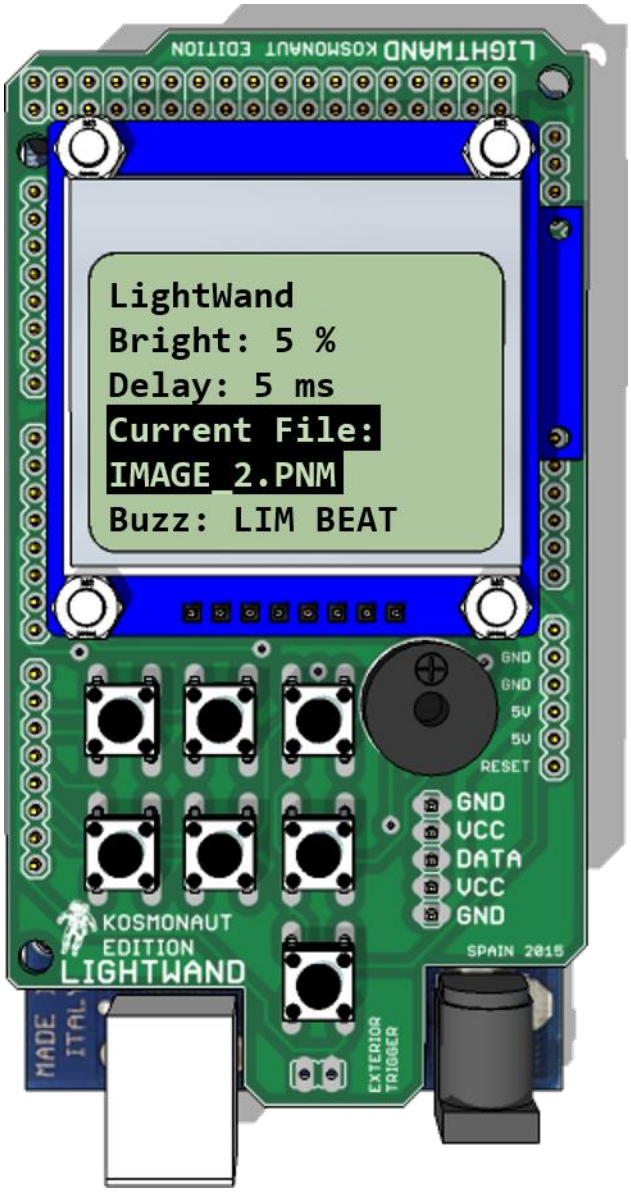

LIGHTWAND KOSMONAUT EDITION ASSEMBLY GUIDE

LIGHTWAND KOSMONAUT EDITION

ASSEMBLY GUIDE

All the related files for this project can be found in the *GitHub* repository:

https://github.com/PabloDMM/LightWand_KosmonautEd#

Designed by Pablo de Miguel:

Pablodmm.isp@gmail.com

Contents

1. Introduction 2

1.1. What is *LightWand Kosmonaut* Edition? 2

1.2. What is this document? 3

1.3. License Information 4

1.4. About the Author 4

2. Hardware Guide 4

2.1. Materials 4

2.2. Tools 5

2.3. Assembly Guide 6

3. Software Guide 17

3.1. Software needed: 17

3.2. *Arduino* Program 18

3.3. GIMP Image Formatting 18

4. Usage Guide 25

4.1. Menu Navigation 25

4.2. Handling 26

4.3. Tips 28

5. About the Logo 29

6. Image Index 30

8. EagleCad Schematic 32

1. Introduction

1.1. What is *LightWand Kosmonaut* Edition?

It is a compact controller for a *LightWand*. A *LightWand* is a tool to achieve stunning accurate images through the Light Painting technique. The original *LightWand* in which this edition is heavily based is the Michael Ross's *LightWand*[1], to whom I thank the work he has done and his decision to upload detailed tutorials.

The *LightWand* consists of a RGB individually addressable LED strip controlled by a microcontroller (an *Arduino* Mega2560 in this case) that reads an image .bmp or .pnm file stored in a µSD-Card and outputs sequentially each Pixel Row into the LED stripe. During a long exposure photograph, if the *LightWand* is moved at a constant speed, the result is an accurate Light Painting image that resembles a Hologram. Here, some results are shown:

Figure 1: *LightWand* Image 1[1]

Figure 2: *LightWand* Image 2

Figure 3: *LightWand* Image 3

Figure 4: *LightWand* Image 4

[1] Michael Ross Photography and Light Painting (2014), *Michael Ross*, http://mrossphoto.com/wordpress32/

Figure 5: *LightWand* Image 5

This same concept has been developed by a number of developers in the last years, being the *Pixelstick* [2] the one that achieved the most popularity through *Kickstarter*[3]. However, this commercial product is not Open Hardware and therefore not suitable for DIY enthusiast or curious developers that want to be able to modify their own instruments to suit their needs in a more efficient way.

1.2. What is this document?

This document is a complete guide of how to build a *LightWand Kosmonaut* Edition covering all steps. It starts with the Hardware Build of the *Arduino* Shield and the complete *LightWand* Assembly. It then covers the Software and the *Arduino* Program that has to be installed. It also contains a small tutorial on how to prepare a *.pnm* image for it to be displayed in the *LightWand* with *GIMP*. Finally, a usage guide is. All the Image Index can be found at the end of the document.

[2] *Pixelstick* Homepage(nd), *Bitbanger Labs*, http://www.the*Pixelstick*.com/
[3] *Pixelstick* – Lightpainting Evolved(2013), *Bitbanger Labs, Kickstarter project*, https://www.kickstarter.com/projects/bitbangerlabs/*Pixelstick*-light-painting-evolved

1.3. License Information

The *LightWand Kosmonaut* Edition controller is released under an *Attributtion-ShareAlike 4.0 International (CC BY-SA 4.0)*. Therefore, anyone is free to:

- **Share** — copy and redistribute the material in any medium or format
- **Adapt** — remix, transform, and build upon the material for any purpose, even commercially.

1.4. About the Author

Hi! My name is Pablo de Miguel. I am an *Electronic Engineering* student in *UPM Madrid* and also a proud member of *AETEL IEEE SB*[4].

To contact me for issues related to this project or for other kind of businesses please send an email to Pablodmm.isp@gmail.com or contact me through my *Linkledin* profile ;-) : https://www.linkedin.com/profile/view?id=296070600&trk=nav_responsive_tab_profile

2. Hardware Guide

This section covers the hardware assembly guide of the *LightWand Kosmonaut* Edition controller and a possible fix into the complete *LightWand* tool.

2.1. Materials

Materials for the controller:

Q.	ITEM	PACKAGE
1	*Arduino* Mega2560-1AU + USB Cable	-
1	PCB *LightWand Kosmonaut* Edition	-
1	PCS 84x48 Nokia 5110 LCD	-
7	Tactile Pushbutton Switch	DIP B3F-10XX
1	Micro SD Card	-
1	Micro SD Socket Module (Catalex V1.0)	-
7	Resistor 10MΩ	SMD 1206
1	Resistor 470Ω	SMD 1206
2	Capacitor 10µF	SMD 1206
1	LM7805CV 5A 1.5A	TO220H
1	Buzzer 5V	F/QMB III
1	Pin Row FEMALE 1x20	-
3	Pin Row MALE 1x20	-
1	Connector 5 Pin MALE	BTWM5
1	Connector 5 Pin FEMALE 90º	BTWM5
1	6 AAA battery Holder + Lead Cable	-
1	Power Jack MALE	-
5	Washer M3	-

[4] AETEL FB Page(nd), https://www.facebook.com/aetel.etsist?fref=ts

5	Nut M3	-
4	Screw M3 15mm	-
4	Screw protector 10mm	-
1	Screw M3 10mm	-

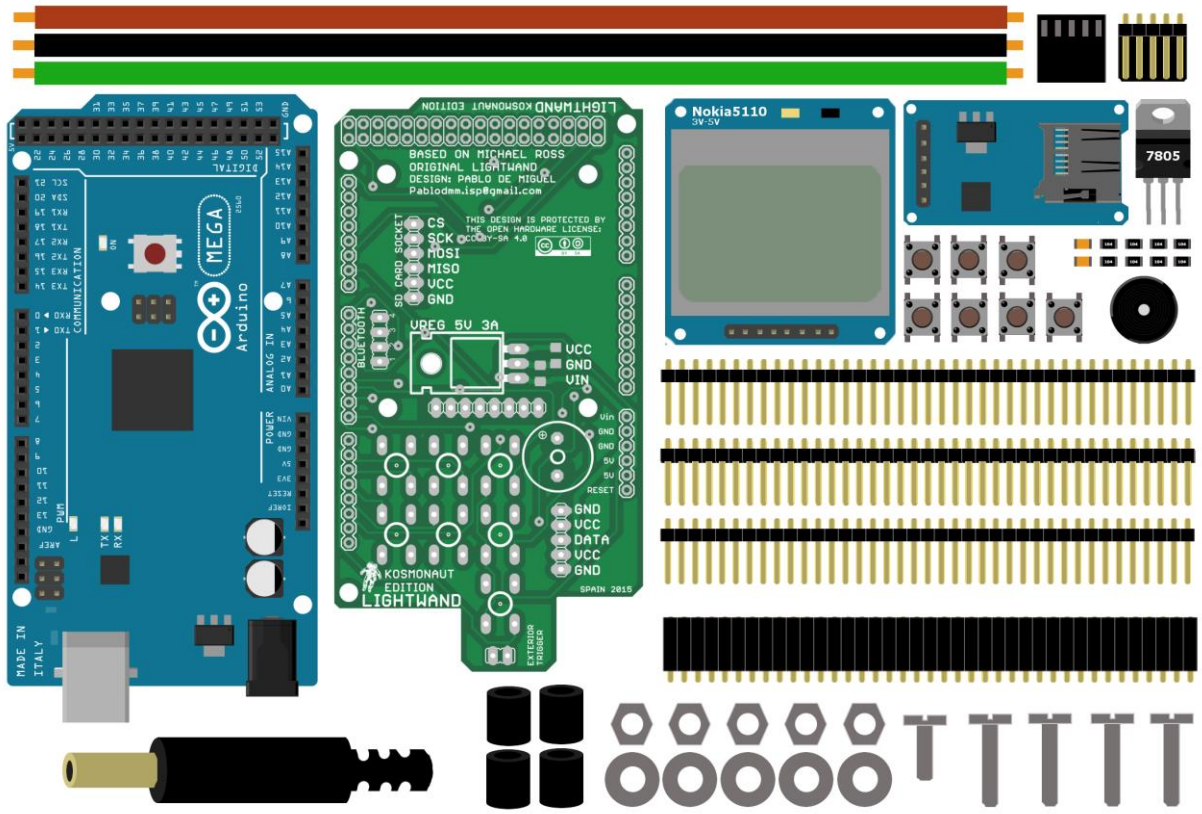

Figure 6: Hardware Materials

Materials for the Structure:

Q.	**ITEM**
1	1M 144Pixel WS2812B (or similar)
1	1M LED Aluminum Profile with LED diffusor*
1	≈20cm Velcro tape
7	≈20cm American tape

*The shape and translucent grade of the LED diffusor is, at the point this document is written, not an issue in which the author can advise at all. For the *LightWand* described, the cheapest and simpler LED profile + diffusor was chosen.

