write, enables writing register 15
Bit 6 - DMX linear (1 = disable logarithmic curve)
Bit 7 - Test channels, sets the flags for register 10

Sequence write has to be set to enable writing a new sequence table via register 15. Writing to any other register than 12 or 15 resets this bit. Completing the write of a sequence table also resets this bit.
DMX linear allows to disable the default logarithmic mapping of DMX 8 bit dimming value to 12 bit PWM values. If this bit is set the DMX values will be multiplied by 16 to generate the PWM values. Default is that the DMX values are mapped via a logarithmic table to get a physilogically optimized dimming curve.
Test channels generates a 2 ms current pulse on all enabled channels to test for short or open circuit conditions. Writing this bit as 1 performs the test, sets the bits in register 10 and resets the test channels bit.

5.1.9 Register 13: DMX512 Start Slot
This 9-bit little endian value will be used as the first slot number of four consecutive DMX slots which will be used to set the PWM channels if DMX512 is set as dimming input in register 11 (Controller Mode 0)

5.1.10 Register 14: Flash Write (write only)
Register 14 allows to write the current settings to the flash memory. On the next power up reset the settings will be retrieved from flash memory and used as default.
Bit 0 - unused, always write as 0
Bit 1 - unused, always write as 0
Bit 2 - Store sequence table in flash
Bit 3 - Store DMX start slot number in flash
Bit 4 - Store controller mode in flash
Bit 5 - Store PWM values in flash
Bit 6 - Store current values in flash
Bit 7 - Restore values from flash

Writing any of the bits as "1" does cause the corresponding currently active parameters to be written to flash memory.
Writing $80 to this register performs a soft reset. All controller variables are set to the values stored in flash memory.

This command resets the LW04 to the same status as a power up does, it can not be combined with any write commands.

5.1.11 Register 15: Sequence Table Writing
Sequence mode allows the LED-Warrior04 to autonomously perform dynamic lighting scenarios. This can be used to generate a power on fading, continous changing light situations, flashing, color changing, or any other lighting applications where a dynamic lighting without a external controller driving it is required.
Sequence mode is controlled by a table containing time and PWM values. The table is specified in 5.2.
Before writing to register 15 it has to be enabled by setting bit 5 of register 12 to "1". The write bit is automatically reset when the table has been written completely or an error condition occured.
Each write transaction to register 15 can contain 1 to 9 data bytes. Write transactions automatically go to ascending table positions until an error condition is detected, or the table is complete.
Reading from register 15 returns a two byte status for the sequence table. If the table has been written successfully the first byte contains the number of bytes written and the second holds a checksum generated by xoring all table bytes.
In case of an error the first byte is set to zero and the second byte contains the error code:
$00 -
$01 - Write bit has been reset before a complete table header was transmitted
$02 - Write bit has been reset before a complete table (number of data sets according to table header) was transmitted
$04 - More data sets than specified in the table header have been written
$08 - Write access to other registers terminated the table writing
$10 - Write attempt to register 15 without write enable bit being set.
$20 - Length data in table header specify too many data sets (>81).

5.1.12 Broadcast Commands
LED-Warrior04 implements three I2C broadcast commands. Broadcast comamnds are write only and are send to address 0.
$04 followed by one data byte sets the I2C address of the LED-Wariror04 to the data byte as the new I2C address, values 1…127 are valid.
$0A triggers the activation of new brightness values for all LED-Warrior04 in sync mode (set in register 11).
$0B followed by one data byte sets the dimming source on all connected LED-Warrior04 simulatneously. This is useful to synchronously start sequence mode on several LED-Warrior04.
The data byte has only two active bits:
Bit 0 - unused, write 0
Bit 1 - unused, write 0
Bit 2 - unused, write 0
Bit 3 - unused, write 0
Bit 4 - Dimming source 0
Bit 5 - Dimming source 1
Bit 6 - unused, write 0
Bit 7 - unused, write 0

Dimming source selects which bus is active or if an autonomous sequence controls the channels:
0b00 - I2C
0b01 - DMX512
0b10 - DALI
0b11 - Sequence Mode

5.2 Sequence Mode Control
If sequence mode is enabled as the active dimming source and a valid sequence table has been loaded LED-Warrior04 will work autonomously executing the sequence table.
The sequence table is made up of the table header and up to 81 data sets.
The table header contains the following 10 bytes:
Byte 0 - Sync 0/1
Byte 1 - Sync 2/3
Byte 2 - Repeat 0
Byte 3 - Repeat 1
Byte 4 - Repeat 2
Byte 5 - Repeat 3
Byte 6 - Length 0
Byte 7 - Length 1
Byte 8 - Length 2
Byte 9 - Length 3

Sync contains the flags for each channel to synchronize with other channels. Sync 0/1 contains the sync bits for channel 0 in the lower half byte and for channel 1 in the upper half byte. Sync 2/3 contains the sync bits for channels 2 and 3.
If a sync bit is set the channel waits for the corresponding channel to come to the end of its sequence instance before it continues with the next iteration of its own sequence.
I.e. if Sync0/1 is $04 then channel 0 will wait for channel 2 to reach the end of its sequence iteration before it starts its own next iteration. If channel 2 had already reached its sequence iteration end then channel 0 will continue immediately. Setting Sync0/1 to $12 will cause channels 0 and 1 to wait

for each other at the end of their sequence iteration to continue together.

