Basic Fursuit Electronics LEDs and Fans - v3.1

Fauntastic 2019 – 31/05/2019

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Disclaimer

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What is this Talk About ?

- A basic introduction on how to build a couple fun and useful devices for your fursuit, for cheap-ish (fans and mainly static LEDs).
- It focuses on the WHAT and WHY, rather than on the HOW.
- Want to get these slides?
  - https://www.robocow.be/events/

Flüüfff 2019

WOW, IT'S MADE!

- Celebrate the craftmanship in our community!
  - I'll be there with my first **animatronics** WIP
  - There's beer brewing, waffle nomming and a variety of untimely-yet-hilarious demises
- Bring safety goggles and a hard hat *
- Don't forget to pay-up your insurance!
- Re-load the website. Catch them all…
  https://fluufff.org/

* Survival with all body parts intact is not guaranteed. Hugs at your own risk.

Content

- Cool
  Build your own silent fan
- Lights
  Static and blinking LEDs
- No Fire
  How to stay alive to tell the story

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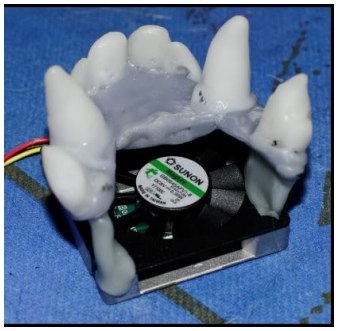
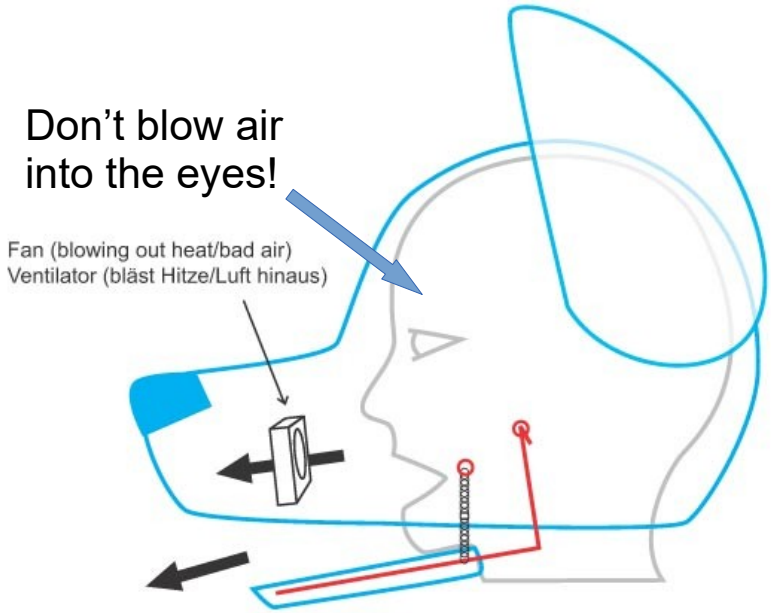
Costume Fans