2.2. Tools

Q.	**ITEM**
1	Solder + Soldering Tin

1	Precision pliers
1	Thermic Fan (an average lighter could also be used)
1	Cutting Precision Blade
1	Standard Slotted Screwdriver

2.3. Assembly Guide

2.3.1. Controller Assembly Guide

For this section, in some cases a render image of the controller will be used instead of using real photographs. This will be done due to the better quality of the rendered images in documentation compared to real ones. This render can be opened with SketchUp 2015 [5]. The file is for public domain in the *Sketchup Warehouse* under the name of "*LightWand Kosmonaut Edition Controller*"[6].

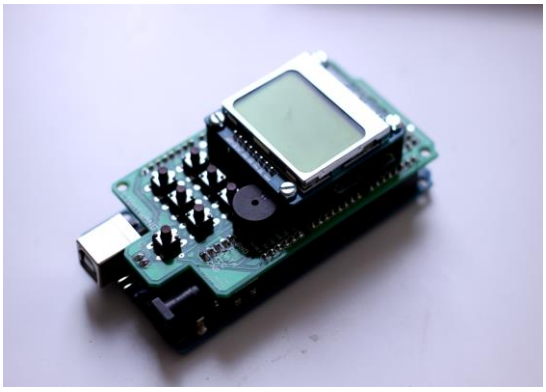

Figure 7: Controller Photograph

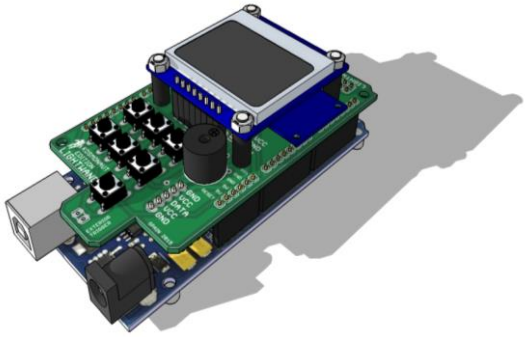

Figure 8: Controller Render

At the beginning of the tutorial, it is important to establish the two sides of the PCB as these terms are going to be used all through the tutorial.

[5] Sketchup 2015(2015), http://www.sketchup.com/

[6] *LightWand Kosmonaut* Edition Controller(March 2015), Pablo dMM, Sketchup Warehouse, https://3dwarehouse.sketchup.com/model.html?id=u972b9cd3-d8e8-4bcd-85a1-9211baa7e9b5

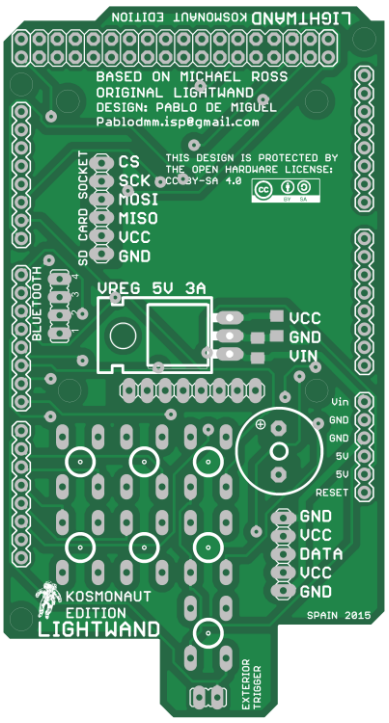

Figure 9: Top Layer

TOP LAYER

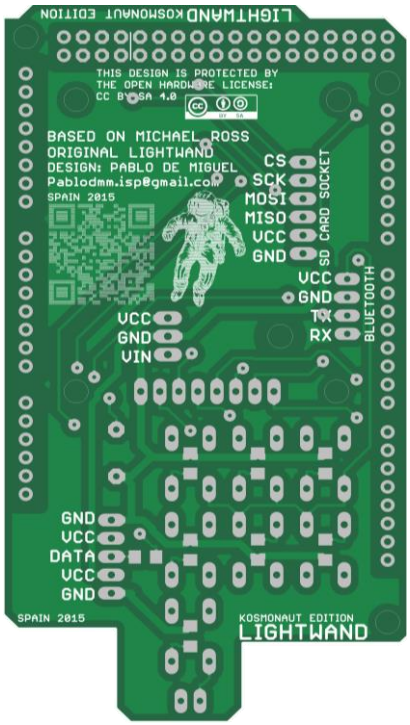

Figure 10: Bottom Layer

BOTTOM(BOT) LAYER

2.3.1.1. Step 1: SMD Resistors and Capacitors Soldering

The first step consists in soldering the SMD resistances in the BOT layer of the PCB. There is a seven 10MΩ Resistance group that act as pull-down resistance for the seven switches. The footprints for theses resistances can be easily identified in between the tactile switch footprints.

There is another 470Ω Resistor that is intended to adapt the *Data signal* of the LED stripe. Through this resistance, the long term degradation of the LED stripe is prevented. If this resistance is not placed, the LED stripe would work anyway, but the degradation will not be prevented.

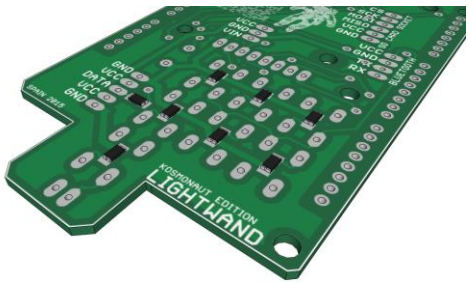

Figure 11: Resistance SMD Colocation

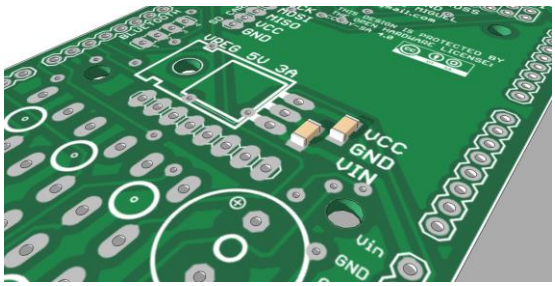

Figure 12: Capacitor SMD Colocation

The two 10µF Capacitors are decoupling capacitors for the Voltage regulator (7805 or similar). For this porpoises, electrolytic capacitors should be used (Not ceramic SMD). However, considering the low voltage used and that batteries are quite stable and don't normally have curling voltages, it works fine enough. The two capacitors must be soldered in the TOP layer next to the Voltage Regulator.

Once the 2 Capacitors and the 8 Resistances have been soldered, the next step can be started.

2.3.1.2. Step 2: Arduino-Connection Pin Soldering

The second step consist in the soldering of the pins that connect the shield to the *Arduino* Mega. For this step, first you have to cut the PIN ROW Male 1x20 in:

- Five 1x08 PIN ROW
- One 1x06 PIN ROW
- Two 1x18 PIN ROW

Once all the segments (Or several smaller segments that can make the combinations) have been cut, the pin rows have to be introduced in the *Arduino* pin sockets through it longest side. Once this has been done, the PCB has to be fitted on top of that. There is only one way it can be fitted.

Once it is fitted, all the pins must be soldered in the TOP layer. Through this technique, the pins are all soldered straight, so it is faster and more comfortable.

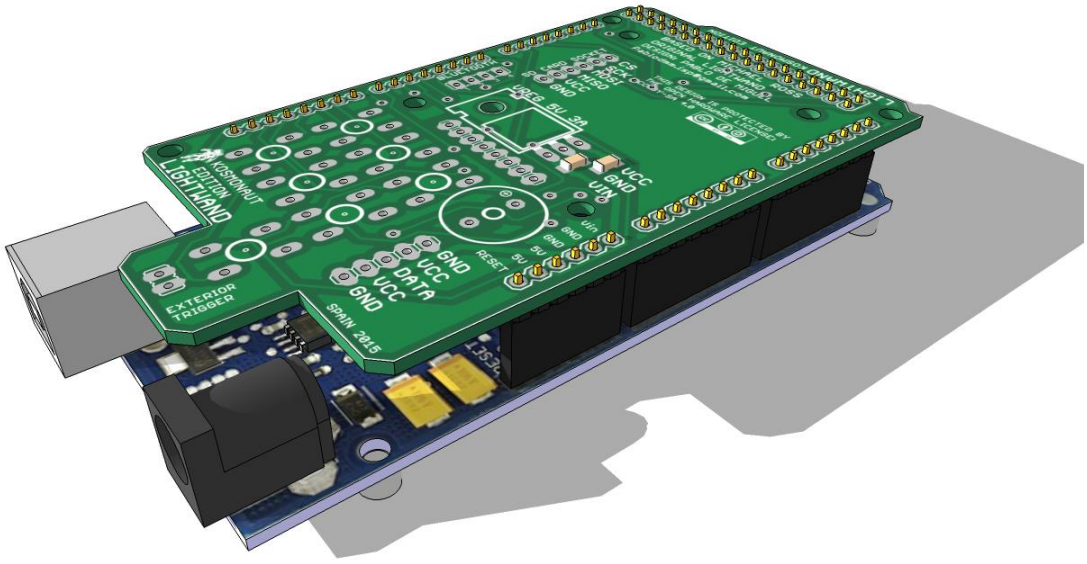

Figure 13: *Arduino*-Connection Pins

Once all the *Arduino*-Connections pins have been soldered, the next step can be started.

2.3.1.3. Step 3: LED Strip Connector Pin Soldering

The third step consist in the soldering of the pin connector for the LED Strip. There are 5 connectors, 2 VCC signals, 2 GND signals and one DATA signal. 5 Signals have been chosen instead of just 3 for the following reasons:

- LED Strips commonly come with 5 wires soldered to the Strip itself (To allow various connections). Therefore, by using this 5 wires no direct soldering over the LED Strip is needed avoiding risky operations.
- As the signal are displayed symmetrically, there is no possibility of wrong connections that could lead the LED Strip to degradation.

The Connector 5 Pin FEMALE 90º must be introduced through the BOT Layer and soldered in the TOP Layer, as shown in the rendered image.

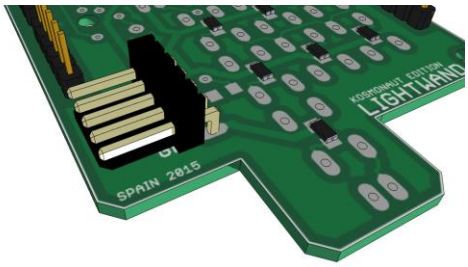

Figure 14: LED Connection BOT view

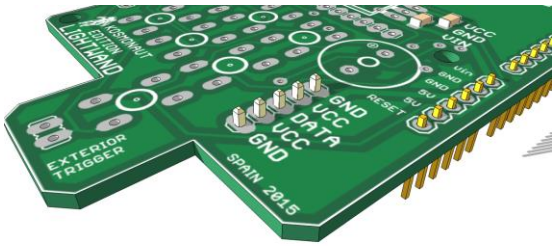

Figure 15: LED Connection TOP view

Once the LED Strip connector has been soldered, the next step can be started.