Repeat contains the number of iterations for the sequence for the corresponding channel. $00 means the sequence will repeat infinitely.

Length sets the number of data sets for each channel. Data sets are stored consecutively in the table, starting with those for channel 0. If there are 0 data sets for a channel it takes up no space in the table.

Data sets contain three bytes each:
Byte 0 - PWM LSB
Byte 1 - Time LSB
Byte 2 - PWM/Time MSB

Byte 2 contains a half byte MSB for Time in its lower half byte and a half byte MSB for PWM in its upper half byte to get a total 12 bit value for each PWM and Time.
PWM is the brightness value that should be reached and Time the time to transition from the currently active value to that target value in 10 ms steps. The maximum transition time in one data set is 40.95 s. A time value of 0 is invalid and automatically corrected to 1. Transition between the values is linear.
For longer transition times or non linear behaviour multiple data sets may be used.

5.3 DMX512 Control

Since DMX512 is a simple lighting protocol it allows only to set the brightness (PWM) values of the output channels.
The starting slot number for DMX512 can be set via I2C, Four consecutive slots are used to control the brightness of the four channels.
To use DMX512 it must be set as the control source in I2C register 11.

5.4 DALI Control

LED-Warrior04 implements the DALI protocol according to DIN EN62386-102 and DIN EN 62386-207, as required for control gear for LED.
LED-Warrior04 shows up on the DALI bus as four separate devices.
To use DALI it must be set as the control source in I2C register 11.

6. Regulator efficiency

The regulator efficieny depends on a number of parameters. Since there are a couple constant losses independent of the total power delivered by the regulator the basic rule is that the regulator is more efficient when used at higher power (i.e. more LEDs connected). A lower difference between input and output voltage does also increase the efficiency.

6.1 Output current

Maximum output current per channel is 1 A.

6.2 Reliability

tbd

7. FCC / CE

The LED-Warrior04 is sold as a module to be integrated into a device. As such it can not be FCC or CE approved.
Code Mercenaries has excerted greatest care in designing this module to minimize RF emission and assure safe and stable operation. Though the use of proper cable materials and correct integration into a device is crucial to assure product safety and interference free operation. The integrator who assembles the module into a device has to take care for appropriate construction and testing.
LED-Warrior04 has been EMC tested in a typical configuration and found to be well within the limits of CE and FCC. Test test documentation is available on demand.

8. Absolute maximum ratings

Input Voltage (Vin relative to GND):	0V to 36V
SDA, SCL pin input voltage (relative to GND):	-0.3V to 5.5V
Input Current:	4.5A (average)
Storage temperature:	-55°C to 115°C
Ambient temperature with power applied (no output driven):	-40°C to +85°C
ESD:	2000V (human body model)

Absolute maximum ratings must not be exceeded or permanent damage to the LED-Warrior04 may result.

8.1. Operating Conditions

Input Voltage (Vin relative to GND):	0V to 32V
SDA, SCL pin input voltage (relative to GND):	0V to 5V
Operating temperature:	-10°C to +60°C in still air
Maximum output power per channel:	25W
Maximum output current per channel:	1A

8.2 Thermal precautions

When operating at elevated ambient temperature, vertical mounting in an air volume sufficiently large to allow convection is recommended to reduce surface temperature of the regulator. Additional cooling measures can help to further reduce the regulator temperature and increase long term reliability.
No part of the module surface may exceed 95°C during operation.

8.3 Failure modes

The most common failure mode seen when the LED-Warrior04 is destroyed due to a departure from maximum operating conditions is that it goes into an inert status. Though it is not impossible that a failure can lead to an internal short circuit.

8.4 Recommended safety measures

Failure current limiting by a fuse dimensioned for the application or by a power source that is current limited is recommended.

9. Ordering information

Partname	Order Code	Description
LED-Warrior04	LW04-MOD	1A intelligent 4 channel LED driver
LED-Warrior04 DALI Module	LW04DI-MOD	Bus driver module for DALI connection of LW04
LED-Warrior04 Wireless Module	LW04BT-MOD	Wireless add on module for LED-Warrior04

The modules listed here are standard products. Customized modules are available on request.

9.1 Packaging info

LW04-MOD somes in anti static bags in single units.

10. Revision history

V1.0.0.4 - Fixed DALI problems:
Writing to persistent memory was delayed indefinitely if the bus power failed.
Actual Power was not reset to 254 by Reset command.

V1.0.0.3 - Further optimization of output behaviour to reduce RF emissions

V1.0.0.2 - Optimized output driver behaviour to increase efficiency

V1.0.0.1 - Fixed maximum current to 1 A, was formerly clipped at 875 mA

V1.0.0.0 - Initial shipping version

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