

PROTO DUEL™/KNIGHT™ RGB AND PIXEL USER MANUAL V2.0





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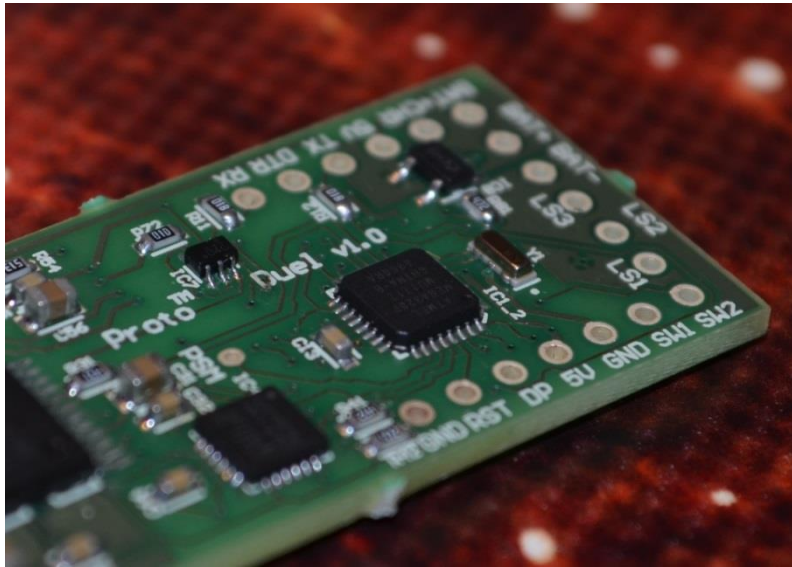


1 INTRODUCTION

The Proto **Duel** and **Knight** V2.0 saber boards for in-hilt blade illumination (**RGB**) and neopixel blades (**Pixel**) are ready to use, plug&play saber cores.

The **Duel** targets serious duelists who want a robust, decent saber for dueling classes, fathers building sabers for their kids and for those who want an excellent yet affordable saber core.

The **Knight** is the choice of saber cores for those who want a saber which can be used for heavy dueling, and at the same time offer the full range of saber effects with extended sound fonts, configurable set of effects ("Saber Skins[™]")



Board features on a glance:

- **Dimensions: 44mm x 21mm x 4.5mm**
- **supports RGB high-power in-hilt LED setups**
- **3(Knight)/2(Duel) sound banks (hum, 4(Duel)/6(Knight) swing, 4(Duel)/6(Knight) clash, boot, power on, power off, fontID sounds, 2 blaster deflect sounds (Knight only), lockup sound (Knight only) - sound fonts exchangable over USB**
- **comes with 3(Knight)/2(Duel) professional sound fonts from a saber font artist installed on-board**
- **supply: single 3.7V Li-Ion battery**
- **Audio: 16-bit digital audio, 22.050ksample/sec, 3W audio amp, 8Ohm speakers - loudest saber core on the market**
- **16/32 color profiles for blade and clash colors, selectable per sound font**
- **single momentary switch operated**
- **battery charging via USB or via RC-port**
- **FXs: AudioTracker blade flickering, EasyClash, flash-on-clash, blaster-deflect-on-the-Move FX (Knight only), lockup-on-Clash (Knight only)**



2 PROTO DUEL AND KNIGHT V2.0 FEATURES

Both major variants, the Duel and the Knight come supporting two different kinds of blade illumination techniques. As the names imply, the RGB is designed to drive high-power LED modules either with 3 different colors (Red/Green/Blue) for a color changing saber, or customized multi-dice high-power LED modules with up to 3 dice (i.e. B/B/Gr or R/R/W, to name just a few excellent combination for dedicated, ultra-bright blades), while the Pixel is designed to drive neopixel stripes.

The set of features common to both boards are:

