Variable Frequency CES/LED Flasher Device

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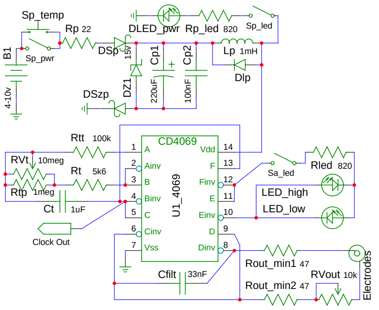
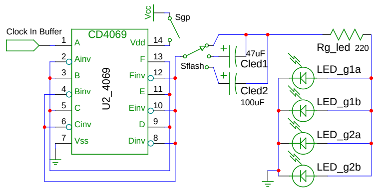


LED Flasher Goggles Add On



This is a variable frequency CES device that is enhanced, has more features, and is generally safer than other schematics found on Internet. This unit outputs a bipolar symmetrical square wave from a single rail power supply. It does this by flipping hot and ground electrodes back and forth each clock cycle. Values used in this diagram can get a little below 1Hz. It was designed this way to be a delta wave generator to help people suffering from chronic insomnia (as opposed to other "alpha" wave generators that will stimulate instead of sedate). With an appropriate booster, the intensity level could be brought up to that of a TENS unit. If an LED flasher is only desired, change the electrodes section of the circuit to something similar to the U2_4069 LED section or use transistor amplifier boosters (transistor boosters is probably simpler).

Power Supply: Considering a CES device is plugged into the head and electricity goes directly into the brain, power needs to be a bit over conditioned for safety's sake (BE PARANOID!). An extra dollar's worth of parts could make all the difference in a bad situation. The CD4069 is safe to run from 3-15v. Battery is shown but wall power may be substituted (but not during lightning storms). A SPST on/off switch would be normally used, but a SPST normally open non-latching push button switch can also be used in parallel as shown for quick testing (safety, so if you pass out the button will be automatically released). The push button is also handy for night time use if only a few minutes on time is desired to help resume sleep. A transistor switch could also be paralleled for digital type control (like from an automated biofeedback controller or digital timing circuit). The 2 DS diodes don't have to be low drop out, but those are preferred. DSp prevents a reverse battery connection and also functions as a half wave rectifier for AC power. DZ1 limits the peak voltage and spikes for safety. DSzp is extra protection for DZ1 if using AC or the battery is reversed (this will increase the zener voltage slightly). Rp is a safety measure to limit current spikes and starts an RC filter. Rp may block too much current if an LED flasher circuit is also added. The LED flasher may also cause too much current ripple when in use. If this is the case, there are 2 options: (1) build another power supply block starting after the power switches (preferred way), or (2) move Rp to the CD4069's power pin that does the CES and add 100nF+47uF filtering capacitors right after it. Either way, make sure that the voltage and current going into the CES CD4069 is clean and smooth (flashing LED's don't care, but electricity directly into the brain does). Cp1+Cp2 are the standard smoothing capacitors. Cp1 may need to be increased if AC power is used and ripple is still present (ripple fed into the brain is bad). Lp is another safety measure to help limit current surges and block any high frequency line noise. Sp_led, Rp_led, and DLED_pwr are an optional status light to show if the circuit is on or not. I prefer this to be switched when running long times off battery since the LED will take more power than the CD4069.

Power Supply Variations: As I typically use 4x AA or AAA rechargable battery packs, over voltage isn't much of a concern for me. If unregulated wall power is being used, that's a different story. If wall and battery are to be used together, that increases complexity. If using AC, a full diode bridge may be desirable instead of Dp alone. A low drop out (or even just regular) voltage regulator circuit could be added before Rp (see its spec sheet for proper wiring). A simple transistor regulator could be added before Rp (might be a good idea anyways for safety for the next version of this schematic). A 47ohm or so resistor could be added in front of DZ1 and DZ1 changed to the desired voltage level (not very efficient, not recommended). There are probably other options, so take your pick as necessary. The main concern is to keep some kind of passive and robust peak voltage clipping circuitry for safety (zeners, MOVs, inductors, fuses, etc.).

If outside RF noise in the circuit becomes a problem, put the circuit in a shielded metal box. If noise is still a problem, connect the metal of the box to power supply ground. Shielding on the electrode wires is also a possibility. Connect the shield wire to power supply ground and NOT to any other point in the circuit. Power supply ground is after DSzp and essentially directly on the battery's negative terminal. Signal ground is considered to be a point before DSzp.

RC Feedback Oscillator: Inverters A+B, Rt+RVt+Rtp, Ct, and Rtt form this. Rtp sets a minimum frequency limit for Ct, turns RVt into a somewhat logarithmic curve, and provides minimum protection if RVt has mechanical problems and hangs the oscillator (my pot went bad and actually hung). Rt sets a maximum frequency limit for Ct. When Ct charges, the inverter gates flip and Ct discharges. The rate can be changed by RVt. If Rtp is over 1meg the oscillator may lock up. To make a slower minimum oscillation, increase Ct size (or parallel it with another Ct) instead of increasing Rtp. Rtt is usually 100k but in theory should be 2*(VRt+Rt) and is used to help reduce timing variations by temperature fluctuations. Inverter gates often charge and sink current unevenly as do capacitors. If the wave form doesn't have enough symmetry, try paralleling multiple smaller capacitors for Ct (lowers the ESR and ESL; 2x 560nF, 3x 330nF). Another inverter paralleled with B may also help. In theory, these should not be needed, but "should" and "actuality" are always two different things. In reality, symmetry will be close but never exact.
Equation: (somewhat dependent on Rtt, temperature, and voltage). Freq = 1/(k*R*C). R is all the resistors added together. k is usually 1.4 or so on my tests and probably not linear.