2.3.1.4. Step 4: Voltage Regulator Soldering

The fourth step consist in the soldering of the Voltage Regulator for the LED Strip. LED Strips work with a 5V Voltage and up to 3A (MAX output). Therefore, a specific Voltage Regulator is needed as the *Arduino* 5V output has a low Current limit. This Voltage Regulator has as an input the direct voltage from the batteries through the *Vin* pin from *Arduino* MEGA2560.

To solder this component, insert it from the top layer and turn it till it fits the footprint as shown in the images.

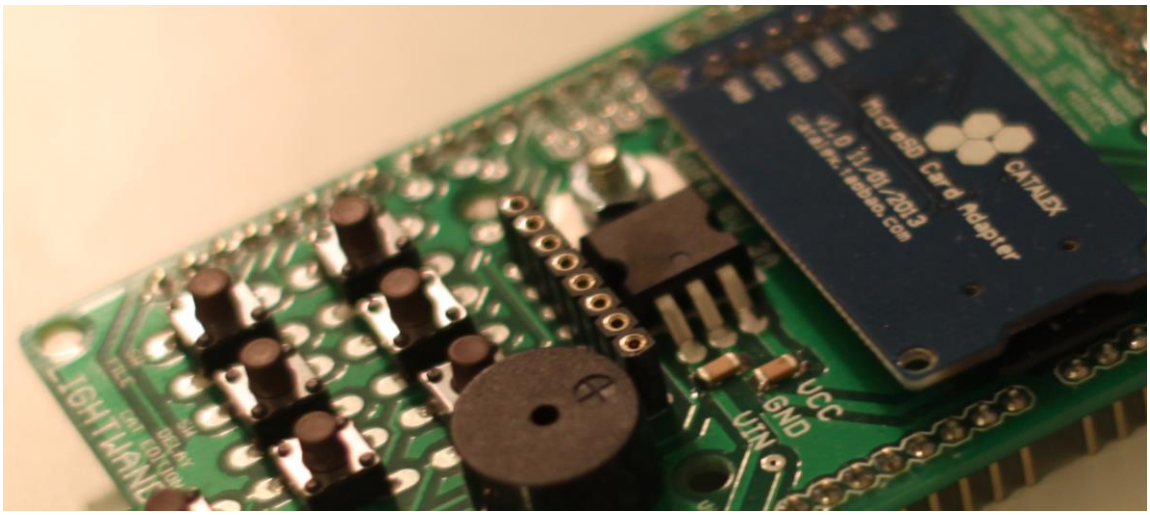

Figure 16: Voltage Regulator

After, the 10mm M3 Screw has to be placed with a nut and a washer. This is done to improve the thermic dissipation of the component, as it gets really hoy when regulating the voltage.

Once the Voltage Regulator and its Screw has been fixed, the next step can be started.

2.3.1.5. Step 5: Tactile Switch Soldering

The fifth step consist in the soldering of the seven tactile switches. This switches have to be introduced from the TOP layer and soldered in the BOT layer.

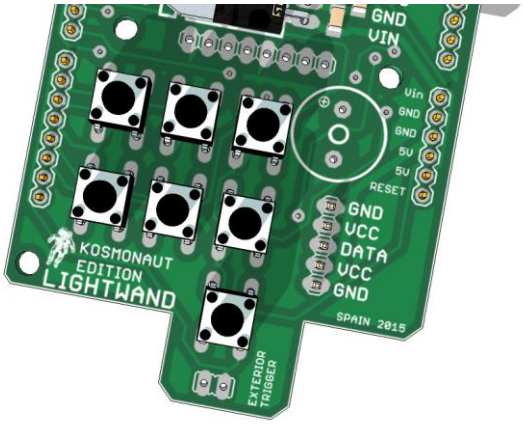

Figure 17: Tactile Switches

Once the seven tactile switches have been soldered, the next step can be started.

2.3.1.6 Step 6: Buzzer Soldering

The sixth step consists in the soldering of the buzzer. This buzzer has to be introduced from the TOP layer and soldered in the BOT layer.

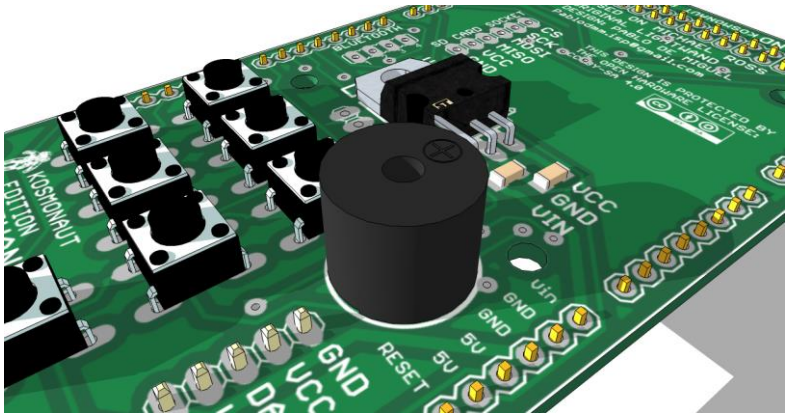

Figure 18: Buzzer

Once the buzzer has been soldered, the next step can be started.

2.3.1.7 Step 7: µSD Socket Soldering

The seventh step consists in the soldering of the SD socket. In order to solder it, the pins of the SD module have to be bended, as they are intended to be used in a straight way. After, they have to be introduced through the TOP layer and soldered in the BOT layer, so that the result is the same as in the image.

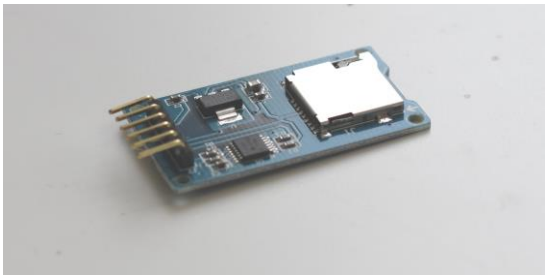

Figure 19: Original CATALEX MicroSD Card Adapter V1.0.

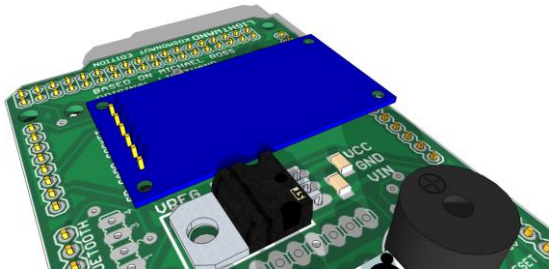

Figure 20: SD Socket

Once the SD Socket has been soldered, the next step can be started.

2.3.1.8. Step 8: Screen Connection Female Pin Soldering

The eighth step consist in the soldering of the 1x08 PIN ROW female. Cut a 1x08 segment and introduce it through the TOP layer and solder it in the BOT layer, so that the result is the same as in the image.

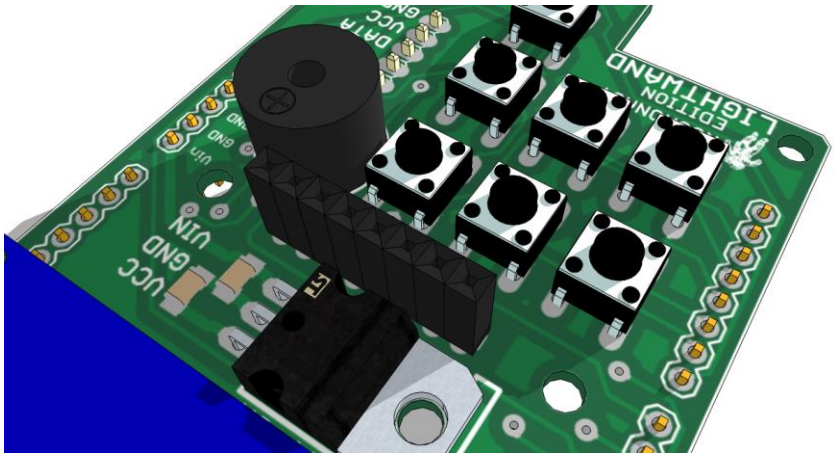

Figure 21: Screen Connection Female Pins

Once the female pins have been soldered, the next step can be started.

2.3.1.9. Step 9: Screen Colocation

The ninth and last step consists in the colocation of the Screen and its Screws. First introduce the screen in the female pins. Once this has been done fit the screws with a nut a washer using the 10mm screw protectors so that the result is similar to what is shown in the image.

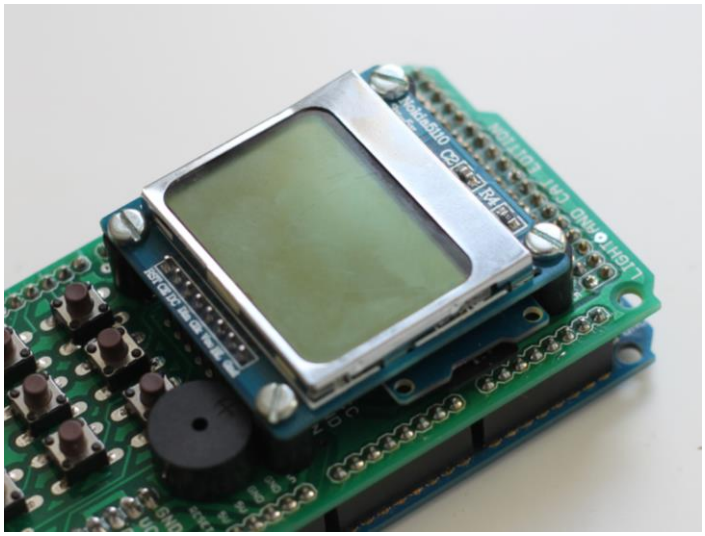

Figure 22: Screen Colocation

Once the screen is fitted in its place, the Hardware assembly process is finished.

2.3.1.10. Extra Functionalities

In the PCB, some not yet supported functionalities are present such a Bluetooth Socket or a connection for an exterior switch for the Shoot Switch. If you find and document a possible use for this please let me know and publish it!

2.3.2. *LightWand* Assembly Guide

Once the Controller is completed, it is time to adapt the LED Strip for it to be connected to the controller and safely hold inside the LED profile.

2.3.2.1. Step 1: LED Strip Connection and Protection

In order to successfully connect the LED Strip to the controller, the appropriate Connector has to be soldered. If the LED Strip has any kind of waterproof protection, it has to be removed. Normally, five wires are connected to both sides of the LED Stripe. For this *LightWand*, only one side wires are needed. In order to locate the right side, check in the LED Stripe for the DATA Arrows.