Relic B. Furry



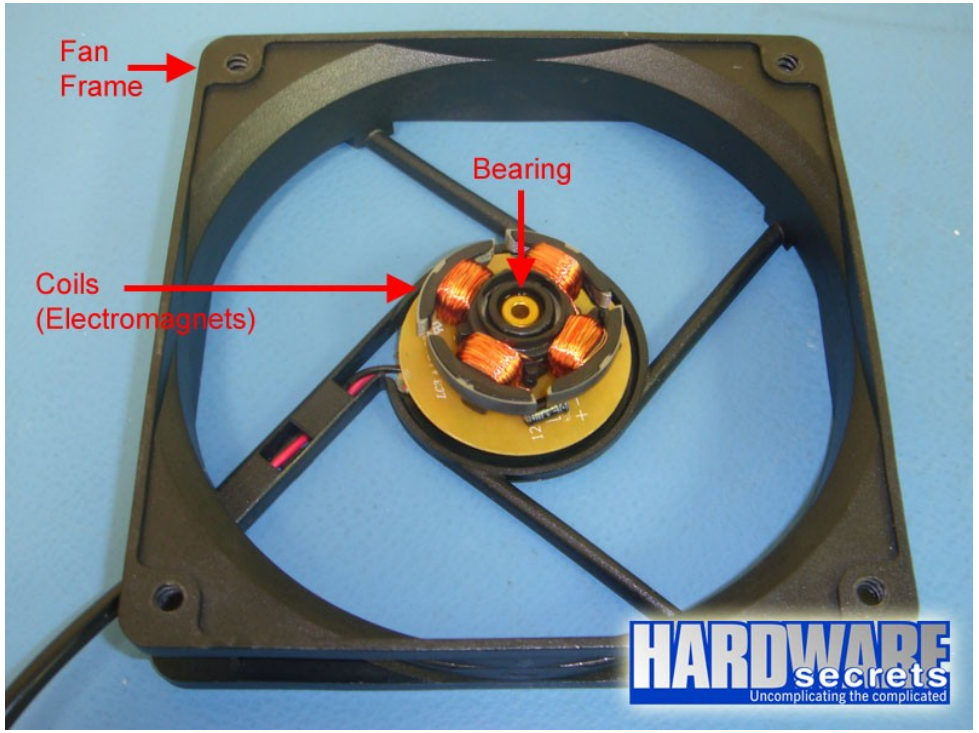
Markus G. Nowak

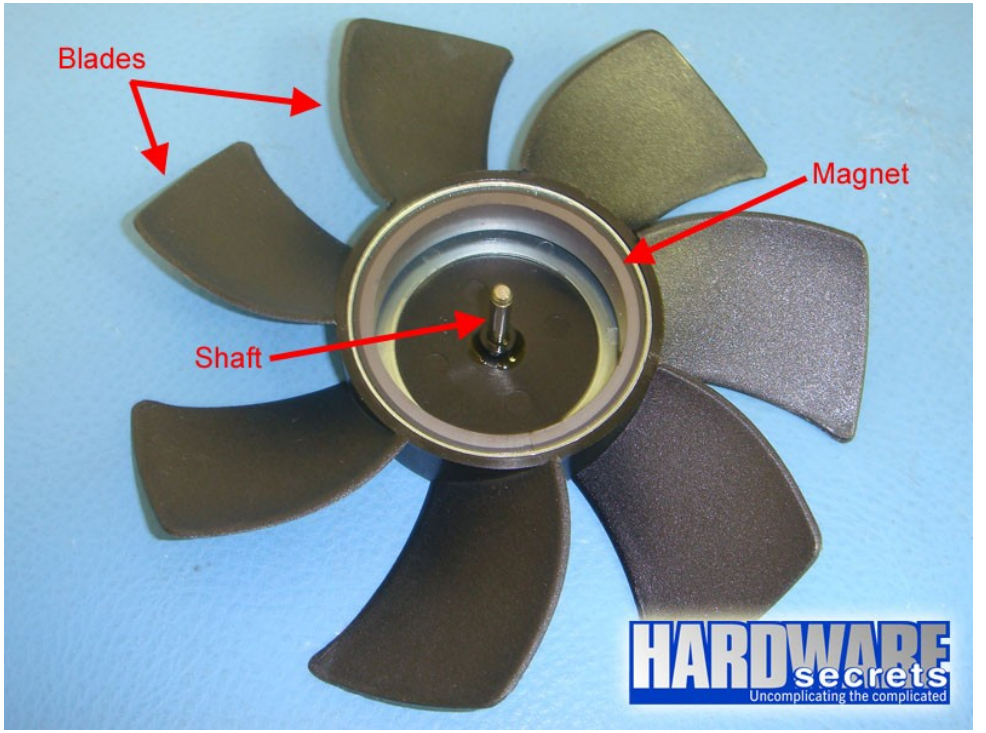


Wendell Wolf

TaniDaReal

Anatomy of a DC Fan

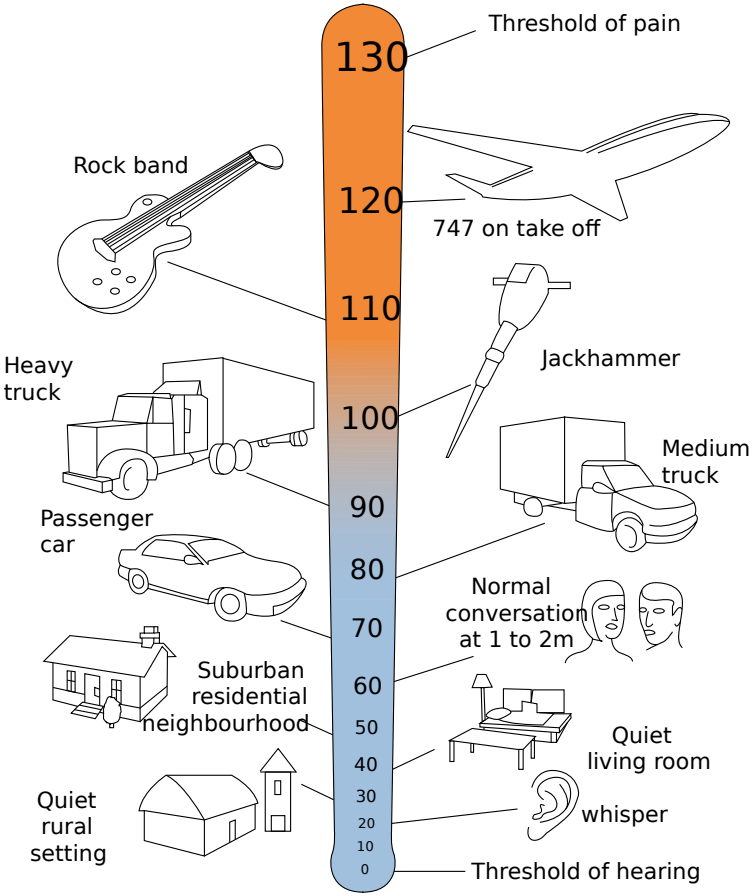




http://www.ebmpapst.com/

Choosing a Quiet Fan

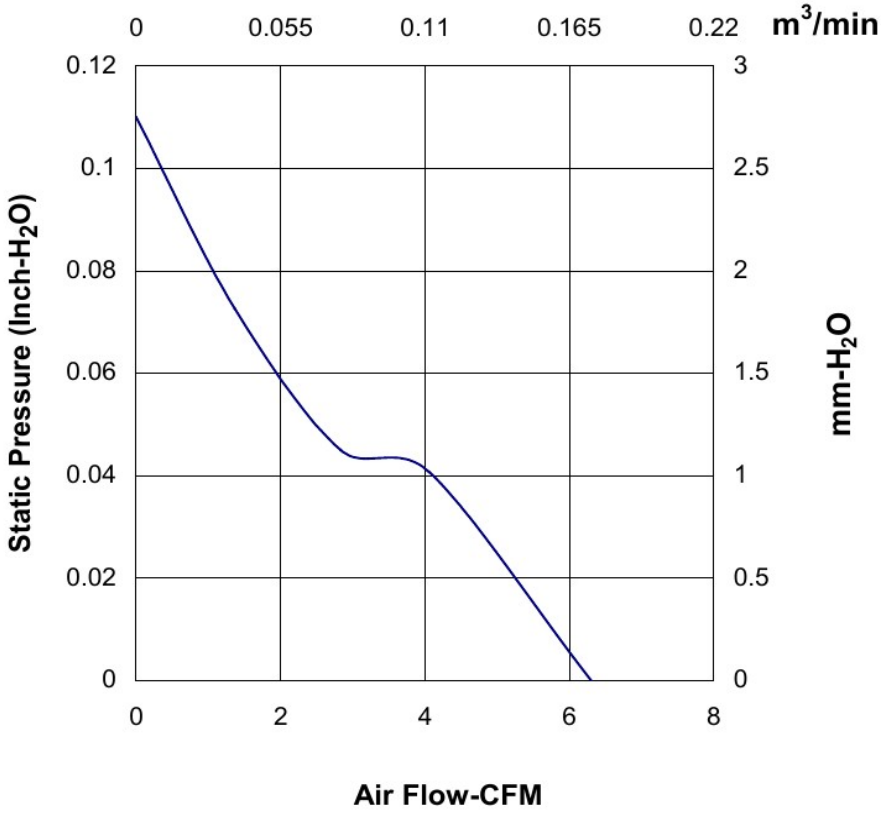
- Don’t buy something because it’s cheap, or expensive.
- Larger & thicker = slower & more quiet (for the same flow rate).
- Manufacturers have data sheets. Go and look them up!
  - When it is not specified, expect the worst.
- Compare apples to apples...
  - Eg: 5 CFM ≠ 10 CFM.
  - <20 dB (@ **1 m**) is decent.
- Power consumption matters!
- Operating voltage convenience:
  - 5V is handy: USB or AA/AAA



Sounds become twice as loud for every 20 dB increase.

How Much Flow?

- Flow is what matters for comfort.
- Hard to stick a number to:
  - Depends on your costume.
  - Static pressure limits actually achieved flow rate.
  - In free-air = ~0 static pressure.
- Just try-out (borrow) a fan with known specifications and make an educated guess from there.
- Help and guide the flow:
  - Vent ports (eg: ears, mouth, nose) and ducts.
  - Mesh vs solid structures.
- Multiple fans are an option.



Sunon MF40200V3-1000U-A99
Rated at 6.3 CFM

Example: Sunon(wealth)

Model	P/N	Size	Bearing (◉ BALL, ● VAPO, ○ SLEEVE)	Rating Voltage (VDC)	Power Current (AMP)	Power Consumption (WATTS)	Speed (RPM)	Air Flow (CFM)	Static Pressure (Inch-H2O)	Noise (dBA)	PDF
MF40201V3-1000U-A99		40X40X20	●	12	0.038	0.46	5000	6.3	0.11	16.5	Download
MF60251V3-1000U-A99		60X60X25	●	12	0.044	0.53	3100	16.0	0.1	16.7	Download
EF40101B2-1000U-A99		40X40X10	◉	12	0.037	0.45	5000	5.5	0.1	17.7	Download
EF40201B3-000U-A99		40X40X20	◉	12	0.034	0.41	5000	6.3	0.14	19.0	Download
EE60251B3-000U-A99		60X60X25	◉	12	0.058	0.7	3000	13.9	0.08	20.0	Download
EE40201S3-1000U-999		40X40X20	○	12	0.052	0.63	5000	6.3	0.11	16.5	€4,39
EE60251S3-1000U-999		60X60X25	○	12	0.06	0.72	3100	16	0.1	16.7	Download
HA40101V4-1000U-A99		40X40X10	●	12	0.031	0.38	5000	5.4	0.09	15.7	Download
HA40201V4-1000U-A99		40X40X20	●	12	0.031	0.38	4500	5.5	0.1	12.3	€4,60
HA50151V4-1000U-A99		50X50X15	●	12	0.025	0.3	3200	7.7	0.07	15.4	Download
MB45100V2-000U-A99		45X45X10	●	5	0.230	1.15	5000	9.2	0.12	27.0	Download
MF40060V1-1000U-A99		40X40X6	●	5	0.087	0.44	7000	6.3	0.1	29.3	€5,05
MF40100V1-1000U-A99		40X40X10	●	5	0.136	0.68	7000	8	0.19	27.3	Download
MF40200V1-1000U-A99		40X40X20	●	5	0.15	0.75	7000	8.9	0.22	25.5	Download
MF40060V2-1000U-A99		40X40X6	●	5	0.065	0.33	6000	5.5	0.08	25.3	Download
MF40200V2-1000U-A99		40X40X20	●	5	0.107	0.54	6000	7.7	0.17	21	Download
MF40100V2-1000U-A99		40X40X10	●	5	0.094	0.47	5800	7	0.12	20.6	Download
MF40200V3-1000U-A99		40X40X20	●	5	0.075	0.38	5000	6.3	0.11	16.5	€6,07
MF50100V2-1000U-A99		50X50X10	●	5	0.085	0.43	4800	11	0.11	25.6	Download
MF50100V3-1000U-A99		50X50X10	●	5	0.075	0.38	4300	8.4	0.08	22.4	Download