- Ready to use: all Proto boards can be used out of the box. They are already programmed for you!
- The Proto boards come with two pre-installed, high quality sound fonts exclusive made for the Proto Saber Platform by Darth PJ, a saber font artist who also offers his sound fonts on <http://www.saberfont.com/>.
 - Proto Flash: a Light Side themed sound font
 - Proto Dark: a Dark Side themed sound font
- The sound fonts include following sounds:
 - Power-up
 - Power-down
 - Hum
 - Boot
 - Font ID
 - 4x Swings (Duel)/6x Swings (Knight)
 - 4x Clashes(Duel)/6x Clashes (Knight)
 - 2x Blaster deflect sounds (Knight only)
 - Lockup sound (Knight only)
- Sound fonts can be accessed and exchanged via USB: this is a unique feature of the Proto boards, they come with excellent sound fonts, however if you want a dedicated character saber with a sound font to match it, you can swap the pre-installed sound fonts with those of your choice. How to do it will be described later in this Manual.
- Interaction with the saber (**options in mauve color are available only for the Knight boards**):
 - After powering the saber or waking it up from Deep Sleep mode, the saber boot sound will be played and the saber will enter Idle Mode.
 - A short press on the Main Switch will activate the saber.
 - If the saber is activated, a long press on the Main Switch will deactivate the saber.
 - A long press on the Main Switch in Idle Mode will start the Configuration Mode.
 - The Configuration Mode has several menu items. Changing between the items can be done with a hit to the saber hilt, similar to making a clash move (Hit-and-Run) or **by a double click (2 short presses on the Main Switch)**. The menu items are:
 - Sound font selection: short press on the Main Switch will toggle the two sound fonts. The saber will announce the new sound font selected by playing its font ID sound.
 - Main Blade Color selection: short press on the Main Switch will let you browse the color profiles of your saber board (16 for RGB and 32 for Pixel) to define the color of your saber.



- Clash Color selection: short press on the Main Switch will let you browse the color profiles of your saber board (16 for RGB and 32 for Pixel) to define the color used for a Flash-on-Clash.
- **Blaster Deflect Color selection:** short press on the Main Switch will let you browse the color profiles of your saber board (16 for RGB and 32 for Pixel) to define the color used for the Blaster Deflect FX.
- **Swing Sensitivity Selection:** you can set the sensitivity of the swing detection in 20 steps. The blade color/bar graph will increase from red over yellow to green with increasing swing threshold. I.e. the bigger the value, the harder the gestures must be to trigger a swing. Default setting is 4, corresponding to the swing sensitivity of the Duel boards.
- Sleep Mode Entry: a short press on the Main Switch will put the saber to Deep Sleep mode with a very low power consumption
- **Saber Skin Selection:** you can use three different Saber Skins to personalize how each individual sound font can be interacted with when the saber is activated:
 - **Warrior:** this setting is for duelist who want only the two basic saber FX swings and clashes to be triggered, without accidentally activating any other FX. Selecting the Warrior Saber Skin will make a Duel-like board from the Knight for the chosen sound font.
 - **Guardian:** using this Saber Skin the blaster-deflect-on-the-move FX is unlocked. Pressing the Main Switch shortly will activate this special mode playing the blaster block FX, after which each swing motion will trigger a blaster block FX. Mode can be left by pressing the Main Switch shortly again.
 - **Hero:** this Saber Skin will unlock the full set of features available to the Knight board. On top of the features mentioned for Warrior and Guardian, the Hero will enter into a lockup-on clash mode by a double click (2 short presses on the Main Switch), triggering the lockup FX upon the next impact/clash. If the lockup-on-clash is triggered, it can be ended with a short press on the Main Switch.
- Volume settings: you can choose between 30 different volume setting, 0 gives you a muted saber (comes in handy for saber classes). After reaching the max setting, a different beep is played to notify you. Pressing the Main Switch again will set back the volume again to 0. In order not to lose track of where you are in the Configuration Menu, if the volume setting is below 15, the saber will maintain the volume setting at 15 in order to make interaction with it possible. Upon activating the saber the set volume will be used (i.e. if 0, saber will be muted).
- Pixel Blade Length (*only for Duel/Knight Pixel*): let's you define the length of your Neopixel stripe. A short press will increase the count by one, continuously pressing the Main Switch will increase the count every 200ms. Please note that you need to exit this menu item with a Hit-and-Run.
- Exiting Configuration Mode is done via a long press on the Main Switch (*except for Pixel Blade Length, see above*)



3 GETTING STARTED WITH THE PROTO BOARD

Warning: the Proto board is an electronic board containing parts sensitive to ESD. Final wiring & assembly is under the responsibility of the user with the appropriate tools and ESD protection. If you're not familiar with ESD, please visit : http://en.wikipedia.org/wiki/Electrostatic_discharge
The manufacturer cannot be held liable or responsible for any damage arising from improper use or assembly of the Proto board.

3.1 BOARD SUPPLY

The Proto Duel board shall be supplied from a single Li-Ion battery cell with a nominal voltage of 3.7V.

Warning: Please note that the Proto board does not implement a reverse polarity protection. Reversing the polarity of the supply will lead to board damage!