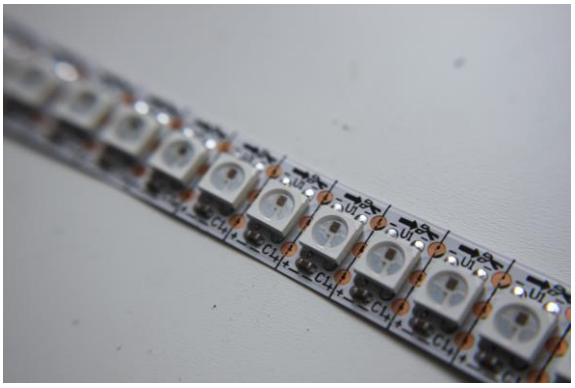

Figure 23: LED Strip Arrow

Figure 24: LED Strip Dead-End

The wires in the side that the arrows are pointing to can be desoldered as they are not needed. The wires in the others side have to be maintained or replaced for longer ones (As in the images) to protect them.

Once the new cables and protections have been placed, the new 5 pin male connector has to be installed replacing the previous connector. Remember to implement the order present in the following image:

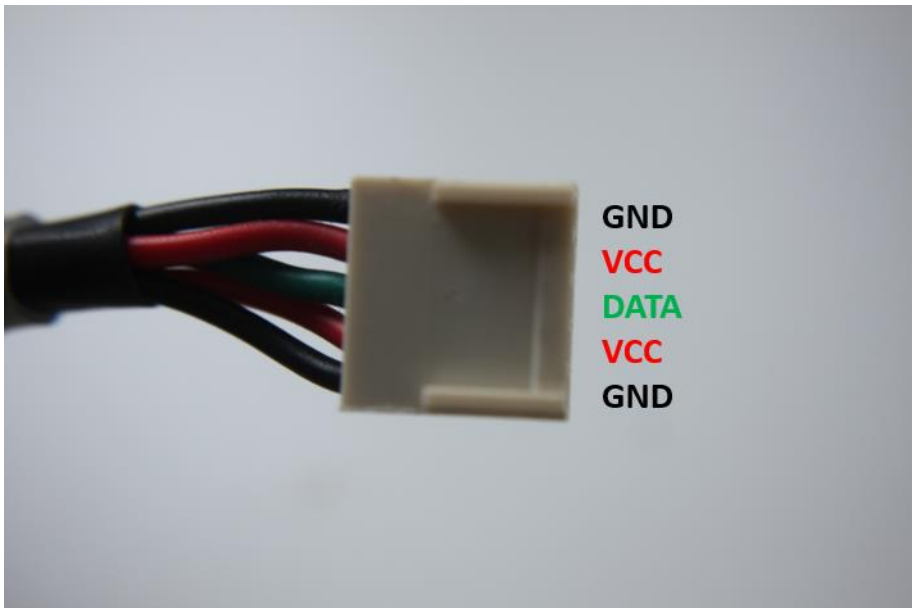

Figure 25: LED Strip Connector

It is highly recommended to use some thermo retractile protection in the extremes of the LED Strip for it not be exposed to bending forces that could break the connections inside the LED Strip.

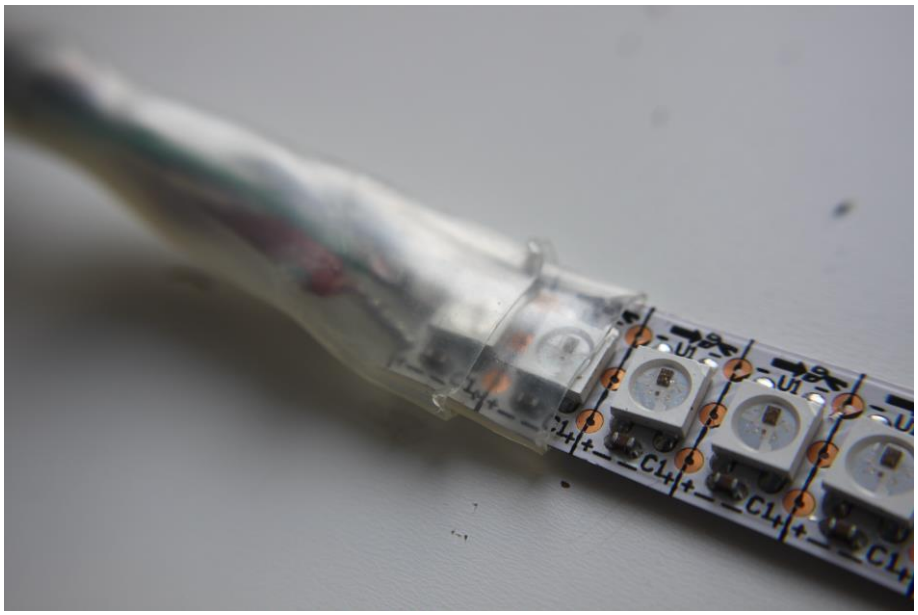

Figure 26: LED Strip Protection

Once the LED Strip connections have been adapted, the next step can be started.

2.3.2.2. Step 2: Introduce the LED Strip into the LED Profile

The next step consist in inserting the LED Strip into the aluminum profile and adding the LED Diffusor.

Figure 27: LED Profile Diffusor

Once the LED Strip has been fitted inside the profile, the next step can be started.

2.3.2.3. Step 3: Controller and Battery Attach

To attach the controller and the battery to the back part of the profile, Velcro tape is to be used. The advantage of Velcro towards other possible mechanism is that it is extremely easy to install, that it is cheap, and that it is stable enough.

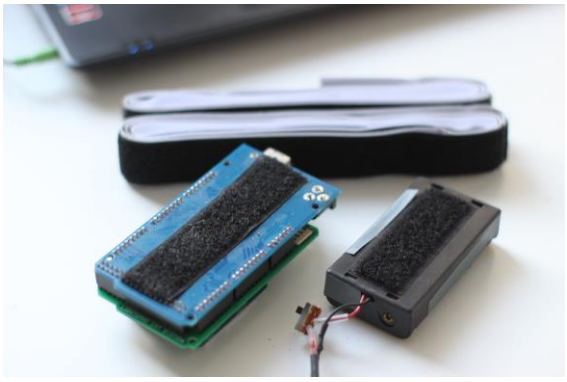

Figure 28: Velcro Tape on Controller

Figure 29: Velcro Tape on Profile

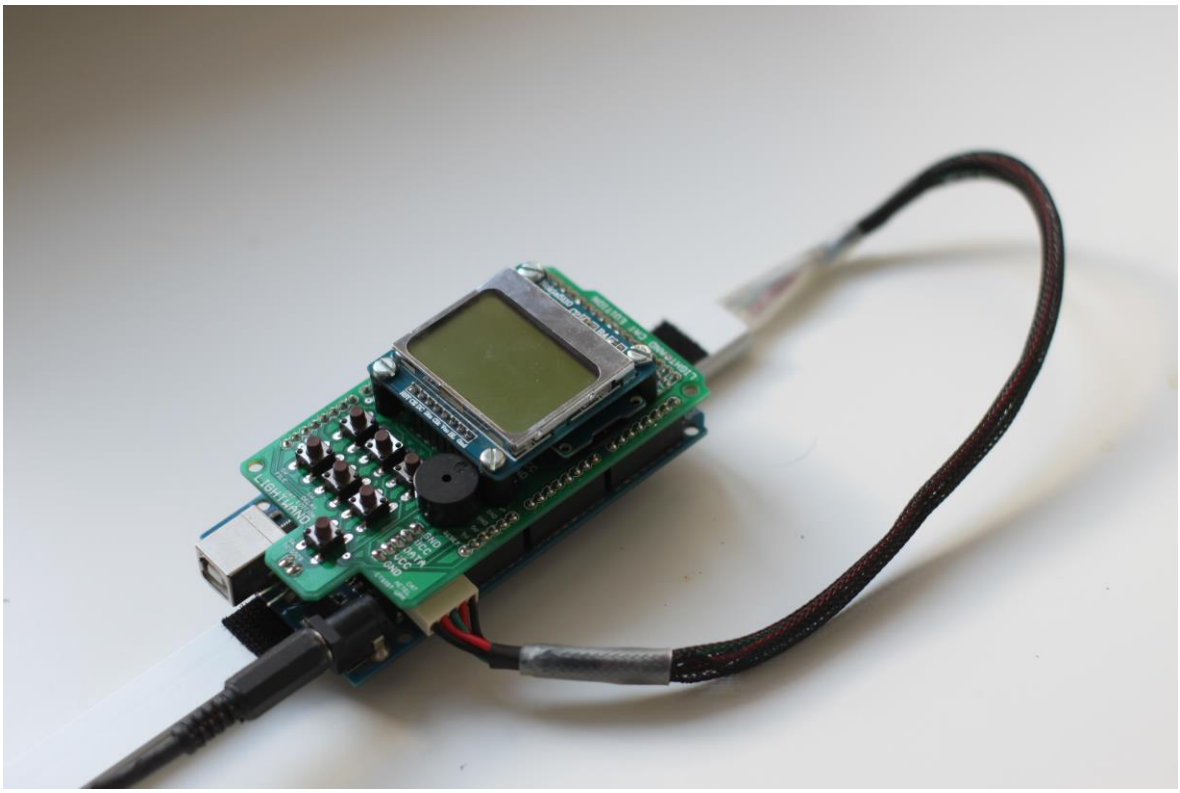

Figure 30: Controller Attached

Figure 31: LightWand Complete

Once the Controller has been installed and connected to the LED Strip, the process of the *LightWand* assembly has been finished.

2.3.2.4. About an external Switch in the battery

An external Switch can be added to the wire of the battery as shown in the image. This makes it safer and faster to witch on and off the *LightWand*.

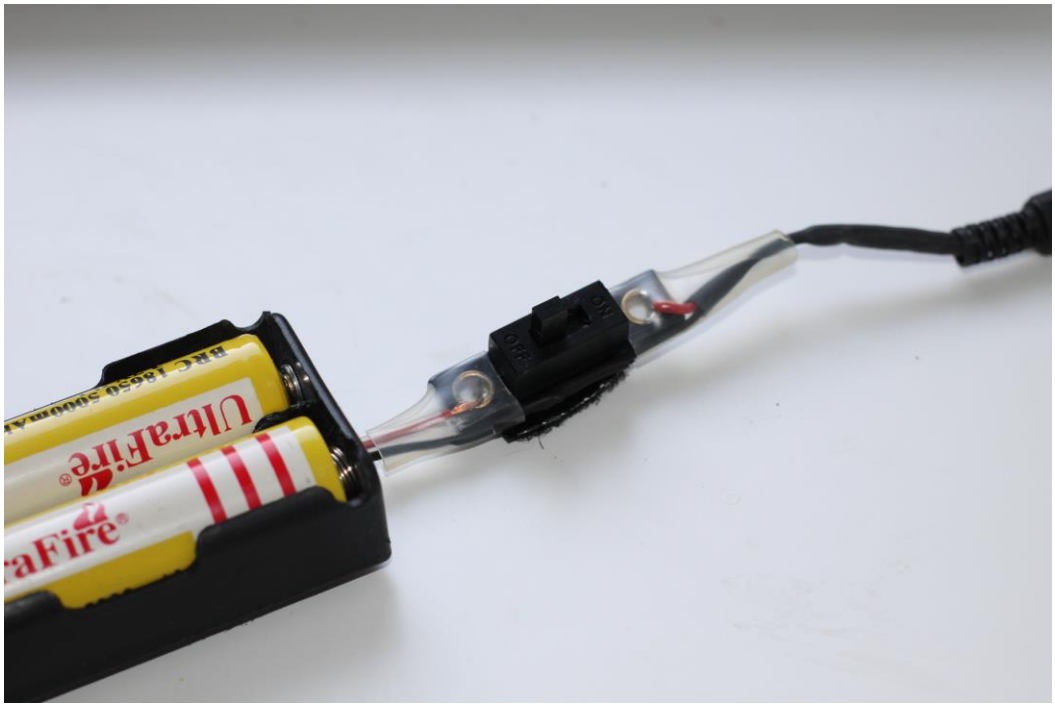

Figure 32: Battery Switch

3. Software Guide

In this section, all the info regarding the software set up of the *LightWand* is included. In this guide, only Windows OS is considered. Anyway, the processes are simple and the programs are all free and available for Linux and Mac too.

