Dynamic Lighting Effects - Strobes - Theory and Usage

A "strobe light" is a device that emits incredibly bright flashes of light, at a timed rate.

There are numerous haunt applications for a device that regularly flashes a bright light. Uses include: flashing at people to disorient them ("dot" rooms), slowing or stopping repetetive motion, startle lights, and simulating lightning.

What Is A Strobe Light?

There are various different kinds of strobe lights. Or perhaps there's a really good definition out there, and some of the products are misnamed. I have seen the following called "strobes":

- A bright light that flashes at regular close intervals, often used to "freeze" motion. An example is an automotive engine timing light.
- A bright light that flashes at regular slow intervals, often as a warning. An example is the flashing red light at the top of radio station antennas, to warn airplanes.
- A bright light that flashes once, often used for photographic purposes. A protographer's xenon flash lamp is a reusable alternative to "flash bulbs".
- Just about anything built with a xenon flash lamp.

Xenon flash lamps are frequently used for strobes, but other things can serve as well. Some old turntables use a tiny NE-2 neon tube as a strobe to help set the rate or rotation.

Warning: Strobe circuits can be dangerous.

Strobe circuits are based on high voltages. This is true of even battery-operated units. It is extremely important to exercise appropriate cautions around this type of equipment to avoid electric shock. You don't have to be a rocket scientist, like my wife, but you do need to be careful!

All strobe units must have their electronics fully enclosed in an insulating case. The xenon strobe lamp must have a cover, in case it shatters during operation. When you purchase a ready-to-use strobe, it should come with these features. Don't open the case - it's dangerous in there!

If you build a strobe, from scratch or a kit, you must make it fully enclosed in an insulating case. The xenon strobe lamp must have a cover, in case it shatters during operation.

Warning: Medical risks of strobes.

People with a particular type of epilepsy (photosensitive epileptics) can have seizures triggered by strobe lights. Strobes are not unique in this respect - any repetetive visual pattern can do it, from flashing video screens to sunlight twinkling off a mountain stream. The color of the light or visual pattern does not matter. The repetition rate does matter - the range of 5-30 repetitions per second is particularly sensitive. Strobes have a reputation for inducing seizures only because they are a relatively common source of precisely timed visual stimulation. If you are not already a photosentitive epileptic, exposure to strobes will not cause seizures. Most haunters accommodate this situation by putting up a sign simply stating that strobes are in use, letting the patrons decide for themselves whether they want to take the risk - photosensitive epileptics usually already know who they are.

There are additional risks posed by the use of strobes. The light is very bright - dazzling. When combined with motion or other visual effects, at can be disorienting. The resulting mental confusion can be used to advantage in a haunt, but in some places might prove dangerous, such as stairways.

Looking straight into a strobe for long periods might injure your eyes. If you are using high-power strobes in a haunt, you might want to bounce the light off of some light-colored surface instead of aiming the strobe straight at patrons.

How does a strobe light work?

Incandescent lamps use electricity to heat up a metal wire (filament) until it glows white-hot (black-body radiation). This heating and cooling process is not instantaneous, due to the heat capacity of the filament. In other words, an incandescent lamp is not capable of flashing very rapidly or of making flashes that crisply turn on and off.