3.2 USB-RECHARGE WIRING

It is very convenient if the battery does not have to be removed from the hilt every time it needs recharging. Therefore so called in-hilt recharge ports found a wide-spread use in saber hilts together with rechargeable batteries (most common type being the 3.7V type 18650). The Proto board has an integrated Li-Ion USB charger module which can be used to charge the battery directly from USB, thus eliminating the need to include a bulky recharge port in the hilt. The USB breakout board provided with the Proto board can be used to connect the USB signals to a port in the hilt.

Error! Reference source not found. shows wiring of the battery to supply the board. If the USB cable is lugged in, the circuit will be supplied both by the battery and by the USB port, with any surplus current used to charge the battery. If there is no battery connected to the board, it can be supplied via USB through the USB charger circuitry, providing ~4.2V to the board with a maximum charging current of 250mA. Please note that if you connect a 2W 8/40hm speaker to the board and supply it only via USB (i.e. no battery connected), depending on the set volume the USB might not be able to supply the powerful on-board audio amp and you might hear a static noise from the speaker, as well as the board resetting due to under-voltage. Therefore it is recommended to connect the battery to the board if you want to use the speaker at full volume.

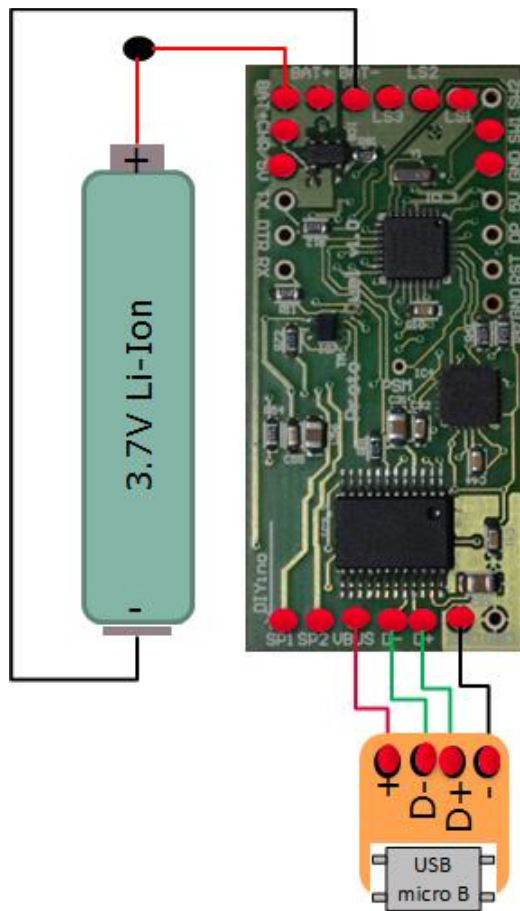


FIGURE 1: IN-HILT RECHARGE USING AN USB BREAKOUT-BOARD



Warning: before connecting any Li-Ion battery to the Proto board, please ensure that your selected battery complies to the charging characteristic of the USB on-board charger (CCCV with 250mA average charge current at 4.2V charge voltage). In case of doubt please consult your battery vendor. The board manufacturer of the Proto board cannot be held liable for any injury or damage due to incompatibility of the used battery with the on-board Li-Ion charger.

To make the Proto board compatible with hilt and chassis design having a so called recharge port (see for example [link](#)), you can use a conventional 2.1mm Recharge Port (or technically equivalent) to charge your single Li-Ion battery.

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3.4 DUAL RECHARGE SETUP

The Proto board is designed for dual-charging, i.e. the single Li-Ion cell can be charged either via USB or via Recharge Port, making it ideally suited for different circumstances like charging at home, quick recharge in the car or on an event/Con. full wiring diagram using the dual-charging scheme can be seen on Figure 7