https://www.sunonusa.com/

Example: Noctua

40mm

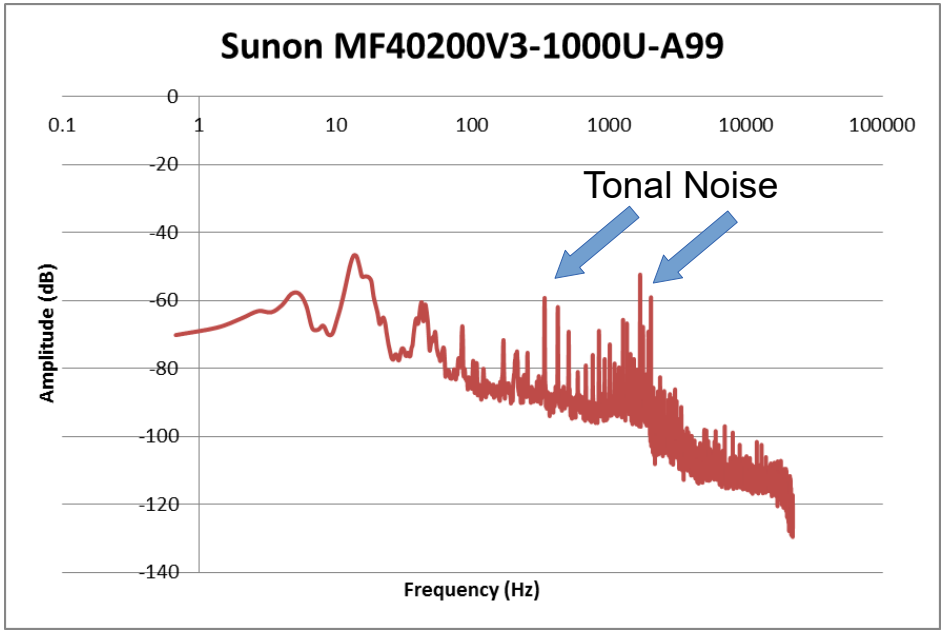
9.4 m³/h → 5.5 CFM
8.2 m³/h → 4.8 CFM
2.26 mm H_2O → 0.09 in H_2O
1.78 mm H_2O → 0.07 in H_2O

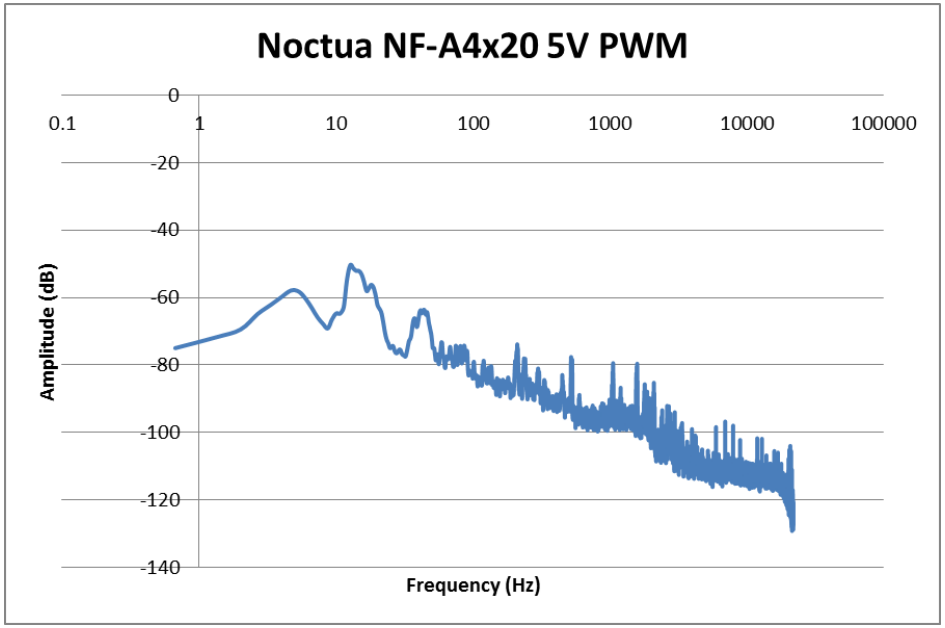
	PRODUCT		mm	RPM	dB/A	m³/h	mm H_2O		
	NF-A4x20 PWM		40x40x20	5000	14,9	9,4	2,26	4-pin PWM	
	NF-A4x20 FLX		40x40x20	5000	14,9	9,4	2,26	3-pin	
	NF-A4x20 5V PWM	●	40x40x20	5000	14,9	9,4	2,26	4-pin PWM	$15.00
	NF-A4x20 5V		40x40x20	5000	14,9	9,4	2,26	3-pin	
	NF-A4x10 PWM		40x40x10	5000	19,6	8,9	1,95	4-pin PWM	
	NF-A4x10 FLX		40x40x10	4500	17,9	8,2	1,78	3-pin	
	NF-A4x10 5V PWM	●	40x40x10	5000	19,6	8,9	1,95	4-pin PWM	$14,00
	NF-A4x10 5V		40x40x10	4500	17,9	8,2	1,78	3-pin	

https://noctua.at/

Fan Noise – SPL & Spectrogram

- SPL @ 10 cm (background: 35dB(A))
  - Sunon: 76 dB(A)
  - Noctua: 70 dB(A)
- dBA does not describe how the noise sounds.
  - Some tones are more annoying than others!
  - White noise is tolerable.
  - Listen to the fans, held close to your ears. (But keep some distance!)





Fan Protection

- Two important features:
  - Polarity protection. (Eg: when using AA/AAA cells.)
  - Blocked rotor protection. (Protects the motor.)
- Don’t skimp, get one that has these (or add a diode for polarity protection)!

- Voltage range limits:
  - Under-voltage is fine.
    - Runs slower, quieter, less air, less pressure.
    - Too low and the fan won’t start-up (again).
  - Over-voltage will destroy the motor driver IC.
    - Beware of battery type: NiMH vs Alcaline!

Estimating Battery Life

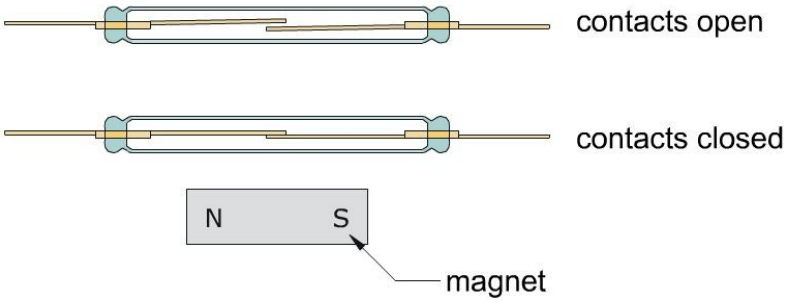
- Quick and VERY rough estimate (using a 5V 50 mA fan):
  - Fan load: 50 mA * 5 V = 250 mW
  - Battery: 800 mAh cells * 4 cells * 1.2 V (NiMH) = 3840 mWh
    - 3840 mWh / 250 mW = ~15 hours
  - Battery: 2200 mAh USB * 1 cell * 3.7 V (LiPo) = 8140 mWh
    - 8140 mWh / 250 mW = ~32 hours
- Notes:
  - USB power banks give the mAh rating of the LiPo cell inside, which is 3.7 V (for 1C devices) and not 5 V.
    → This is why I did the calculations in mWh!
  - They also don't mention the conversion efficiency.
    → Multiply the run-time by 0.8. (Assume 80 % typical efficiency.)
  - Batteries age and vendors lie.
    → Multiply the run-time by 0.5. (Cynical bastard correction.)

Building a Fan Kit

- Choose a 5 V fan(s).
- Choose a power source.
  - AA/AAA/AAAA battery box.
    - 3 x alcaline (open cell ~1.65 Vmax, 1.5 Vnom)
    - 3 x NiZn (open cell ~1.85 Vmax, 1.6 Vnom)
    - 4 x NiMH (open cell ~1.45 Vmax, 1.2 Vnom)
    - Use a fuse as close as possible to the battery pack.
  - 5 V USB power bank.
    - Pick smallest size for useful autonomy.
    - Use a LiPo bag!
- Choose a switch if desired.
  - In-line lamp cord switches are easy to install.
    - Big and clunky, easier for paws.
    - Use wire-end ferrules in screw connections, not solder.
    - BUT: they likely will not last due to oxidation.
  - There exist USB cables with a switch ready-made.
  - These exist battery boxes with built-in switches.