3.1. Software needed:

***Arduino* IDE + *Arduino* Drivers (1.6.4 or previous)**[7]
Free Download in:
http://www.*Arduino*.cc/en/Main/Software

***Arduino* SD library**[8]
Download in:
https://github.com/adafruit/SD

***Arduino* Adafruit_GFX library**[9]
Download in:
https://github.com/adafruit/Adafruit-GFX-Library

***Arduino* Adafruit _PCD8544 library**[10]

[7] *Arduino* IDE 1.6.4. Download (nd), *Arduino*, http://www.*Arduino*.cc/en/Main/Software
[8] *Arduino* SD library (2010), Adafruit, https://github.com/adafruit/SD
[9] *Arduino* Adafruit_GFX library(2014), Adafruit, https://github.com/adafruit/Adafruit-GFX-Library
[10] *Arduino* Adafruit _PCD8544 library(2015), Adafruit, https://github.com/adafruit/Adafruit-PCD8544-Nokia-5110-LCD-library

Download in:
https://github.com/adafruit/Adafruit-PCD8544-Nokia-5110-LCD-library
***Arduino* Adafruit_Neopixel library**[11]
Download in:
https://github.com/adafruit/Adafruit_NeoPixel
GIMP 2.8. GNU Image Manipulation Program[12]
Free Download in:
http://www.gimp.org/

3.2. *Arduino* Program

The following *Arduino* Program can be found in the GitHub under the *Arduino Files* folder. It is self-explanatory through the commentaries.

3.3. GIMP Image Formatting

The following Steps cover the preparation of a standard image into a *LightWand* .pnm compatible image usign the free software program GIMP.

3.3.1. Step 1: Choose an Image

The first step consists in finding a proper Image to be displayed with the *LightWand*. In general, the two things to be considered are:

- An Aspect Ratio not superior to 1x2. The reason for this is that, as it has a fixed 144LED 1m side, a larger Aspect Ratio will mean having final images taller than 2m. This can be challenging for the user holding the *LightWand*. In case the image is mean to be horizontal, no limits are considered.
- A not extremely detailed Image. Even do 144 Pixels are quite a good resolution, it cannot be expected for the *LightWand* to display an extremely accurate image.

For this guide, the image chosen has been "The Kiss" by *Gustav Klimt*[13]:

[11] *Arduino* Adafruit_NeoPixel library(2015), Adafruit, https://github.com/adafruit/Adafruit_NeoPixel
[12] GIMP 2.8. Download, GNI Iniciative, http://www.gimp.org/
[13] The Kiss(Gustav Klimt)(1909), Wikipedia, http://en.wikipedia.org/wiki/The_Kiss_%28Klimt%29

Figure 33: Gustav Klimt Raw Image

The resolution chosen for this raw image is of 3768x5051. The higher the resolution the better results will the final image have, as any change (Contrast correction, Brightness correction) in a LOW quality image will be a lot more noticeable.

Once a proper image has been chosen, the next step can be started.

3.3.2. Step 2: Open the Image with GIMP

The second Step consist in opening the image with GIMP through *File/Open*.

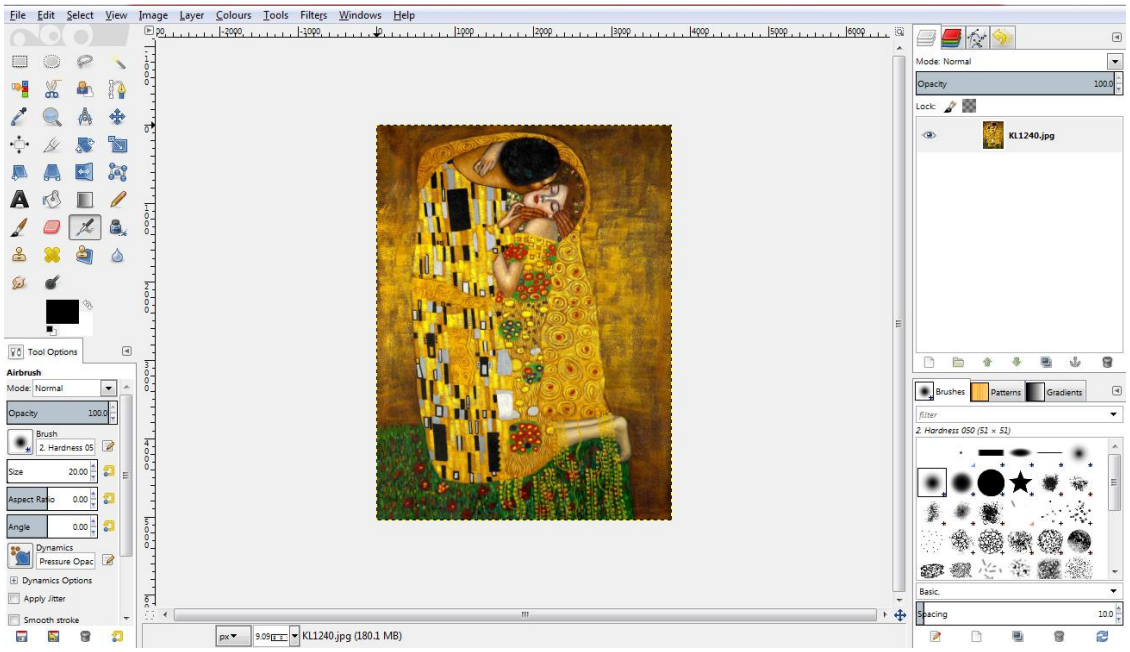

Figure 34: GIMP File Open

Once the Image has been opened, the next step can be started.

3.3.3. Step 3: Cut the desired section of the Image

The third step consists in cutting the part of the image that is to be displayed. This normally consist on separating the main figure from the rest of the image. Through this process the Canvas is eliminated improving a lot the final image as no straight lines or edges exists. Without this straight lines, any mistake in the Photographic process is less noticeable.

To cut the desired Image, first duplicate the original layer doing right click in the layer in the *Layer Window* and selecting *Duplicate Layer*.

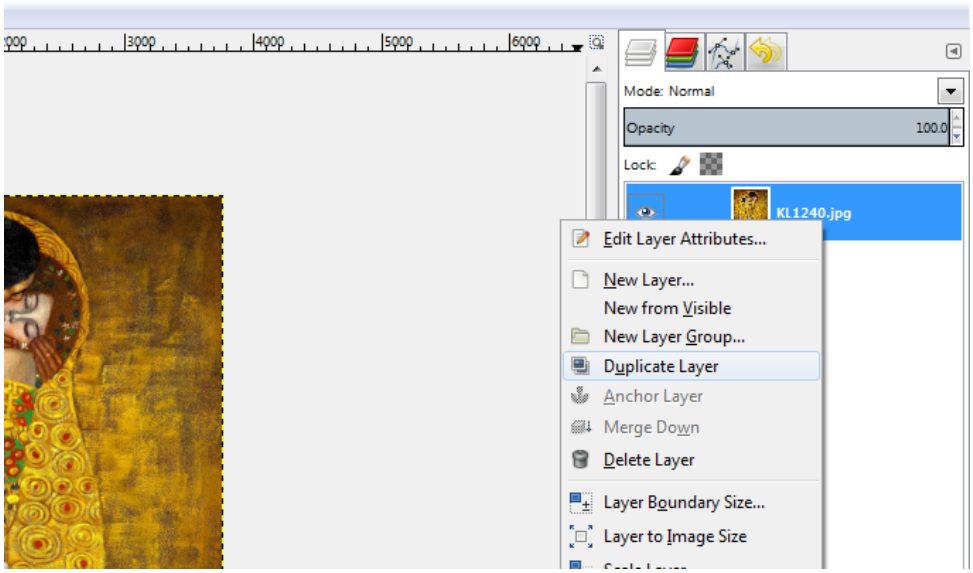

Figure 35: GIMP Duplicate Layer

Once the layer has been duplicated, cut the main figure with the *Free-selection tool* (*Shortcut I*). This process can be long and tiring. Once it has been cutted, transfer it to a new layer using To new Layer (Shortcut Ctrl+Shift+N).

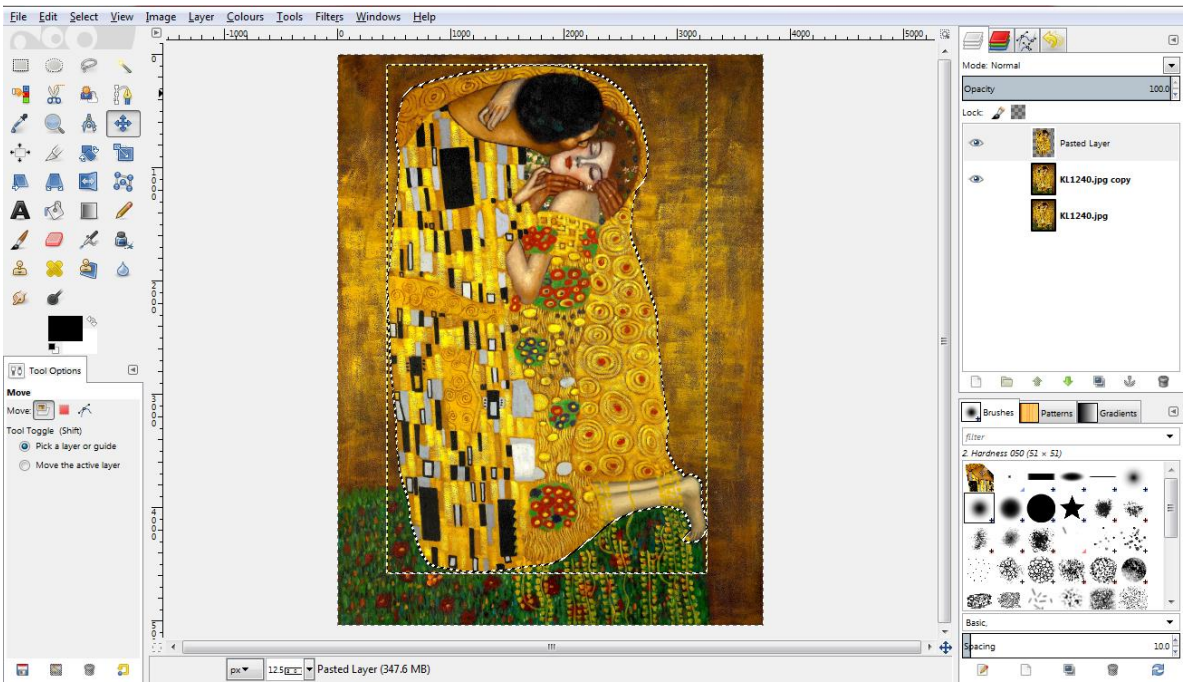

Figure 36: GIMP To New Layer

Once this has been done, delete the previous layer maintaining only the main figure.