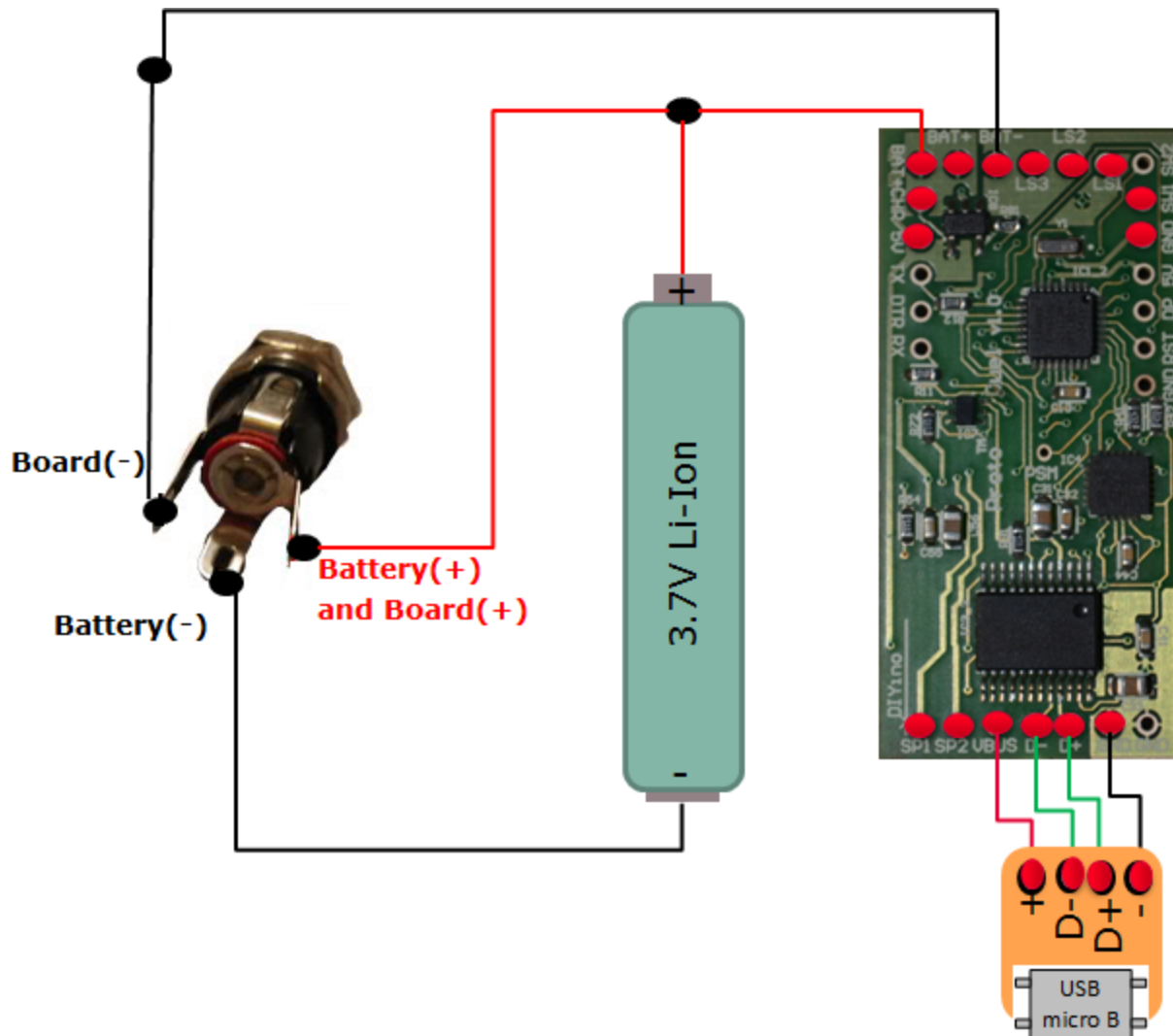


FIGURE 3: DUAL CHARGING SETUP WITH BOTH A 2.1MM RECHARGE PORT AND EXTERNAL USB PORT



3.5 WIRING BUTTONS AND SPEAKER

Figure 4 shows wiring of the switches and that of the speaker.

The speaker has to be connected between the SPK1 and SPK2 terminals/pins of the board. 4Ω/8Ω speaker can be used, up to 3W output power. It does not matter which terminal of the speaker you connect to which pin.

The main switch shall be connected between SW1 and GND. Only momentary switches are supported.

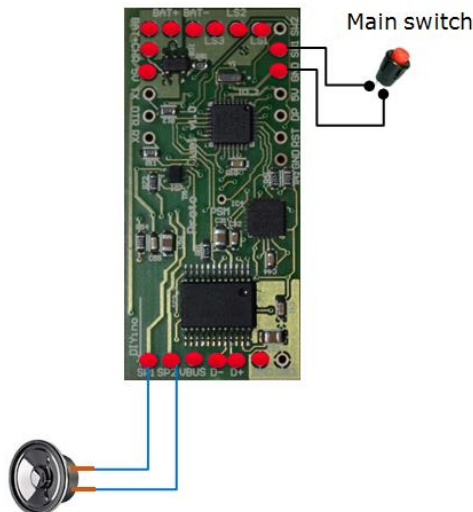


FIGURE 4: WIRING SWITCHES AND THE SPEAKER.