Cfilt capacitor is small and helps prevent ringing, RF frequencies, and general noise on the square waves. Too large a value will start rounding the corners of the square wave and start turning it into a modified sine wave. The usual valid values for Cfilt are 22-39nF.

RVout is used to variably reduce the amperes to the electrodes. Rout_min1+Rout_min2 (summed) sets the maximum safe ampere level. These have been split to help protect the CD4069 chip from static from the electrodes. Safe current levels are generally considered less than 1mA. Do not go above 10mA. Safe voltages are considered to be less than 10v. 1v at 1mA is the preferred operating level. The quick rule of thumb is 1k ohm/volt for output resistance (maybe a little more or less depending on the person).

Extra CD4069 inverter inputs should not be left floating (disconnected) for danger of oscillation. If unused, tie the inputs to the Vcc source (causing the outputs to go to ground). Left over inverters may be paralleled to boost the output on the electrodes or used to drive activity status LED's.

In this diagram, I used left over inverters E+F to drive the optional activity status LED's. The LED switch is used to turn them off if not needed (on battery as they will pull more power than the CD4069). One LED will light when the clock goes high, the other will light when it goes low. A bi-color LED may be used to save space. These make a good safety and simple calibration device. As the battery voltage drops, the RC oscillator will slow (maybe to an undesired point). The LED's will also show if the RC oscillator has hung (which would be bad for the brain). A modified version of this would have only one LED installed and flashing for reduced power usage. Be warned that if running on a low battery, the illuminated LED may end up taking power away from the CD4069 and distorting the square wave.

Problems. My first VRt pot had some problems tracking the wiper and would hang the oscillator. If this is to be a fixed frequency CES devices, calibrate it to the desired frequency and replace the pot with a fixed resistor using the VRt value. Using this method and a SPTT switch, three fixed frequencies could be set up in a safe way (more if using a multi-position rotary switch).

Calibrating and Set Up: An oscilloscope should really be used the first time to make sure the unit is actually functioning as intended. A volt meter set on AC will give a close voltage reading, but it will not be fully accurate unless the meter has a setting for square wave AC instead of sine wave. Likewise the same is true for the AC amps setting. Ohm's Law makes amps setting easier since I=V/R. If there is a biting or slapping feeling on the electrodes, that generally means the amps (or sometimes voltage) is too high and RVout needs to be increased. If usage causes a headache, too high amps are often the same problem. Generally speaking, most people will be using a frequency of 15Hz or less. People with epilepsy should not go above 10Hz and should definitely see their neurologist before using any type of unit like this. Generally speaking, a person should consult a physician first, anyways. Some meters have a setting to measure frequency. These usually aren't very accurate below 10Hz. The better way is to use an oscilloscope and mark off the desired frequencies on the pot. Most people won't be able to count fast enough if you use the activity LED's. You could use a video camera with a little math and count the frames to get a close estimate, though. Many other people just won't care and will go by the activity LED's and personal feeling.

Another CD4096 could be chained to the first oscillator and be used for synchronized flashing LED goggles (shown on the right part of the schematic). These goggles are the usual cheap pair of sunglasses with holes drilled in the middle of the lenses to mount the LED's. Adjust Rg_led based on the number of LED's used, the type of LED, and the voltage supplied to them. I haven't built that part of the circuit, but I'm guessing it could drive about 8 LED's total. If not, it would need some type of simple transistor booster circuit. A darlington transistor booster circuit may be simpler and drive more LED's if designed correctly. Inverter A on U2_4069 is used as a clock buffer to not overload the clock signal from U1_4069 (that could cause an oscillator freeze up). If the current drain from all the LED's is too great, it could cause a ripple or drop out on the CD4069 doing the CES work (bad for the brain). If that is the case, make another power supply circuit block before Rp to drive the LED's separately (described in the power supply section). Sflash+Cled1+Cled2 are optional to make the LED's flash instead of stay on during the square wave. The larger the capacitor value, the longer the flash should be. Long flashes at high frequencies probably won't work so well, so just flip the swith to the bypass wire. LED's flashing like this will create current ripple (see the power supply section). Pay attention to polarity in the CledX capacitors. LED color isn't overly critical, but colors of red and towards lower end of the color spectrum supposedly don't block melatonin release as much as the colors of blue and towards the higher end of the spectrum. Keep this in mind if using this device for a sleep aid.

Standard warnings and disclaimers. While I have successfully built and used this device, results are not guaranteed. Use at your own risk. I hold no responsibility for your medical conditions. Persons who are epileptic, pregnant, nursing, on prescription drugs, have pace makers, or any other bioelectric device or medical condition should consult with their doctor before using. This device is not recommended for general usage for persons under 21 due to continuing brain development (although it may have far fewer long term side effects compared to prescription drugs, consult with your doctor). If one of these units is used in a medical or mission cirtical situation, build it to reflect that: use military grade parts, capacitors with 2-3x voltage ratings (maybe even paralleled), increase resistor wattage, increase diode reverse voltage and amp ratings, use a strong shielded box, waterproof the box, shock proof the box, all wires should not be thin and scrawney, and use gold plated connectors and switches. In short, use your head, be paranoid, plan for disaster, and build it like a tank. My schematics are not for resale nor commercial use. My schematics are for educational and private use only.