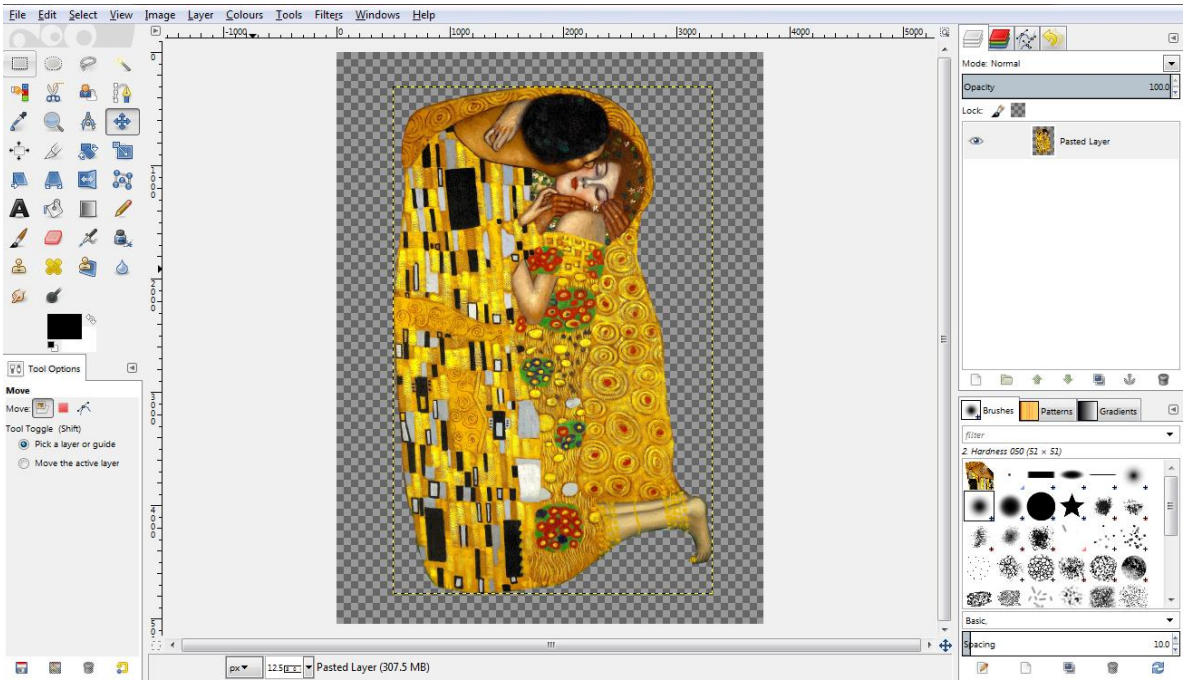

Figure 37: GIMP Main Figure

Once the main figure has been isolated, the next step can be started.

3.3.4. Step 4: Resize the Image

The fourth step consists in resizing the image for it to adapt to the 144 LED Strip. This means to have the horizontal dimension of 144 pixels. To do this, the tool *Scale Tool* (Shortcut shift+T) is used.

Once in the tool, first of all select the proportional scale option. Once this has been done, establish 144 as the *Width* parameter and press *Scale*.

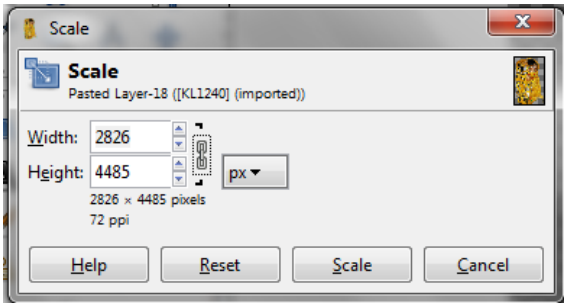

Figure 38: GIMP Scale Proportional

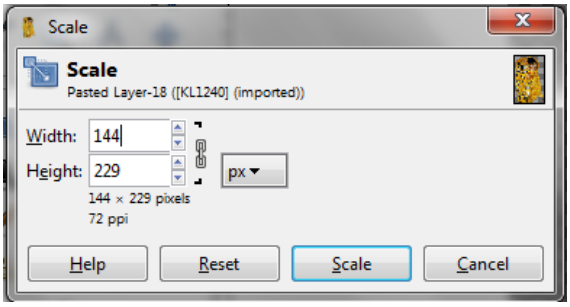

Figure 39: GIMP Scale Parameters

Once the image has been scaled, change the canvas size through Image/Fit Canvas to Layers. The new Canvas should have a 144 Width dimension.

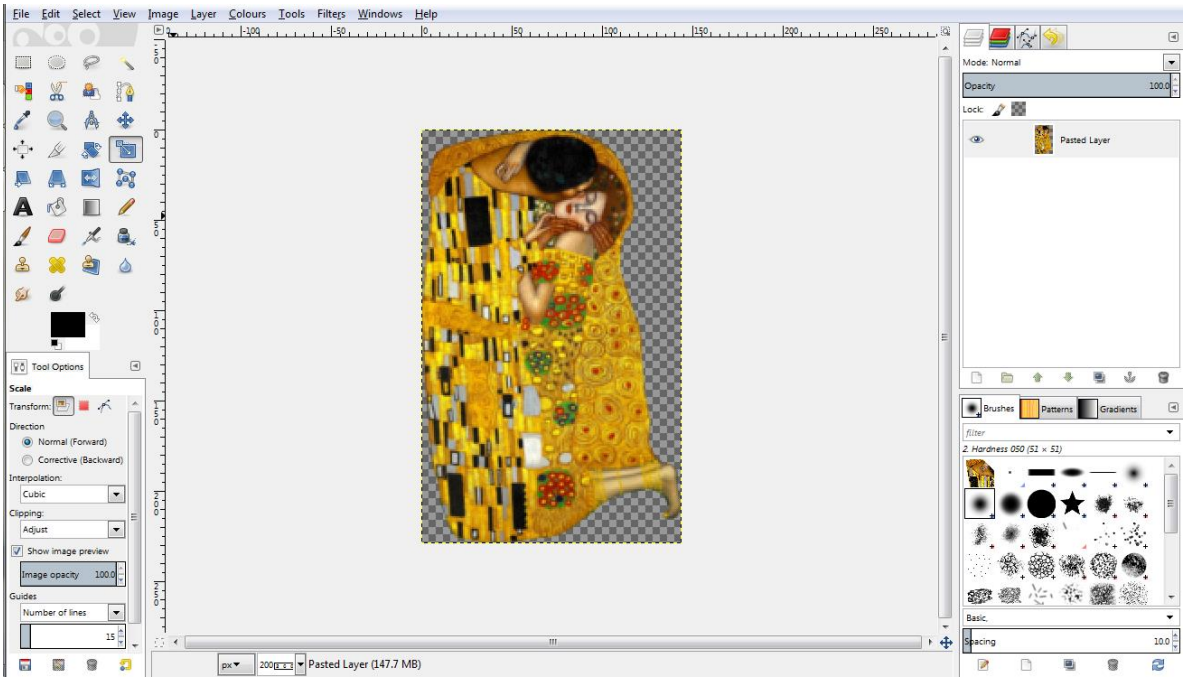

Figure 40: GIMP Resized Image Canvas

Once the Image has been resized, the next step can be started.

3.3.5. Step 5: Turn the Image 180º

The fifth step consists in turning the image around for it to be displayed from down to up. This step is only important if the image has to be in contact with the ground. Otherwise, this step can be skipped. To turn the image use the *Rotate Tool (Shortcut Shift+R)* and make a 180º flip.

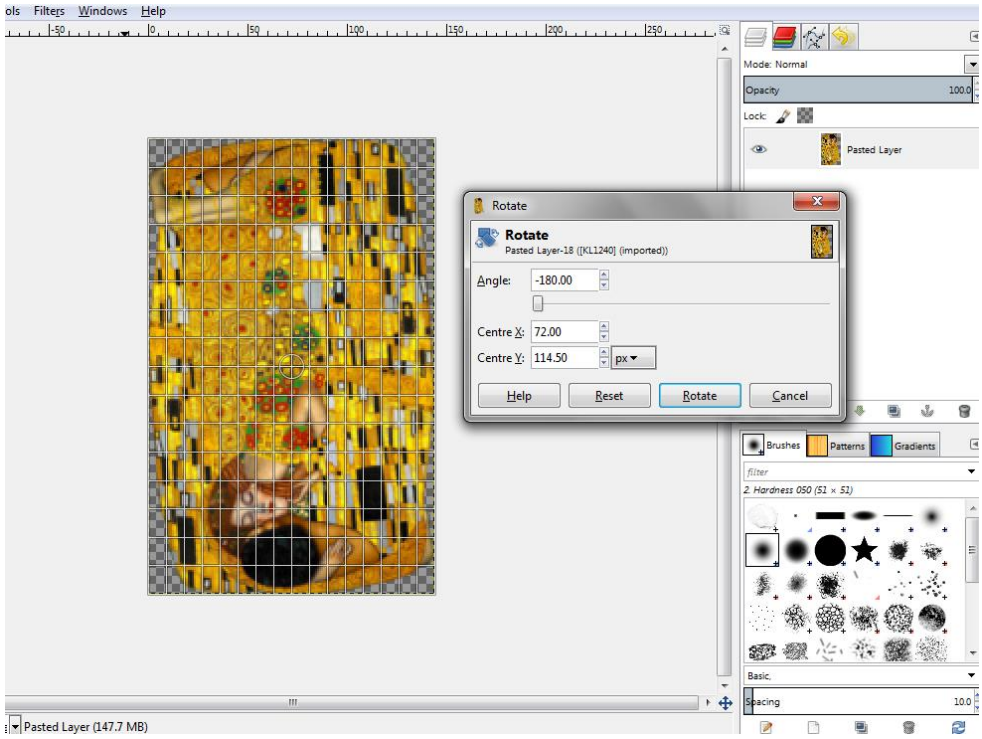

Figure 41: GIMP Image Rotation

The *LightWand* reads the images starting from the top pixel row, therefore, that is the first displayed.