3.6 ACCENT LED AND CHARGE STATUS INDICATION LED CONNECTIONS

The on-board USB charger includes a charge status indication signal which can be accessed on the board via the CHR signal. The signal remains logic low during charging and changes to logic high when the battery is fully charged. This signal can be used to connect a charge indication LED via a proper resistor to light up when charging completes. Connect the LED anode (+) to the CHR signal (via a resistor if needed) and the cathode (-) of the LED to board GND.

You can also connect an Accent LED between SW2(LED+) and GND (LED-) properly resistored. The Accent LED pad has the unregulated voltage of the Battery for resistor selection purposes. The Accent LED will be off in deep sleep mode, and on otherwise. In case of the Proto Knight boards, the Accent LED will start to blink if the saber is activated and a special mode is triggered (i.e. Lockup-on-Clash or Blaster-deflect-on-the-move) to notify the wielder that the activation of the special mode was successful.

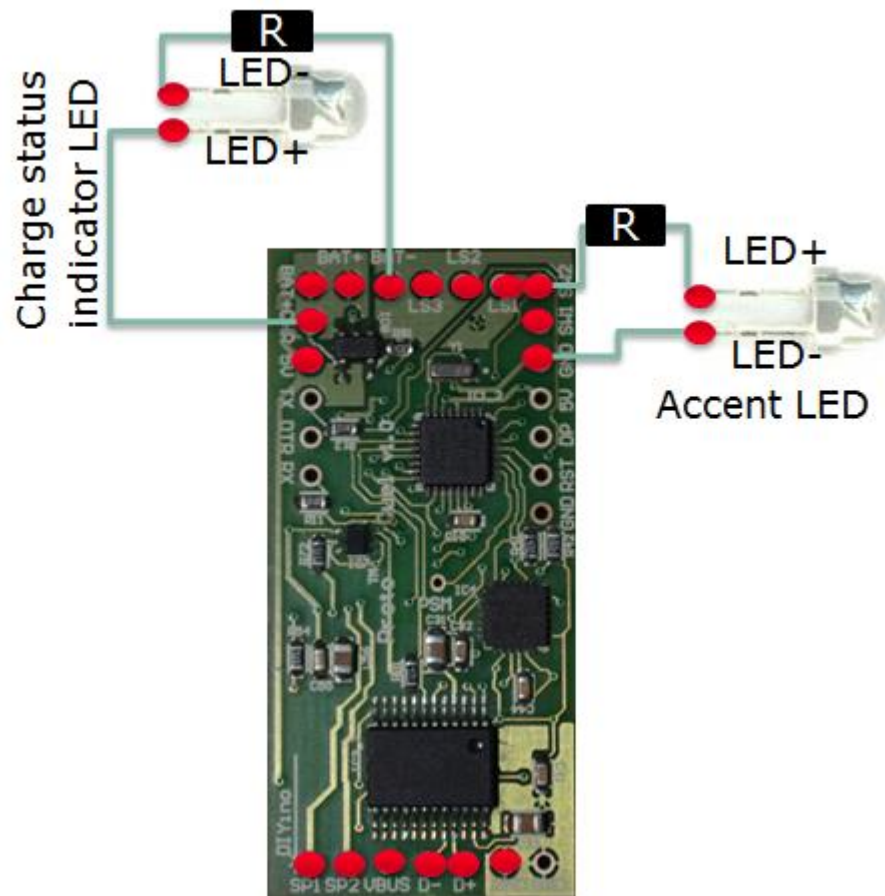


FIGURE 5: WIRING OF THE USB CHARGE STATUS INDICATOR LED AND THE ACCENT LED



Warning : High-power LEDs (such as the Luxeon, Cree etc.) and strings/strips of LEDs (such as LED strings composed of many single LEDs or neopixel LED modules such as WS2812B) are extremely bright. Especially High-power LEDs are considered “class 2 lasers”! You should neither look directly to the beam nor point someone with it when the light source is not diffused/blocked, just like a powerful lamp or flashlight. Manufacturer of the Proto Duel board could not be held responsible or liable for any injury resulting from the use of high-power or other type of LEDs/LED modules. To avoid injuries and retina damage due to the high brightness of LEDs, always use protective goggles or other means to avoid looking directly into the light source and also take care to protect others (like children) from being able to look directly into the light source.