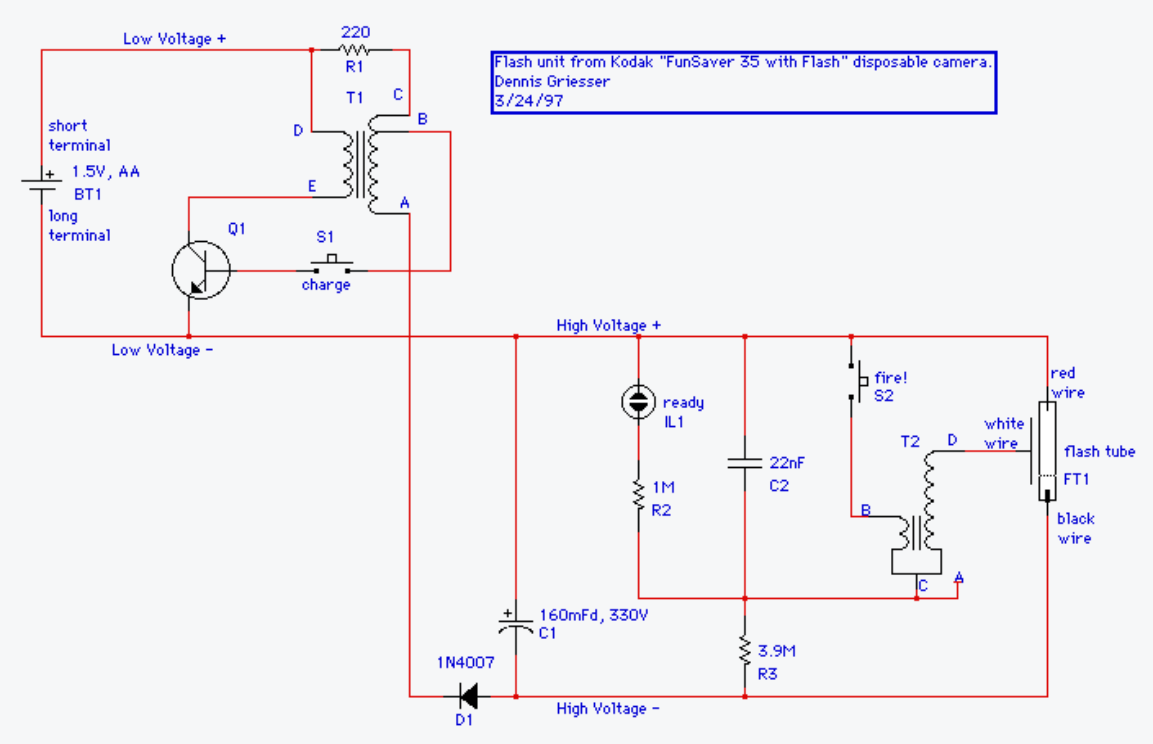
But there is an alternative: the strobe light.

A strobe light is an interesting beast, producing light by a means utterly unlike the hot filament wire in an incandescent light bulb. A strobe light stores up energy in an electrical component called a "capacitor", and then suddenly dumps it all into a lamp bulb filled with xenon gas. The normally insulating gas in the bulb suddenly conducts electricity. This produces a sudden, brief, and intense flash of light.

WARNING — Strobe light circuits can be very dangerous to work with, because they store up a large amount of energy in a capacitor and can release it all at once. If you purchase any kind of flash unit prebuilt, don’t open the case - there are potentially lethal voltages inside. Just use it. If it breaks, take it to a qualified repair facility. Even

unplugged and turned off, these units can be lethal! Every strobe light should have a transparent cover over the lamp.

Whether you know it or not, you have probably seen hundreds of strobes before, in the form of flash units on cameras. The following schematic approximates the electrical contents of a Kodak Funsaver disposable camera.



This particular circuit contains two gas discharge tubes. Understanding how they function is the key to operation of a strobe light, and how they might be useful to the haunter.

We will start with a discussion of the common NE-2 neon lamp. This is a small tube that has two leads that go through the bottom of the glass envelope and attach to metal electrodes inside the lamp. The neon gas that separates the electrodes within the tube makes a poor conductor of electricity. You could try all day to pass 75 volts through the NE-2 and it would act like an insulator. But if you crank the voltage up high enough, the gas ionizes and suddenly turns into a good conductor of electricity. This is called the "turn-on threshold" voltage, and is roughly 90 volts for a NE-2. We would see that as an orange glow in the tube, and a meter would indicate that there is plenty of electricity flowing through what was formerly an insulator.

Once the tube fires up, it continues being conductive, even if the voltage is reduced below the turn-on voltage. When you drop to about 60 volts, the NE-2 goes out. This is the turn-off threshold. In order to start it up again, you must get back up to the turn-on threshold. This is an example of the phenomenon called hysteresis.

The flash circuit uses a miniature neon lamp, similar to the NE-2, for the "ready" light. The lamp is actually about half the size of a NE-2 and has a higher turn-on threshold of roughly 180V.

The other gas discharge tube in the circuit is the flash lamp. It is a thin cylinder 22 mm long, filled with xenon gas instead of neon gas. The electrodes exit at opposite ends of the tube. Like the other gas discharge tubes that we have discussed, the xenon lamp has a threshold at which it will suddenly begin to conduct electricity, but the turn-on threshold is even higher for the xenon flash lamp. Just like the neon lamp, it acts like an insulator until you hit the threshold, then it ionizes and conducts well, even at a subsequently reduced voltage. The nice thing about the xenon tube, however, is that it makes a nice white light that is well suited for photography - or lightning.