3.3.6. Step 6: Add a Black Background

The sixth step consist in adding a black background to the image for it not to be displayed by the *LightWand*. This can be done in the Layer window by right click *New Layer/Foreground* Color.

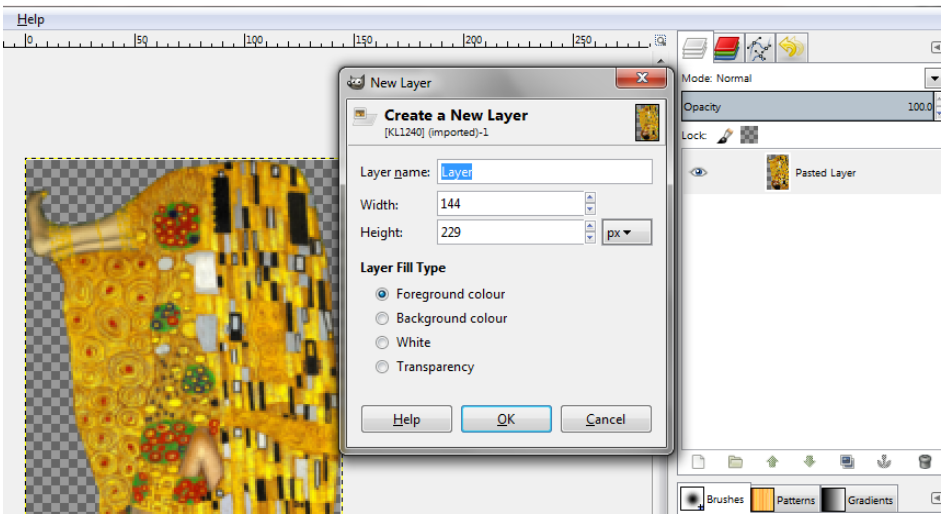

Figure 42: GIMP New Layer

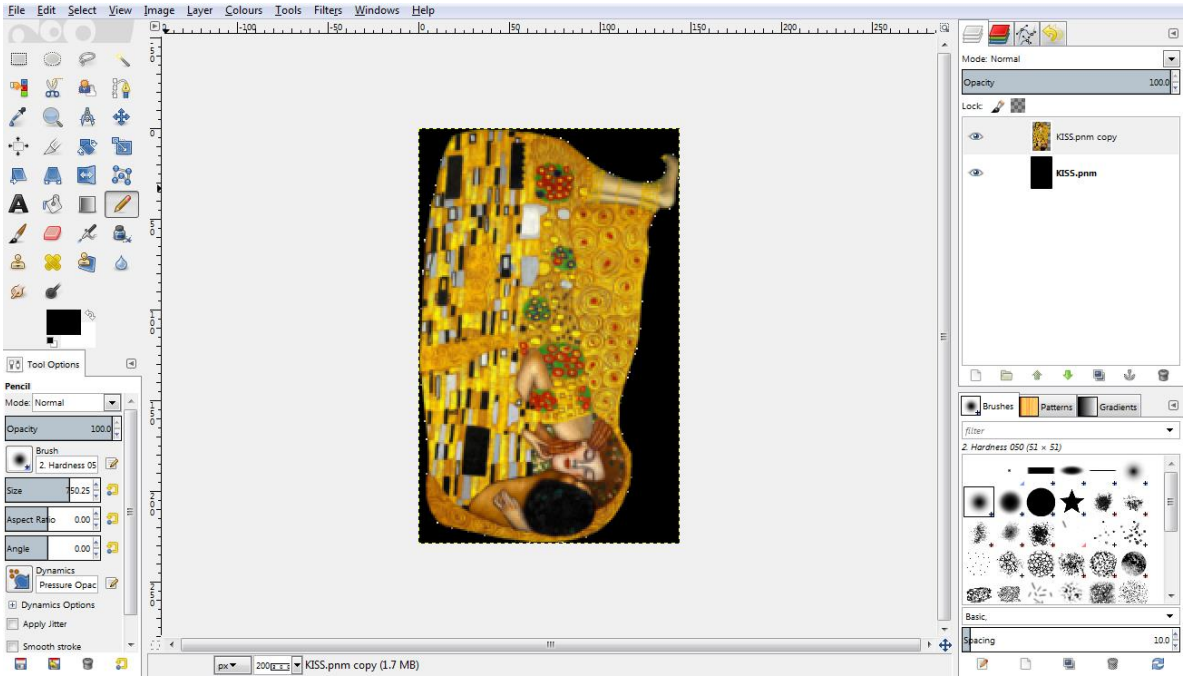

Figure 43: GIMP Black Background

Once this has been done, the next step can be started.

3.3.7. Step 7: Export .pnm File

The seventh step consist in exporting the image in a *.pnm* file that can be read by the *LightWand* Kosmosnaut Ed. This can be done through *File/Export as* by setting a name with the *.pnm* termination. The *Select File_Type(By Extension)* must be selected.

When exporting the *Raw Data formatting* must be selected instead of *ASCII*.

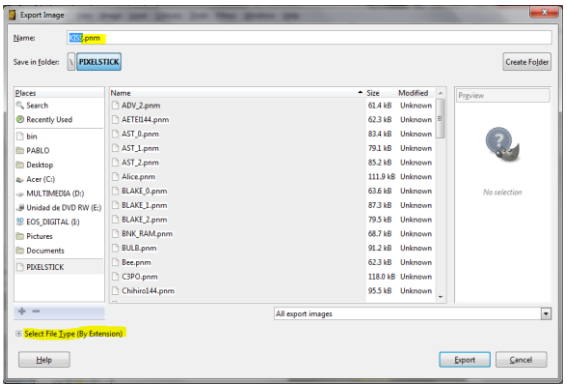

Figure 44: GIMP Export

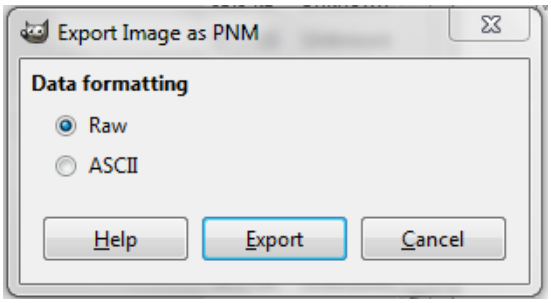

Figure 45: GIMP Raw .pnm Mode

Once this step has been done, the GIMP process is finished and the image file can be stored in the SD Card.

4. Usage Guide

This section contains a Usage Guide on how to work with the *LightWand Kosmonaut* Edition once this has been fully assembled and programmed and therefore ready to be used.

4.1. Menu Navigation

In the following section this reference will be done:

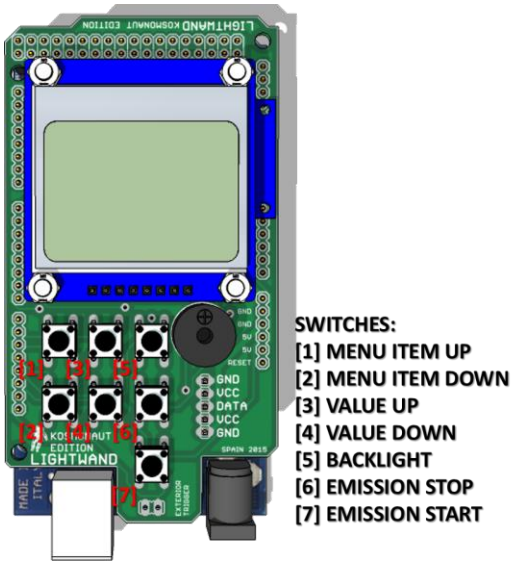

Figure 46: Switch Index

Once the *LightWand* is connected, the following will sequentially appear in the Screen. If there are no errors in the initialization, finally the main menu will be displayed. In case any errors occur during the SD Initialization, a failure message will be displayed in the screen after the *INI Screen 1*.

Figure 47: INI Screen 1

Figure 48: INI Screen 2

Figure 49: INI Screen 3

Figure 50: Main Menu

Once in the Main Menu, the selected Menu Item is highlighted in Black while the others remain with a white background. To move around the menu, use the MENU ITEM UP and MENU ITEM DOWN switches.

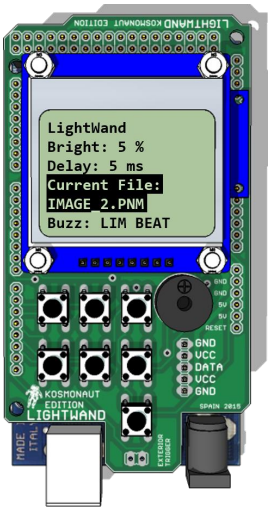

Figure 51: Main Menu 2

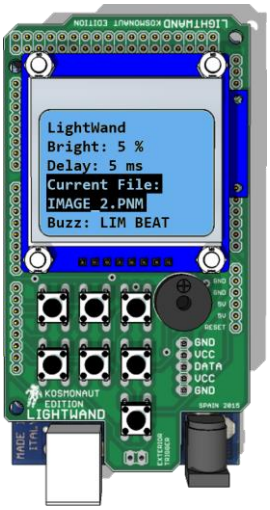

Figure 52: Backlight ON

The options given as parameters in the Main Menu are:
Bright (Brightness): Controls the general intensity of the LED Stripe. It can be set from 5% to 100% in 5% Steps.
Delay: Controls an extra delay between pixel rows (There is always a computational delay that cannot be eliminated). It can be set from 0 to 100ms in 5ms Steps.
Current File: Controls the current file that is chosen. The Image Index is stored in alphabetical order.
Buzz: Controls the Buzzer Mode. It can be set in *NONE*, *LIMIT BEAT* and *PROGRESSIV*.
Backlight: It is turned ON and OFF. If an Emission starts, it disables automatically.

4.2. Handling

This section contains information on how to handle and move the *LightWand Kosmonaut* based on the author experience.

Once all the settings have been correctly set, use your skilled hand to support the controller end the way shown in the image. This way you can easily press the EMISSION START switch while holding the whole structure.

Figure 53: Handling

To use it, just hold both end of the *LightWand* and, after pressing the EMISSION START switch just slide it at a regular speed. This process takes some time to master and more than one try to achieve the desired effect.

The result is a good looking pic with the image displayed in it as shown. It can also be intensely improved by digitally adjusting the contrast and brightness.

Figure 54: "The Kiss" Final Image

4.3. Tips

This section contains some tips that the author considers valuable.

4.3.1. Transport Bag

To comfortably transport the *LightWand*, a bag can be made. Normally the LED profile is delivered inside a cardboard cylinder (if not, a cheap PVC pipe could be used). With this cylinder, a bag can me made just by making some kind of cover with somewhere to attach a strap.