Caution: in order not to violate the maximum ratings of your chosen high-power LED module (which might lead to damage or degradation of the LEDs), current limiting resistors must be used (see R_r , R_g , and R_b in Figure 6) to limit the current flowing through the individual LED dice of the module. Please consult the Data Sheet of the high-power LED module and include appropriate current limiting resistors in series to the LED dice according to the formula below:

$$R_{series} = \frac{V_{battery} - V_{th_LED}}{I_{LED}}$$

Example: suppose you use a Red LED with $V_{th_LED}=2V$ and you want the current to be $I_{LED}=700mA$, you use a $V_{battery}=3.7V$, type 18650 battery. The value of the resistor you need to wire in series to the LED is:

$$\frac{3,7V - 2,0V}{0,7A} = 2.4\Omega$$

Please check the power rating of the resistor you intend to use.



4.2 FULL WIRING DIAGRAM OF THE PROTO DUEL PIXEL BOARD

On Figure 7 the full saber wiring diagram can be seen for the Proto Duel Pixel board, using the duel charging setup.

“NeoPixel” is Adafruit’s brand for individually-addressable RGB color pixels and strips based on the **WS2812**, **WS2811** and **SK6812** LED/drivers, using a single-wire protocol. Commonly used neopixel stripes are composed of individual LED segments connected together to form a ladder similar to LED-strings. The stripes can be cut at any joint and multiple striped can be connected together at these joints as well.

Neopixel LED modules integrate RGB LEDs and a control circuit which uses PWM (Pulse Width Modulation) to control the brightness of each die individually. For that purpose each LED module has a shift register composed of 24-bits, 8-bits belonging to each of the colors Red, Green and Blue. The shift registers are connected between the DI (Data-In) and DO (Data-Out) pins of the individual segments. In a stripe configuration one segment shift register is connected serially to the shift register of the next segment. If a blade has a stripe with 100LEDs, it means during programming $100 \times 24 = 2400$ bits of data have to be transmitted to the stripe using neopixels own serial protocol to fill up all PWM registers, which in turn determine the brightness of the LEDs. This takes only a few μs , so programming can happen so fast, that transitions seem smooth to the eye.

A neopixel stripe has only 3+1 signals:

5V: supply of the stripe

DI: Data-In for the single-line serial protocol

GND: Ground or negative of the stripe

DO: Data-out, this signal has to be used only if you want to connect several stripes together.

When connecting the programmable neopixels stripe kill-key, you have to calculate max. current consumption of your LED stripe and connect the LSx pins accordingly. Each LS pin can carry a max. of 2.4A. Up to max. 7.2A over all LSx pins.