Some Gotchas

- Some USB power banks fail with a low load.
  - They just turn-off, or won't turn-on.
  - Small banks seem to generally work.
- The switches in AA/AAA battery cases may fail over time due to sweat-related corrosion problems.
  - Use an external, sealed switch.
  - Reed switches are useful for small loads.
- Seal your wire splices. Sweat gets everywhere!



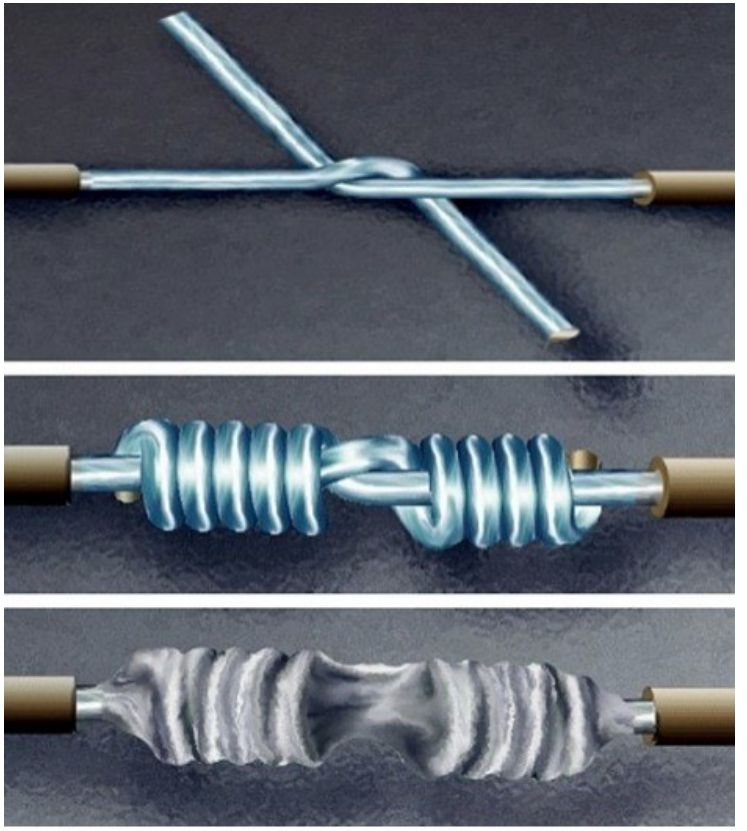
http://iamtechnical.com/sites/default/files/reed-switch.jpg

Dealing with Sweat

- It gets **everywhere**!
  - Both conductive and corrosive
  - Leaves salt deposits
- Remediation
  - Conformal coatings on circuit boards
  - Adhesive-lined heat shrink (stronger splices!)
  - Suitable, IP-rated switches, enclosures, connectors, etc...

Joining (Splicing) Wires

- Tin, twist, solder and use adhesive-lined heat shrink.
  - Splice is stronger than wires.
  - Adhesive-lined heat shrink keeps-out moisture.
- BUT: reliability issues:
  - Thin wires are very weak.
    - Pull forces will break the conductor with ease.
  - Stranded wires wick solder.
    - Wire become stiff.
    - Fails **fast** to bending-induced metal fatigue.
- Solution: use strain relief!



Lineman's splice

1. The conductors shall be pre-tinned.
2. There shall be at least 3 turns around each conductor and the wraps shall be tight with no gaps between adjacent turns.
3. The wraps shall not overlap and the ends of the wrap shall be trimmed flush prior to soldering to prevent protruding ends.
4. Conductors shall not overlap the insulation of the other wire.

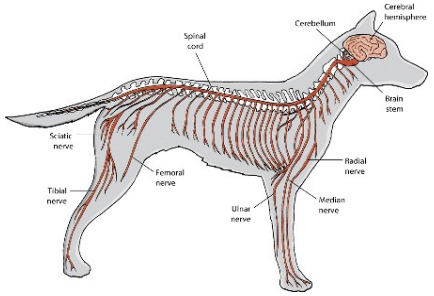
NASA-STD 8739.4A

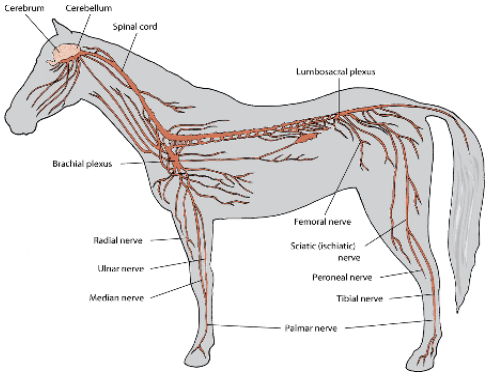
Strain Relief is Not Optional

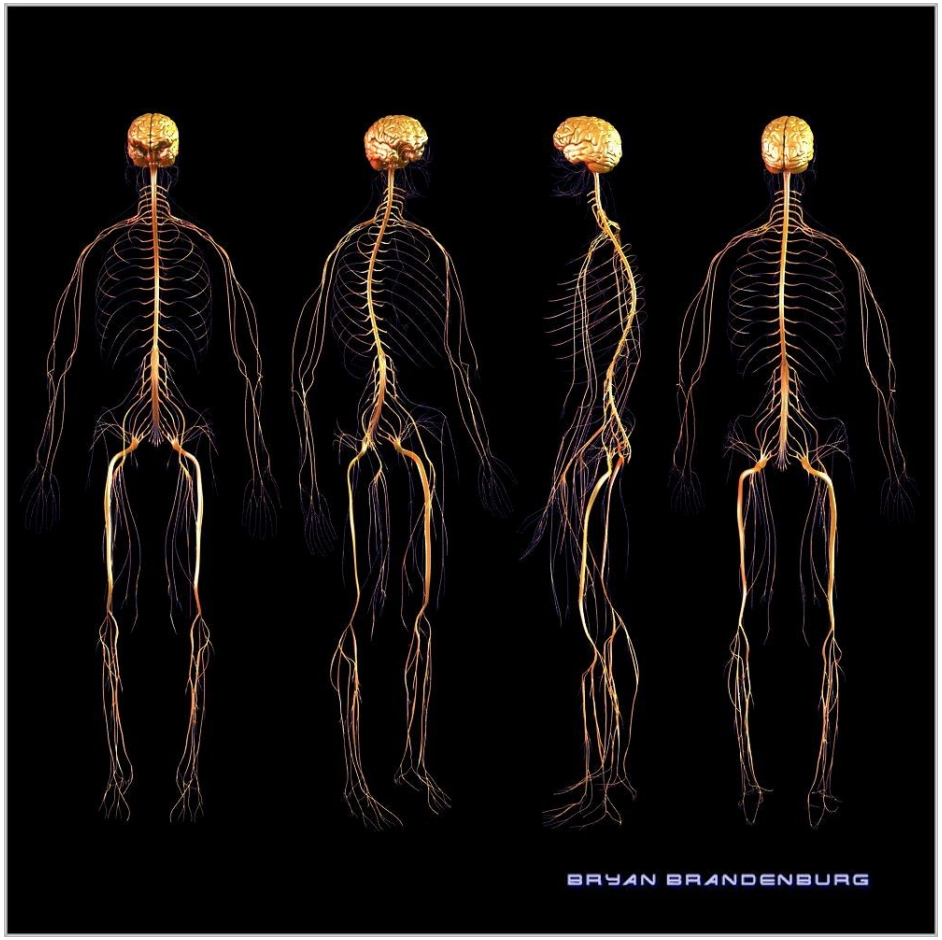
- Take the force and bending before/ after the splice!
  - Also where the wire attaches.
- Can be as simple as:
  - Hot glue, cable ties.
  - Sewing the wire into the fabric.
- Glue-lined heat shrink works well.
  - Additional strength as it attaches to the cable jacket.
- Foam and fabric stretches!
  - Absorb the stress in a wire loop, not the solder joint.
  - Use ‘S’, ‘U’, or ‘loop’ wire routing to add ‘stretch’ to the wires.
  - Consider your body plan.

Biomimicry: Nervous System

- Route wires along the paths of the main nerve bundles.
  - Reduced flexing and stretching.
  - Reduced forces on the wiring.







Obtaining Parts and Tools?