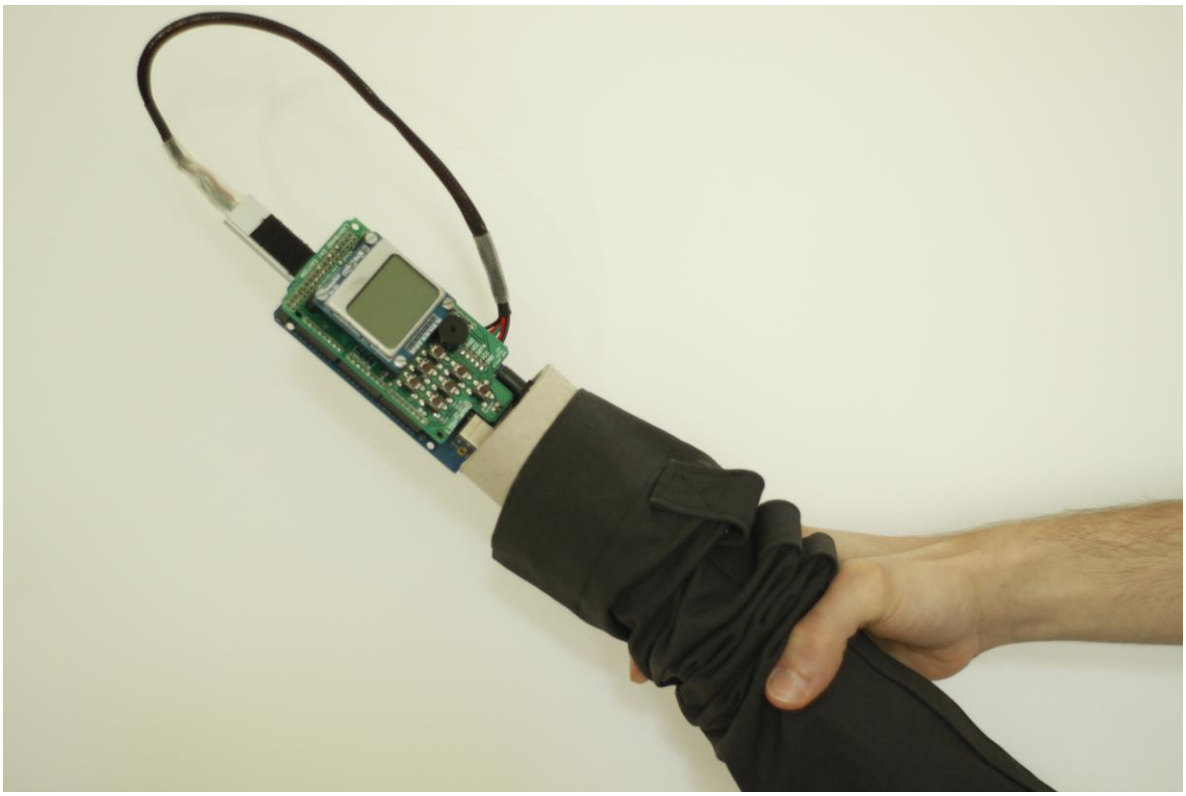

Figure 55: Transport Bag

5. About the Logo

The Logo of the *LightWand Kosmonaut* is a creation of the artist *LeftHandOfDoom*. You can check more of his great works in his *DeviantArt* website[14]. The Image was not originally designed for this purpose and the permission of its usage has been naturally granted.

[14] LeftHandOfDoom(nd), DeviantArt Artist Profile, http://lefthandofdoom.deviantart.com/

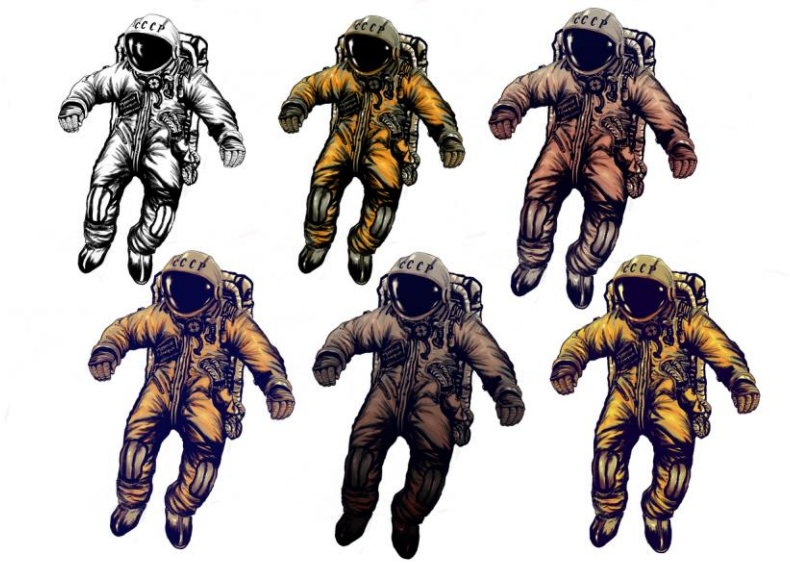

Figure 56: *Kosmonaut* Logo Original Image[13]

6. Image Index

Figure 1: *LightWand* Image 1[1] 2
Figure 2: *LightWand* Image 2 2
Figure 3: *LightWand* Image 3 2
Figure 4: *LightWand* Image 4 2
Figure 5: *LightWand* Image 5 3
Figure 6: Hardware Materials 5
Figure 7: Controller Photograph 6
Figure 8: Controller Render 6
Figure 9: Top Layer 7
Figure 10: Bottom Layer 7
Figure 11: Resistance SMD Colocation 7
Figure 12: Capacitor SMD Colocation 7
Figure 13: *Arduino*-Connection Pins 8
Figure 14: LED Connection BOT view 9
Figure 15: LED Connection TOP view 9
Figure 16: Voltage Regulator 10
Figure 17: Tactile Switches 10
Figure 18: Buzzer 11
Figure 19: Original CATALEX MicroSD Card Adapter V1.0. 11
Figure 20: SD Socket 11
Figure 21: Screen Connection Female Pins 12

Figure 22: Screen Colocation 12
Figure 23: LED Strip Arrow 13
Figure 24: LED Strip Dead-End 13
Figure 25: LED Strip Connector 14
Figure 26: LED Strip Protection 14
Figure 27: LED Profile Diffusor 15
Figure 28: Velcro Tape on Controller 15
Figure 29: Velcro Tape on Profile 15
Figure 30: Controller Attached 16
Figure 31: LightWand Complete 16
Figure 32: Battery Switch 17
Figure 33: Gustav Klimt Raw Image 19
Figure 34: GIMP File Open 19
Figure 35: GIMP Duplicate Layer 20
Figure 36: GIMP To New Layer 21
Figure 37: GIMP Main Figure 21
Figure 38: GIMP Scale Proportional 22
Figure 39: GIMP Scale Parameters 22
Figure 40: GIMP Resized Image Canvas 22
Figure 41: GIMP Image Rotation 23
Figure 42: GIMP New Layer 24
Figure 43: GIMP Black Background 24
Figure 44: GIMP Export 25
Figure 45: GIMP Raw .pnm Mode 25
Figure 46: Switch Index 25
Figure 47: INI Screen 1 26
Figure 48: INI Screen 2 26
Figure 49: INI Screen 3 26
Figure 50: Main Menu 26
Figure 51: Main Menu 2 26
Figure 52: Backlight ON 26
Figure 53: Handling 27
Figure 54: "The Kiss" Final Image 28
Figure 55: Transport Bag 29
Figure 56: *Kosmonaut* Logo Original Image[13] 30
Figure 57: EagleCad Schematic 32

8. EagleCad Schematic

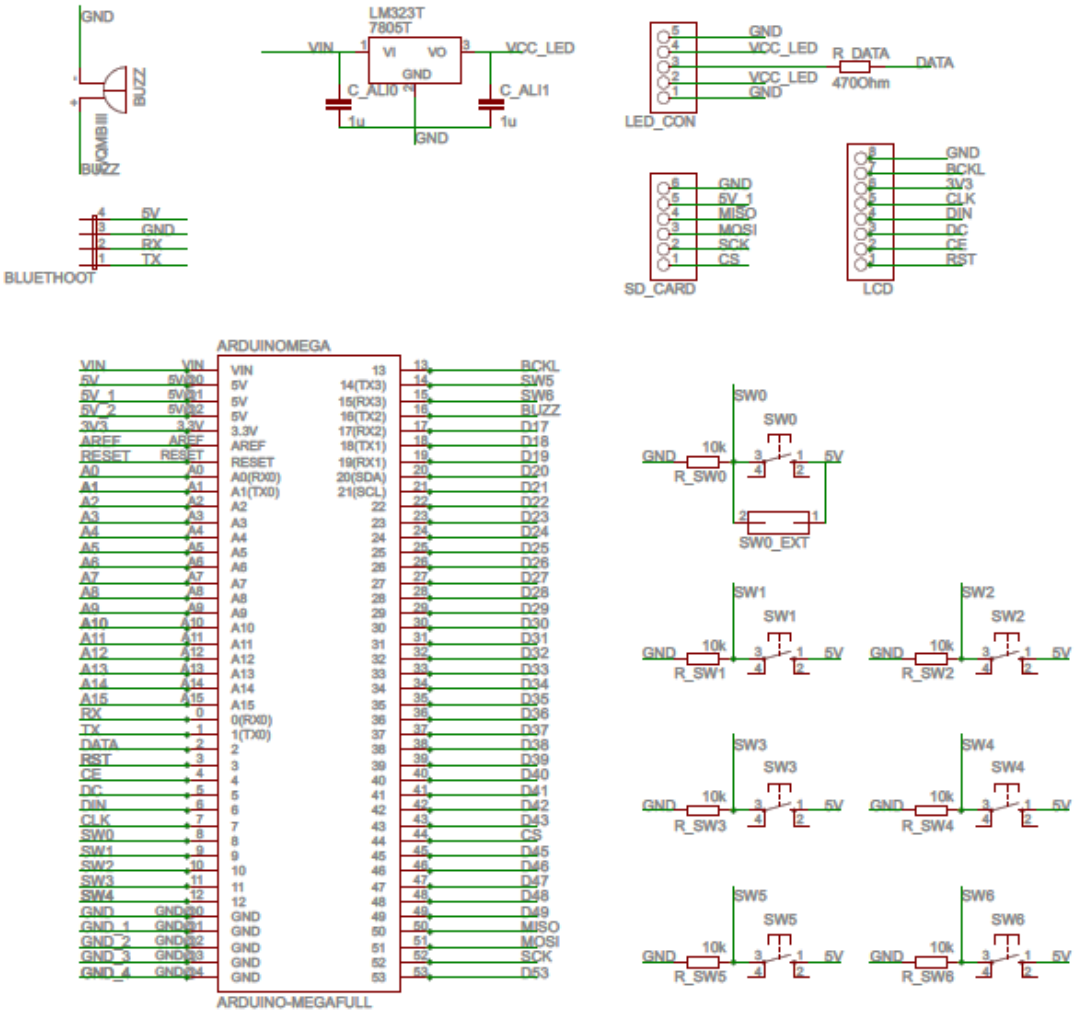

Figure 57: EagleCad Schematic