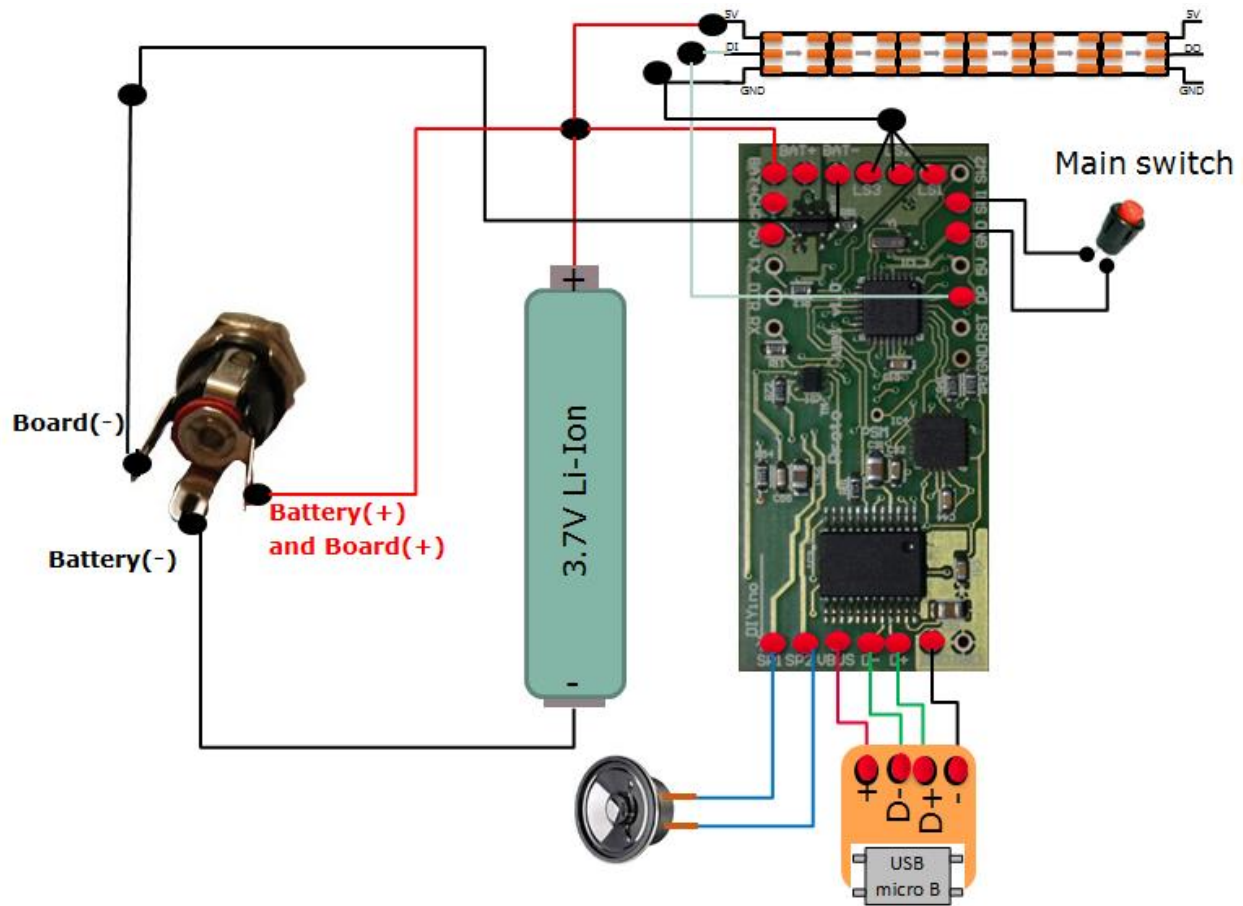


FIGURE 7 FULL WIRING DIAGRAM OF A PROTO PIXEL BOARD



The specification of the neopixel LED segments defines 5V as nominal voltage for the stripes, however the module can work with a much lower voltage as well. A lower voltage is even necessary to minimize power loss during operation, because any excess voltage above the voltage threshold of the used LEDs (Red ~2V, Green and Blue ~3.5V) is “wasted” over protection circuits in the control logic. Therefore a voltage source around the LED Vth is ideal to power neopixel strings.

For a complete characterization of neopixel brightness and current consumption please see [LINK](#). Neopixels chips consume considerable power even when all the LEDs are switched off (all 0's). This static current consumption amounts to 1mA per LED. You can quickly calculate what this means to your battery life time if you use – let's say – 60LED/m type of neopixels, back to back, in a 80cm blade. There will be 100 LEDs in your blade, drawing 100mA even if all LEDs are switched off. It will even discharge the best battery in less than one day. It is not hard to predict, that with the introduction of the 144LED/m type neopixel stripes, some blades will include much more than 100 LEDs, which will lead to an even quicker discharging of the battery. Killing power to the circuitry using a kill-key is a good method to lengthen the shelf life of your saber, but quite annoying during a show if you have to keep plugging in/out the kill key. Therefore a unique method was invented using the existing Proto board architecture. If the GND pin of the neopixels stripe is connected to the LS pins instead of the GND of the battery/Proto board, the transistors of the LS pins can be used to cut power to the neopixels stripe. If the blade is activated, the transistors have to be fully switched on (using the digitalWrite function) to connect the GND of the neopixels to the Battery(-), therefore powering the stripe. If the blade is retracted/switched off, the transistors have to be fully switched off in order to avoid the static current consumption of the stripes discharging the battery. Please take note that the restrictions as to the maximum current capability of the Proto board apply also here (max 7.2A!!!).

4.3 EXCHANGING SOUND FONTS VIA USB

Note: use this feature on your own risk. Please make a back-up of the original content of the USB drive before you format it. Protowerkstatt cannot offer any support nor can it be held liable for mixed up or wrong order of sound files once you format the USB drive of the Proto board.

The Proto boards come with professional sound files already included. However users might want to experiment with different sound or simply want to make a character-themed saber with a particular sound font. Therefore the Proto boards offer the possibility to exchange sound fonts. It can be done conveniently over the USB connection. All Proto boards come with an included external USB breakout board, which can be hooked up to the PCB (see Figure 1). Connecting to the Proto board over the USB while the board is not in deep sleep mode will cause the on board storage media to be recognized as an external USB drive. To exchange the fonts, make the following steps:

1. Plug-in the USB cable to your PC
2. Plug in the other end of your USB cable to the hooked-up USB breakout board (or equivalent)
3. If the saber was in deep sleep mode, wake it up!
4. Enter into Config Mode (sole reason is to keep the saber from entering deep sleep mode again)
5. The on-board storage media should be recognized as an external USB drive.
6. Use explorer to view the content. In the original state, the board has only single Folder (Image_Duel or Image_Knight) with all the sound files installed there.