- Local electronics store
- Hobbyist web shops
  - Adafruit Industries
  - Sparkfun
  - Polulu
  - Hobbyking
  - etc…
- General e-commerce
  - AliExpress
  - Amazon
  - eBay
  - etc...
- Professional mail-order companies (For specific parts, eg: the fan)
  - Digikey
  - Mouser
  - Farnell/Element14
  - RS
  - TME
  - Conrad
  - etc…
- Bribe your local, friendly electronics hobbyist.
- ~~“Borrow” from work.~~

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Lights!

SarahDee

Viola Mutt – Dragonfox

Unknown

Unknown

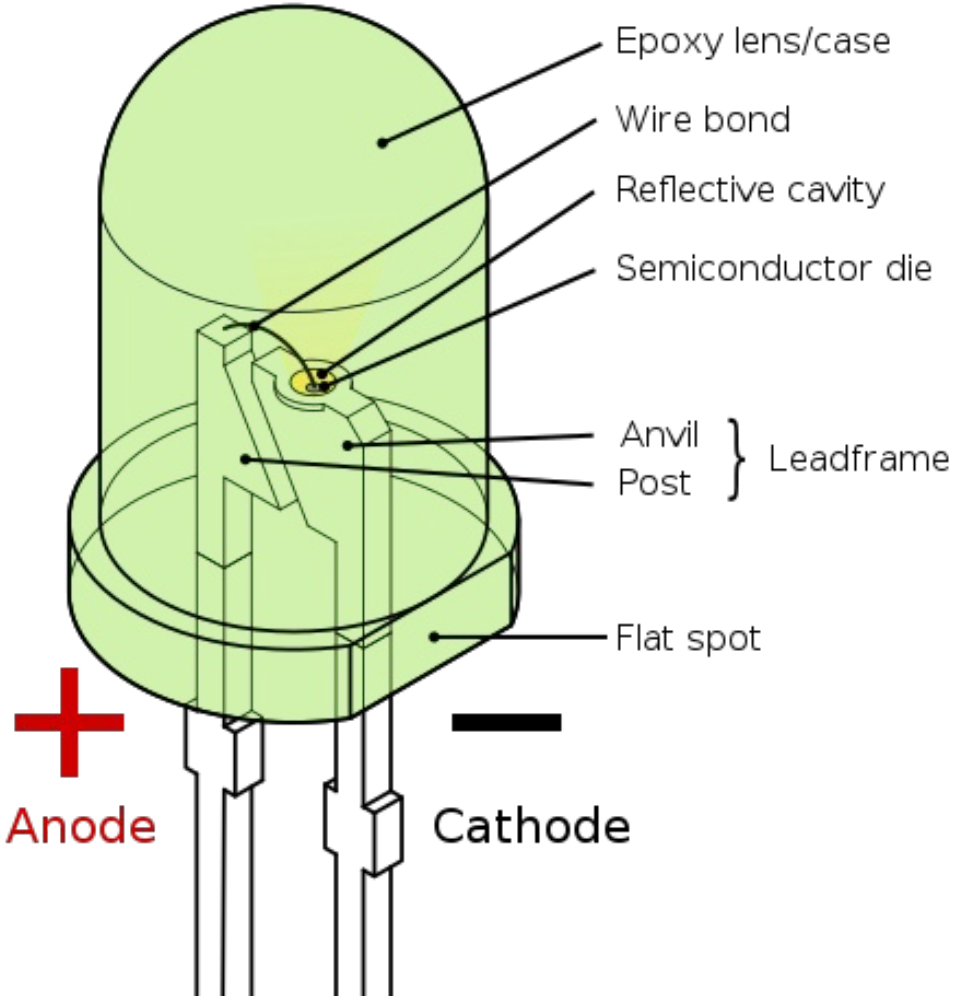
Primal Art Fursuits - LevantiFox

Wolfem Works

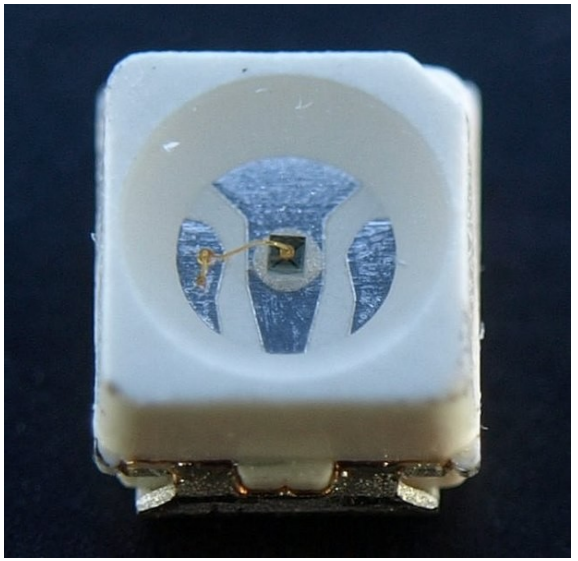
Kaiborg Studios - Ascii

TheKareliaFursuits - Gweincalar

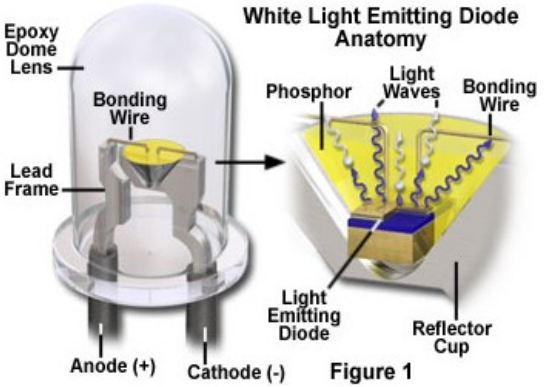
Anatomy of a LED



Wikimedia Commons - Inductiveload



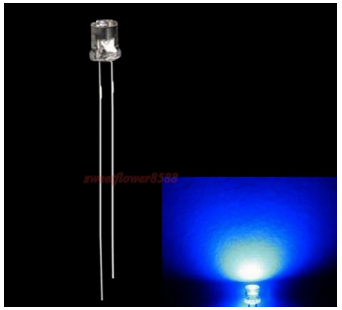
Wikimedia Commons – Thomas Wydra



Olympus

Choosing a LED

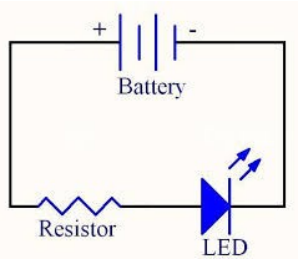
Furrista



Sweetflower8588

- Colour.
  - Given by energy levels in the semiconductor.
  - Other colours use phosphorous converters or RGB mixing.
- Illumination Angle.
  - Most conventional packages are narrow. (15°- 60° typical)
  - Straw-hat and surface-mount types can be very wide. (>120°)
- Brightness / Efficiency.
  - Amount of light for a given current (say, 20 mA) varies widely.
  - More efficient = fewer devices needed and longer battery life.
  - Brighter = visible under more lighting conditions. (Eg: during the day.)
    - Consider adding a dimming circuit for use at night! (Eg: variable resistor.)
- Form factor.
  - 3 mm and 5 mm radial leaded types are most common.
  - Lens shape matters → illumination angle.
  - Surface-mount types in larger package are still quite manageable.