If you so desired, you could make a flash unit that worked by accumulating energy in a storage capacitor until the turn-on threshold voltage of the xenon lamp is reached. It would then fire, producing all of that nice light. This is a bit of a problem because it takes awhile to generate a high enough voltage to fire the lamp and store enough energy in the capacitor to make the flash long enough to be useful. So you might press the shutter release on your camera and a little while later, the threshold would be reached and the flash would go off, too late to do any good.

One could put a switch between the storage capacitor and the tube. The capacitor could then be charged in advance to well over the turn-on threshold of the flash lamp. Since this part of the preparation, it doesn’t matter that it takes a few seconds to build up this potential in the capacitor. Closing the switch would then fire the lamp. The problem with this approach is that a huge amount of energy must be switched. This requires a switch built and rated for large current spikes and high voltages (read "expensive switch").

Most photographic strobes use a bit of a trick. They put a voltage across the xenon tube that is lower than the turn-on threshold, but higher than the turn-off threshold. Nothing happens because the turn-on threshold has not been reached. Now, if only you could start the xenon tube conducting, it will continue to conduct and produce light. All it needs is a kick. This is done by introducing a third electrode to the tube, aptly called the trigger electrode. When the shutter is released, a high voltage pulse is applied to the trigger electrode. The pulse is high enough to start ionizing the tube, but doesn’t have enough oomph behind it to produce a usable quantity of light. But awhile ago, we set up a potential that was just waiting for somebody to give it a kick, and the flash lamp burns until it drains enough energy from the capacitor to make the potential across the xenon tube drop below the turn-off threshold.

Here's how the Kodak Funsaver circuit works:

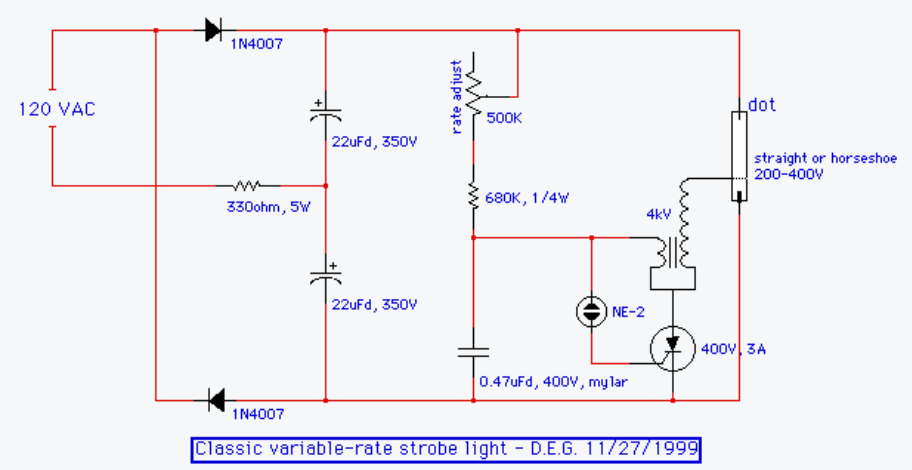
1. Transistor Q1 acts as a switch, turning power on and off to the primary of transformer T1 in accordance with feedback from that transformer applied to the base of Q1.

2. The oscillation applied to the primary of T1 produces a high voltage at the secondary. This is half-wave rectified by D1 and stored in capacitor C1, which charges to roughly 350 volts.
3. While C1 is charging up, C2 is also charging, through R3. When C2 reaches approximately 190 volts, neon lamp IL1 starts to glow.
4. At first, IL1 may blink on and off. This is because when C2 accumulates a potential sufficient to turn on IL1, the lamp fires, draining energy from C2 until it reaches the turn-off threshold and IL1 goes off again.
5. When C1 charges to roughly 225 volts, C2 charges from it at least as fast as IL1 drains power from C2, and the "ready" lamp stays on solid.
6. Releasing the shutter closes SW2, dumping all of the energy from C2 into trigger transformer T2. This produces an output pulse of approximately 4,000 volts, which is applied to the flash lamp trigger electrode.
7. The high voltage trigger pulse ionizes the xenon gas in the flash lamp, which begins conducting. Most of the energy in C1 is poured into the xenon lamp, stopping only when the capacitor is exhausted enough that its output voltage falls below the xenon lamp's turn-off threshold of about 40 volts.

The strobe from a disposable camera is designed to be cheap and reliable. It produces a single bright flash of light, when and where you need it - then requires several seconds to charge up again. Fancier units, for more expensive cameras, can provide brighter light, with a faster recharge time.