7. Make a backup of the content, so that later on you can recover it if needed! This step is important, as you will need at least the config sounds even if you install new sound fonts.
8. Format the USB drive.
9. Once formatted, you need to organize your config files in the backup and the sound files of your selected sound fonts
 - a. Make a folder on your PC called Config_Sounds and copy all files from the backup beginning with "CS_" into that folder.
 - b. Make 2 folders on your PC for the 2 sound fonts (SoundFont1 and Soundfont2).
 - c. Prepare your sound fonts to be compatible with the Proto boards, to ensure that please follow the instructions outlined here: [LINK](#)
10. Populate your 2 sound font folders following the naming convention on the following Figure (Figure shows the names for Knight, for Duel leave out *_swing5 to 8, *_clash5 to 8, *_blaster* and *_lockup files). Make sure that all the files together, including Config Sounds do not exceed the maximum size of the USB drive (16Mbytes).

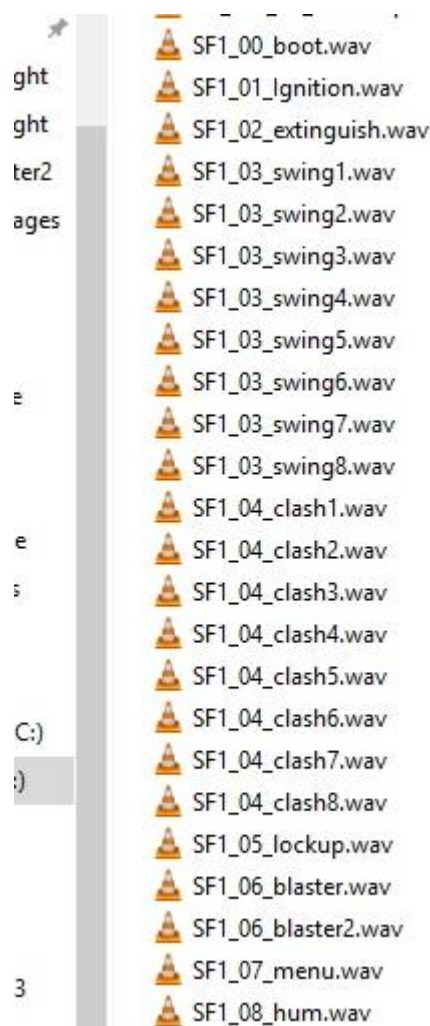


FIGURE 8: FILE NAMING CONVENTION FOR CUSTOM SABER FONTS

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11. Now comes the most important step: drag-and-drop the 3 thus created folder in the order: Config_Sounds, SoundFont1, SoundFont2 to the USB drive of the Proto board. Do not copy+paste but move (drag-and-drop). Always move whole folders, never single files. Wait until the move process is ended before moving the next folder. Never drag-and-drop folders from another USB drive which has exFAT data storage type! In case your sounds reside on such an external drive, copy them to your PC first.
12. Once all the three folders are on the USB drive, you can unplug the USB from the board and use your saber with the new sound fonts.



5 TECHNICAL SPECIFICATION

5.1 CIRCUIT PINOUT

Pin	Functionality
BAT+ (2x)	Positive terminal of a single Li-Ion 3.7V battery cell.
BAT-	Negative terminal of a single Li-Ion 3.7V battery cell.
LS1	LED driver 1, connect cathode (negative) of a high-power LED over appropriate resistor
LS2	LED driver 2, connect cathode (negative) of a high-power LED over appropriate resistor
LS3	LED driver 3, connect cathode (negative) of a high-power LED over appropriate resistor
CHR	Charge completed signal of the USB charger circuit.
5V (2x)	Board logic supply.
RST	Board reset pin
SW1	Main switch, connect main switch between this terminal and GND
SW2	Aux switch, connect main switch between this terminal and GND <i>(not used in Proto Duel)</i>
DP	Serial data pin of the Neopixel, connect to DI of the Neopixel stripe.

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GND (3x)	Logic GND signals. Connected to logic GND plane of the PCB.
SPK1	Speaker terminal 1. Connect to speaker directly. Other speaker terminal to SPK2.
SPK2	Speaker terminal 2. Connect to speaker directly. Other speaker terminal to SPK1.
VBUS	USB supply voltage
D+	USB positive
D-	USB negative



6 RELATED LINKS

Protowerkstatt Web Site: www.protowerkstatt.com

Free downloadable, 3D printable Protowerkstatt Chassis designs on Thingiverse:

<https://www.thingiverse.com/Protowerkstatt/designs>