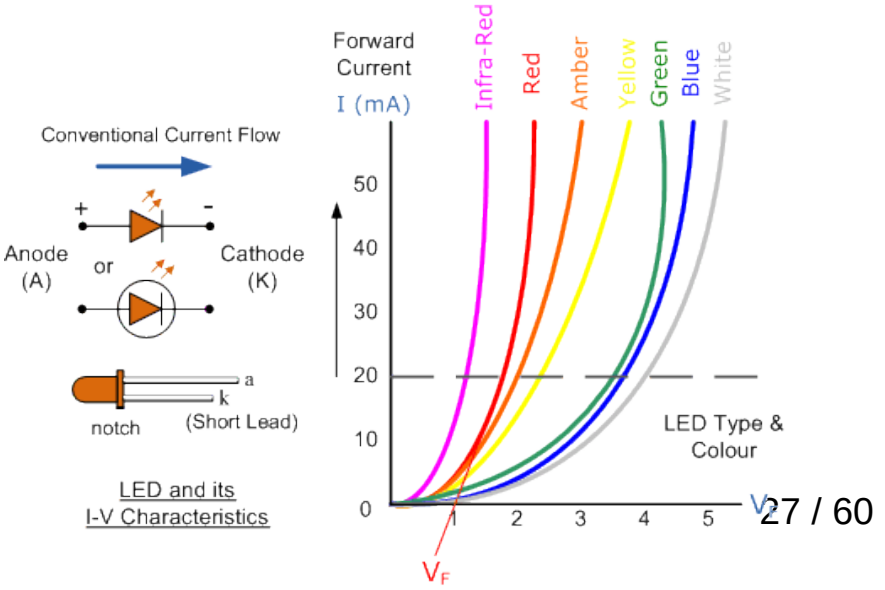
Driving a Small LED



- LEDs need a constant-current.
  - Current relates to brightness.
  - Too much current = boom!
- To calculate the resistor you need:
  - Battery voltage. (V_{BAT})
  - LED forward voltage drop. (V_{LED})
  - LED current. (I_{LED})
- Equation: $R = (V_{BAT} - V_{LED}) / I_{LED}$
  - (5 V – 1.7 V) / 20e-3 A = 165 Ω
  - Nearest larger E12 value: 180 Ω
  - Keep the units consistent!
- If you can't find the data sheet:
  - V_{LED} depends on the colour: ~2.2 V or ~3.5 V (InGaN).
  - I_{LED} is ~20 mA (most small ones).
- Too bright? Use a lower current.
- Confused? Use a LED calculator.

LED P/N Suffix		Description	Chemistry	# of Elements	Color Temperature (CCT Typ)	Peak Wavelength (λ / x-coord)	Dominant Wavelength (λ / y-coord)	Forward Voltage (Vf Typ)	Forward Voltage (Vf Max)	Brightness
H		High Efficiency Red	GaP	2	~	700	660	2.0	2.5	Standard
SR		Super Red	GaAlAs	3	~	660	640	1.7	2.2	High
SR		Super Red	AlInGaP	4	~	660	640	2.1	2.5	High
SI		Super High Intensity Red	AlnGaP	4	~	636	628	2.0	2.6	High
I		High Intensity Red	GaAsP	3	~	635	625	2.0	2.5	Standard
ZI		TS AlInGaP Red	AlInGaP	4	~	640	630	2.2	2.8	High
SO		Super Orange	AlInGaP	4	~	610	602	2.0	2.5	Standard
A		Amber	GaAsP	3	~	605	610	2.0	2.5	Standard
SY		Super Yellow	AlInGaP	4	~	590	588	2.0	2.5	Standard
ZY		TS AlInGaP Yellow	AlInGaP	4	~	590	589	2.3	2.8	High
Y		Yellow	GaAsP	3	~	590	588	2.1	2.5	Standard
SUG		Super Ultra Green	AlInGaP	4	~	574	568	2.2	2.6	High
G		Green	GaP	2	~	565	568	2.2	2.6	Standard
SG		Super Green	GaP	2	~	565	568	2.2	2.6	Standard
PG		Pure Green	GaP	2	~	555	555	2.1	2.5	Standard
UPG		Ultra Pure Green	InGaN	3	~	525	520	3.5	4.0	High
UEG		Ultra Emerald Green	InGaN	3	~	500	505	3.5	4.0	High
USB		Ultra Super Blue	InGaN	3	~	470	470	3.5	4.0	High
UV		Ultra Violet	InGaN	3	~	410	~	3.5	4.0	Standard
SUV		Super Violet	InGaN	3	~	380	~	3.4	3.9	Standard
T		Turquoise	InGaN	3	~	0.19	0.41	3.2	4.0	Standard
V		Violet / Purple	InGaN	3	~	0.22	0.11	3.2	4.0	Standard
P		Pink	InGaN	3	~	0.33	0.21	3.2	4.0	Standard
MW (Warm)		Warm White	InGaN	3	3000K	~	~	3.3	4.0	High
NW (Neutral)		Neutral White	InGaN	3	4000K	~	~	3.3	4.0	High
UW (Cool)		Cool White	InGaN	3	6000K	~	~	3.3	4.0	High

Lumex



http://www.electronics-tutorials.ws/diode/diode_8.html

Lumex LED Chart

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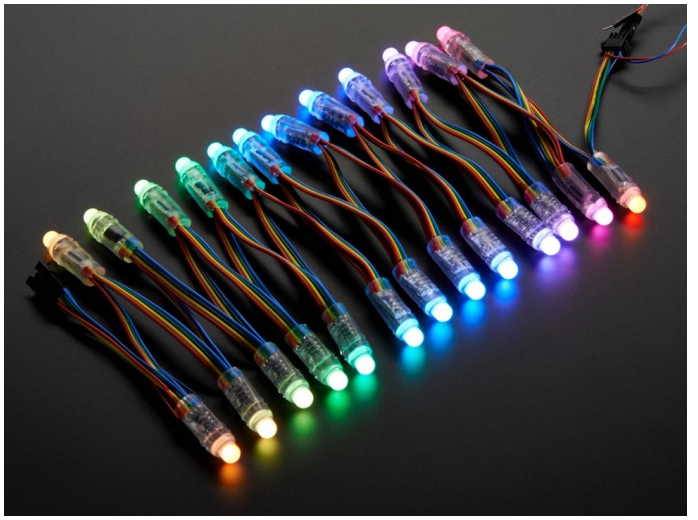
SR		Super Red	GaAlAs	3	~	660	640	1.7	2.2	High
SR		Super Red	AlInGaP	4	~	660	640	2.1	2.5	High
SI		Super High Intensity Red	AlnGaP	4	~	636	628	2.0	2.6	High
I		High Intensity Red	GaAsP	3	~	635	625	2.0	2.5	Standard
ZI		TS AlInGaP Red	AlInGaP	4	~	640	630	2.2	2.8	High
SO		Super Orange	AlInGaP	4	~	610	602	2.0	2.5	Standard
A		Amber	GaAsP	3	~	605	610	2.0	2.5	Standard
SY		Super Yellow	AlInGaP	4	~	590	588	2.0	2.5	Standard
ZY		TS AlInGaP Yellow	AlInGaP	4	~	590	589	2.3	2.8	High
Y		Yellow	GaAsP	3	~	590	588	2.1	2.5	Standard
SUG		Super Ultra Green	AlInGaP	4	~	574	568	2.2	2.6	High
G		Green	GaP	2	~	565	568	2.2	2.6	Standard
SG		Super Green	GaP	2	~	565	568	2.2	2.6	Standard
PG		Pure Green	GaP	2	~	555	555	2.1	2.5	Standard
UPG		Ultra Pure Green	InGaN	3	~	525	520	3.5	4.0	High
UEG		Ultra Emerald Green	InGaN	3	~	500	505	3.5	4.0	High
USB		Ultra Super Blue	InGaN	3	~	470	470	3.5	4.0	High
UV		Ultra Violet	InGaN	3	~	410	~	3.5	4.0	Standard
SUV		Super Violet	InGaN	3	~	380	~	3.4	3.9	Standard
T		Turquoise	InGaN	3	~	0.19	0.41	3.2	4.0	Standard
V		Violet / Purple	InGaN	3	~	0.22	0.11	3.2	4.0	Standard
P		Pink	InGaN	3	~	0.33	0.21	3.2	4.0	Standard
MW (Warm)		Warm White	InGaN	3	3000K	~	~	3.3	4.0	High
NW (Neutral)		Neutral White	InGaN	3	4000K	~	~	3.3	4.0	High
UW (Cool)		Cool White	InGaN	3	6000K	~	~	3.3	4.0	High

Driving Many LEDs the Simple Way: Digital LED Pixel (Strips)

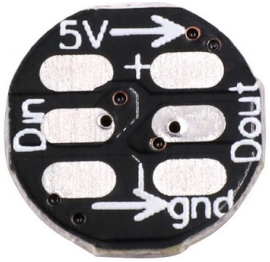
- Full digital, software control over each “pixel” (RGB LED) colour and brightness.
- No need to build a control circuit or wire all the LEDs yourself.
- To make it work:
  - Connect a 5 V supply. (Check!)
  - Connect your microcontroller to the digital lines + GND.
  - Download a compatible library. (Buy a strip that has one!)
  - Modify and program an example.
- Arranged in a matrix, these could display simple animations. (E.g.: winking smiley face.)