The strobe lights that escaped from the camera shops and sought refuge in discotheques are not triggered by camera shutters. Instead, they have a "repetition" control that tells the unit how frequently to flash. Once you set a strobe to, say 3 flashes a second and turn it on, the unit will emit bright short flashes, 3 per second, for hours on end.

Various electronic circuits are used to provide the repetitive trigger of a strobe light including: neon lamp relaxation oscillators; programmable Unijunction Transistors; and integrated timer chips, like the 555. Here is an example of a repeating strobe light based on a neon relaxation oscillator:



The light tends to be a very nice white or blue-white color. The combination of color, intensity, and brevity make xenon strobes look a lot like lightning flashes. In fact, one could argue that they actually *are* miniature lightning flashes, since lightning is itself a rapid gas discharge of energy stored in cloud capacitors!

How do different strobes differ?

There are a *lot* of strobes out there. The year 2000 seemed to be The Year of the Cheap Strobe - I got one for free when I bought some lighting gells. It's quite natural to ask - what's the difference between all these units?

- power output

  The output power of a strobe is usually rated in "Watt-Seconds". This is sometimes incorrectly reported as "Watts". Most cheap strobes are 20 Watt-Seconds. 20 doesn't sound like much, but all of that energy is released at once, usually while you are in the dark, so it hits fairly hard.

- flash rate

  It is more difficult to build a strobe that flashes rapidly than one that fires slowly. You have to worry about rapidly recharging the capacitors. You have to worry about the xenon tube getting hot. This amounts to a different technical design, and higher grade of components.

  If a really fast flash rate is important to your application, expect to pay more for it. But for simple haunt applications, most standard strobes will work fine.

- adjustable flash rate

  Almost all strobes allow you to set the rate of the flash, from slow to fast. But not *all* of them offer this feature. Strobes intended for photographic use don't even have a flash rate - they only fire once.

- dimming

  You won't find this on inexpensive units. High-end, higher-power units can be dimmed so that each flash is only a fraction of what it usually would be.

- remote operation

  Two rules here: (a) the more remote controls, the costlier (b) digital remote costs more than analog.

Starting at the first rule, the ideal strobe allows you to remotely control anything that you can control via a local knob on the strobe. Thus a strobe with a knob for flash rate and intensity would also allow remote control of both these features.

According to the second rule, the cheapest form of remote control is an analog signal, such as a DC voltage on a 1/4-inch jack. The most flexible (and costly) is remote control via DMX.

- input power

  Watch out for high-power strobes that require 220. Most haunts aren't wired with it!

  Also check the number of Amps drawn by the strobe, if it is a large unit.

- regulatory acceptance

  You will probably want a strobe that is U.L. listed. Ultra-cheap units might not be. Check the box before you buy it.

- duration of flash

  Most strobes dump all their energy instantly, providing a very short, but very bright flash. Strobes at the high end can spread out the emission for a longer flash. Strobes that can do this are quite expensive.

- price

  Price varies a lot, but isn't always an indication of what you are getting. As an example, a typical low-end strobe is a 20 Watt-Second unit with 110 VAC input, variable-rate, and a short linear tube. I have seen these for sale at prices ranging from $5 through $40, $20 being quite common. Although the circuitry inside may be different, they share all the same essential features. Why pay for the costly version of the same thing?

  At the same time, additional features, like high power and DMX, must cost more money.

  It's just that paying a high price isn't a guarantee that you are getting more. You have to pay close attention to the features that you are getting.

Just as an illustration, we will look at three strobes, representing the low, medium, and high end:

- ADJ S-81

25W mini strobe light; compact; variable speed knob to adjust strobe flash rate; plastic casing. Dimensions: 2" H x 3.25" L x 5", weight: 1 lb.

Power requirements: 120V.

List Price $27.

- ADJ Mega Strobe/DMX

  750W; flash rate from 1 to 15 flashes per second; rear speed control knob. Dimensions: 13" x 11" x 6"; weight: 7 lbs.

  Remote control via DMX for rate and brightness; 0-10V signal for speed.

  Power requirements: 120V.

  List Price $350.

- Diversitronics 5000-DMX Monster Strobe

  200 joules/flash, 36,000 Watts Peak flash. Air cooled with auto fan control. 5 ultrabright Hyperflash effect emission modes including lightning and continuous illumination. 3 operation modes including normal (rate and intensity), single flash and Hyperflash (5 effects emission modes) in both DMX and analog.