https://www.adafruit.com/

Pixel String Gotchas

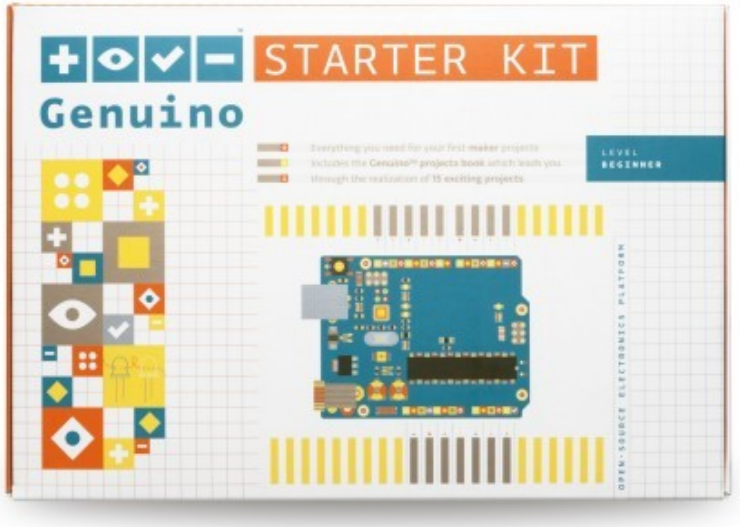
- Current can get large, quickly. (20 mA x 3 x # RGB LEDs)
  - USB power banks top-out at 1 or 2 A. (16 or 33 RGB LEDs.)
    - Split the strips in groups, and use several power banks.
      - All share ground with each other and the controller.
      - Positive from each bank goes to one strip group only.
  - Large loads / sources are outside the scope of this talk!
- Flat LED strips do not like repeated bending and will fail.
  - Old style, wired pixel strings are better, but bulky.
  - Use individual LED pixels, joined by flexible wire, covered in glue-lined heat shrink (strain relief + moisture seal).

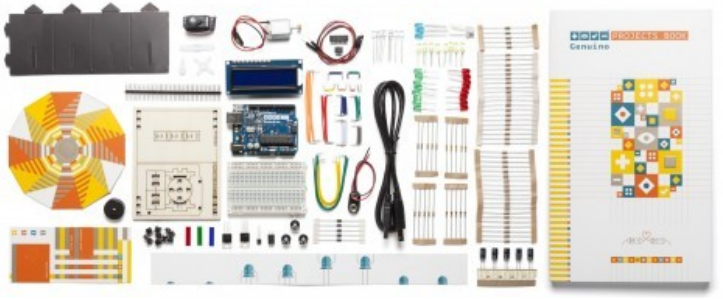


XUNATA Light-Life, WS2812B-based, 1 cm diameter, €12 for 100 on AliExpress

Control: Arduino and Co.

- For dynamic effects you need a programmable controller.
- There are many easy-to-use options today.
  - Arduino / Teensy
  - Raspberry Pi
- Just go out, buy a good starter kit, and go!
- Caveat emptor: 5V vs 3.3V logic levels.
  → Beginner? Stick with 5V.

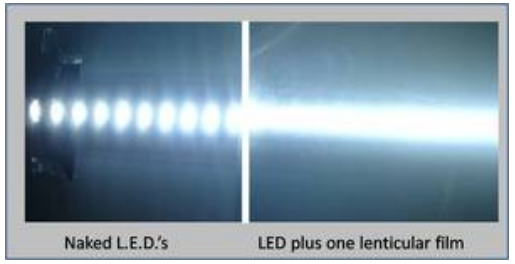




https://www.arduino.cc/

Some Optical Tricks

- For more even LED lighting
  - Use lenses.
  - Use multiple LEDs.
  - Use an optical diffuser:
    - Privacy window film.
    - Thin, translucent foam.
    - Frosted plexiglass.
    - Fibre packing tape.
    - Real diffuser film.

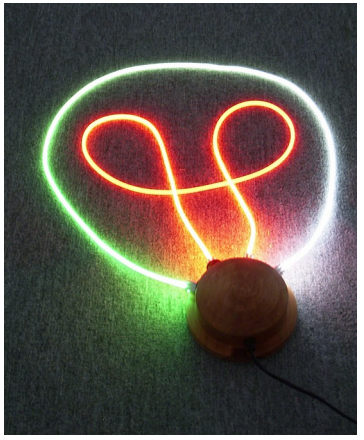


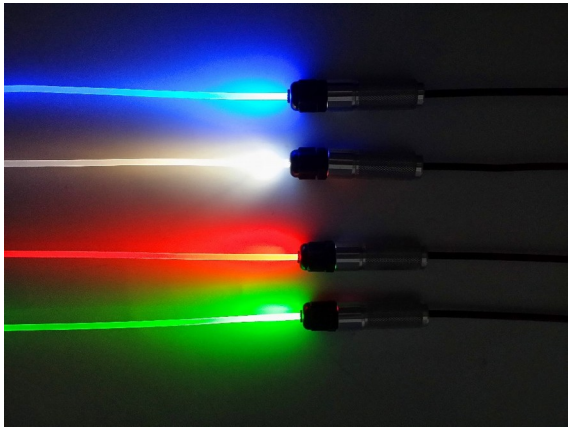
- Complex shapes with a decal
  - Print on overhead projector transparency film. Or cut out a shape from some opaque material.
  - A diffuse light source will make a big difference.
  - Idea: glowing tattoo under fur!

Some Optical Tricks

- For tiny points of light
  - 1 mm plastic optical fibre (POF) is inexpensive.
  - Join several strands to a bright LED, or use a real light engine driver module.
  - Feed the other ends to where you want lights.
  - Jacketed vs non-jacketed POF.
  - Idea: glowing whisker tips!

- For glowing lines
  - Side-emitting fibre is inexpensive. (about €1/m on AliExpress)
  - Small light engine (3 W) is also cheap. (€5 on AliExpress)
  - Much easier to use and far more robust than EL (electro-luminescent) wire. Also: no high-voltage.
  - Idea: glowing line art on your suit!





Content

- Cool
  Build your own silent fan
- Lights
  Static and blinking LEDs
- No Fire
  How to stay alive to tell the story

The Costume Environment...

- Is a harsh mistress indeed!
  - Constant motion.
  - Regular high-velocity impacts.
  - Lots of wire flexing and pulling.
  - High humidity.
- Here are some tips to improve safety.

Costuming Safety

- The risks (non-exhaustive) discussed in this section:
  - Electrocution
  - Fire
  - Mechanical



Costuming Safety

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Electrocution

- There is a risk of a lethal voltages appearing on the costume electronics due to a faulty external device.
- As you are wearing the system, you cannot disengage!
- Simple mitigation: **Batteries Only!**
  - No mains-powered energy source is allowed while wearing the costume. Thus, no adapters, chargers, lab power supplies, etc...
  - Nothing may be connected to anything that is not exclusively battery powered itself and isolated from outside systems.
  - No electrical connections to outside systems (such as phone lines, network cables, audio/video systems, etc…) are allowed.
  - If you need to send audio to the DJ/PA system, use a wireless approach (e.g. mic pack, Bluetooth), or just hold a microphone.
- Avoid CCFL/EL light sources, as their inverters run at high voltages.

Costuming Safety

- The risks (non-exhaustive) discussed in this section:
  - Electrocution
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Fire

- Common Sources of Fire
- Materials Flammability
- Escapability
- Fire Fighting

Fire

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Common Sources of Fire

- Batteries
- Wiring
- Electronics
- Electro-mechanical components

- Root Causes:
  - Joule heating
    $P = R \times I^2$
  - Chemical
    - Thermal runaway
    - Ignition of H_2
    - Ignition of Li
  - Arcing

LiPo Battery Fire

- LiPo batteries are VERY sensitive.
- Do not abuse.
- DO NOT ABUSE!
- FOR THE LOVE OF ALL THAT IS DEAR, DO **NOT** ABUSE A LiPo!!!
- If you REALLY must:
  - Use protected cells.
    - USB power bank
  - Use a LiPo bag!

https://www.youtube.com/watch?v=gisdMQbtJqk

https://www.youtube.com/watch?v=gz3hCqjk4yc

Also, have a good look at the link below. It is a series of test of various, common LiPo storage options:
https://www.youtube.com/watch?v=CnNId0mDnBo

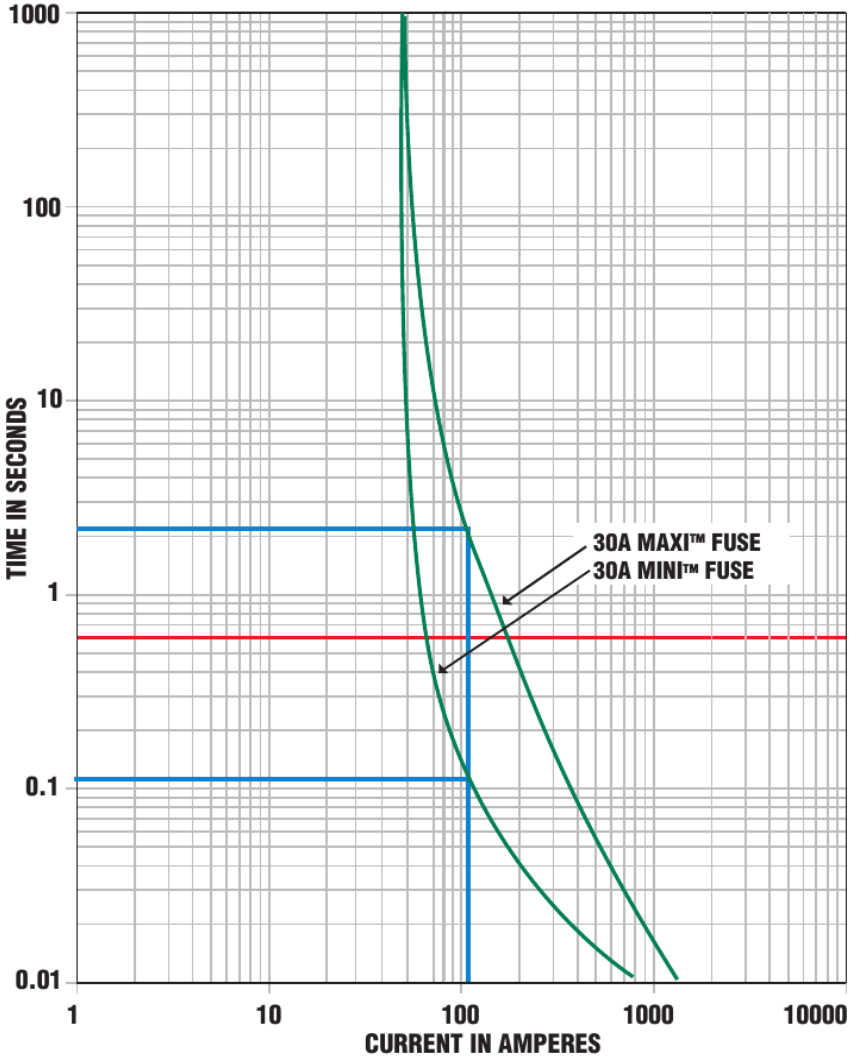
HobbyKing

Batteries - SSDD

- Consider them all as dangerous and follow LiPo handling safety recommendations.
- Isolate them from your body and by-standers:
  - Mechanically
    going in → impacts, deformation
    going out → shrapnel, flames, smoke, fumes
  - Thermally
- Implement a safety “pack eject” procedure.
- Keep the battery external to your costume.
- Store and charge them in a fire-proof container.

Sizing a Fuse

- Complex topic!
  - Read manufacturer's guides.
    Eg: Littlefuse's "Fuseology" primer.
- Key point: fuses are slow for low fault currents and may not even blow at all.
  - The time-current (I^2t) curve shows this.
  - But don't go to close to the edge either.
    → The fuse will wear too fast.
- As a rule of thumb:
  - For loads with a low inrush current (LEDs, most DC fans):
    - Fuse current = 1.2 x max. load current.
    - Choose a 'fast' type.
  - Make sure that your source can blow the fuse in a reasonable time.
    - Most USB power banks can source 1 A.
      - If it fails, the LiPo inside can source 10s of amps (wiring permitting).
    - A pack of NiMH can source many amps.



Littlefuse

Fire

- Common Sources of Fire
- Materials Flammability
- Escapability
- Fire Fighting

Materials Flammability

- Most costume materials are polymers or polymer blends.
  - Nylon, polyester, polycotton, polyurethane or latex foam, resins, glues, ...
  - Many have large surface areas (imitation fur, fleece).
- All these materials ignite easily and burn exceptionally well.
  - Some emit toxic fumes.
  - Many also melt.
    → This is very bad news for burn wounds!

Materials Flammability

- **Fire retardants** are of vital importance!
  - They make the fire self-extinguish and keep it from spreading.
- How do you know if your costume materials are properly treated?
  - One practical way: test each material with a gas (butane/propane) torch.
  - The fire should stop when the flame is removed.
  - Best to test samples of all the materials used.
    - But, no guarantee that there won't be material and structure interactions!

Dr. Faux Lights Faux Fur on Fire

- Video Used (Source: YouTube)
  - “Settings Fire To Faux (Fur) - Dr. Faux Tests Fur vs Fire”
    https://www.youtube.com/watch?v=UvipL_6m9-0

Polyurethane and Synthetic Latex Foam – On Fire

- Videos Used (Source: YouTube)
  - “Flame Retardant Reduces Flammability of Upholstered Furniture”
    https://www.youtube.com/watch?v=mgdWQYl5ZVc
  - “Synthetic Latex and Natural Latex Blends are Highly Flammable”
    https://www.youtube.com/watch?v=SWuxLIuPZ0U

Materials Flammability

- Initial material conclusions (from the videos):
  - Good quality fur appears properly flame retardant.
  - Cheap fur definitely is not!
  - Foams are a problem. You must definitely test the foam in your costume!
- Don’t wear normal underclothes!
  - They burn and melt into your skin.
  - Buy Nomex (or more modern materials)!
  - Go shop at motor sports places, they have this stuff for driver fire safety.

- In the videos, fires seem to build slowly with good-quality materials.
  → There is some time to extinguish or escape.
- If the electronics are only in the head, just use a fire-proof balaclava.

Fire

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Escapability

- Oh dear! You're on fire and can't put it out. There are toxic fumes building-up inside the costume. Now what?
- Design the costume so it can be escaped!
  - Access to fresh air! (Removable head piece?)
  - Quick egress from the costume!
    - No fiddly things. You have to get out in seconds, even when panicking.
    - Your underclothes may not catch fire or melt as you do this!
    - Consider Velcro escape seams, an escape knife that your handler carries, ripable seams, etc…
- Can you quickly dispose of large costume features during an evacuation? (E.g.: wings.)
- Have a plan and test it!

Fire

- Common Sources of Fire
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Fire Fighting

- The good news: most fire hazards are easily extinguished.
  - Plain old water will work for:
    - Small, rechargable LiPo battery fires.
    - Most of the other, common costume materials.
- When on fire:
  - STOP – DROP – ROLL
  - Do not run! You may have to bring a person to the ground if they are panicking and running (leg sweep).
  - Have the usual fire fighting devices on hand:
    - Water
    - Fire blankets (your handler can carry these!)

Fire Fighting

- Be cautious with using fire extinguishers.
  → You are aiming at a person!
  - Water-based is best.
  - CO_2, in a pinch, but not on the skin or face.
    → Extreme cooling! Suffocation hazard!
  - Powder: Do not use!
    → Very irritating to mucous membranes! (lungs!)
- Do not remove clothes that have already burned under any circumstances.
  - Leave them on, even if it is a charred mess.
  - Cover burned areas with sterile cotton.
- Above all: call the medics! They know what to do.

Costuming Safety

- The risks (non-exhaustive) discussed in this section:
  - Electrocution
  - Fire
  - Mechanical



Mechanical

- Sharp structures are the main risk, both to your audience and yourself.
  - What if you fall-down in your suit? Is there anything that can impale anyone? (E.g.: screws, horns, claws, spikes, etc…)
  - Padding and foam WILL compress or puncture.
    → Trim, cap, or mount so the sharp feature will collapse or detach easily.
  - Design for safety!
- Electrical parts can explode.
  - Enclose and shield (especially face and eyes).

Suiting Safety in One Line:

Think it Through

and

Have Fun!

Yes, that is Comic Sans. Got your attention, didn't it?


RoboCow
Industries