  Remote control: DMX; 0-10 volt analog inputs/outputs.

  Power requirements: 240 Volt 50/60Hz operation; 1 fixture per 30Amp circuit.

Where to get strobes and kits

We devote an entire page to commercial strobe lights.

Tips for scratch builders

- Do be careful! High voltage is dangerous, especially when stored in capacitors for rapid release.
- If you have to work on a strobe that has been used, make sure that the capacitors are discharged before you go poking around in there.
- Put a bleeder resistor across the energy storage capacitor, even if the design does not call for one.
- Electronic Goldmine usually has a good selection of strobe parts: xenon tubes, trigger transformers, SCR, etc.
- Disposable cameras can be salvaged for strobe parts: xenon tubes, trigger transformers, capacitors, inverters, etc.

Frequently asked questions

We have a few frequently-asked questions about strobes...

What's the cheapest I can get?

The cheapest strobe I've ever gotten was free. Free like "in a box of Cherrios". In 2000, I mail-ordered some gells from a lighting supplier, and when the order arrived, they had thrown in a free strobe light. Oh, not a fancy one. In fact, it was a cheapie. But to me, it was free. And I didn't even know they had a promotion going!

It looks like 2000 was the year of the cheap strobe lights. Near Halloween, you could buy them at WalMart for $15. My theory is that "China, Incorporated" geared up to make strobes. And whatever they make in quantity, sells in the U.S. for cheap.

And, honestly, if you built from scratch a comparable strobe, it would cost twice that! And that's not even counting your labor!

My point is simply this... Electronics is a fascinating hobby. It can be fun. It can be educational. But if you want an existing product at the best possible price, find out who is commercially manufacturing them in quantity. And *buy* one from them.

Can I build one myself for cheaper?

Probably not!

Why does it cost more to build one yourself? You buy the tube (markup), the storage caps (markup), switch and pot (markup), assorted minor components (markup), the case to put it in (markup), bulb shield (markup), power cord and fuse (markup), board to build it on (markup). And what's the labor cost? You need to lay out and assemble the unit; drill and cut the project box to fit; put it all together; and you must have run all over town to find the parts. When you are done, your unit lacks U.L. certification and a warranty.

Just about the only valid excuse for building something like this yourself is that you are willing to pay more in order to learn about the innerds of a strobe, or you want something different from the commercial units - something you can't buy.

There is a halfway approach: buy a kit and build that. The kit vendor has already done the engineering and the shopping for you. He bought his parts in quantity (for cheaper that you could). And since his parts cost less, the markup on the kit is probably a little less than on parts you would buy yourself.

Of course, you still have issues with U.L. certification and warranty. And many kits come without a case. For other projects, a case is optional - but for a strobe a case and proper shield over the bulb is mandatory!

25 Watts doesn't sound very bright

With strobe lights, you pay more for more power. Inexpensive strobes are often marked "20 Watts" or "25 Watts", which causes some purchasers to remark "25 Watts doesn't sound like very much." They're wrong - the strobe could be just right!

Technically, there is no good reason to measure a strobe in Watts. Anybody who writes "25 Watts" on the box is a bit nutty. The energy released by a strobe is not measured in Watts, but in measured in Watt-Seconds (WS), also called Joules. Perhaps they are quoting this figure, but incorrectly marking it "Watts" instead of "Watt-Seconds". The power consumed from the line may be measured in Watts, but is probably a peak figure and has little relationship to the light output.

Let's assume they really mean "Watt-Seconds". Light bulbs are measured in Watts. This tempts you to compare "I have a 100W lamp in the living room, so a 25WS strobe won't be too bright."

First, you have to compare apples to apples. Imagine if you had the ability to capture all the light emitted by that 100W lamp for a second. Gather all that light in a box. That's 100WS. Now, take a quarter of that (25WS). That's what the strobe puts out. So you think it's going to be dimmer. But it took the ordinary light bulb a full second to put out all that light. And the strobe light dumped out all that light in the short duration of a single flash (say 1/100 second). So the strobe put out 1/4 of the energy in 1/100 of the time. That makes the light from the strobe 25 times more intense than the living room lamp.

Now, we add a few more factors: a xenon lamp is much more efficient than an incandescent lamp, so more of the strobe's energy shows up as light. And you usually flash strobes in dark or dimly-lit rooms, where the eyes aren't expecting much light anyway.

Overall, that cheap strobe, confusingly marked "25W", *may* be just what you need. So, try it out under the conditions in which it will be used, and see for yourself.

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