

# Build a joule thief

Disposable batteries often have quite a bit of life left in them when they will no longer power many devices. This kit allows you to drain the last remaining energy in those 'flat' batteries and provide you with usable light for several days per battery.



Most 'flat' batteries still have a lot of life left in them, it's just that most battery-powered devices can't extract this energy as the battery's terminal voltage may have dropped below a level that the device can use.

The Joule Thief kit is a very simple circuit designed to step that voltage up so that it can be used by a superbright LED (light emitting diode) to provide a small amount of usable light.

The circuit will discharge the battery down to around 0.4 volts, at which voltage there is very little energy left in the battery.

## How it works

The circuit is quite simple. When power is first applied, current flows from the battery through the 1K resistor and one winding of the transformer into the base of the transistor, turning it on. This causes a larger current to flow through the transistor via the other transformer winding.

This current causes the base current to the transistor to be cut off, as the two windings are connected in opposite phase. When the transistor turns off, the current keeps trying to flow through the transformer winding, but it can't pass through the transistor so it has to go elsewhere. The voltage builds up until there is enough voltage to switch the LED on, so the LED lights.

The current in the transformer falls, and the whole cycle repeats. This is a bit simplified, but serves as a reasonable explanation of how the circuit works.

The circuit runs at up to 30 to 50,000 cycles per second, so the transformer needs to be made from a material suitable for those frequencies. Fortunately, small ferrite beads used for electrical noise suppression etc are readily available and work

well for this task.

The two components shown in grey in the schematic are there to protect LEDs that might have an inbuilt circuit from excessive voltage, such as single colour flashing LEDs. RGB animating LEDs don't work too well in this circuit. If you are not using flashing LEDs, then leave out the capacitor and Zener diode.

## Building it

There isn't much to building this kit, just put the components into the board at their appropriate places and solder them in place. The PC pins go at the four corners of the board. They serve two purposes. Two of them provide connection points for the battery holder, and all four of them are used to hold the dome lens in place—just push it down over the pins, as it has holes at each corner.

You can choose to mount the switch on the copper side of the board so that you don't have to keep removing the lens to turn the circuit on and off.

The only tricky part is the transformer. To wind this, you take the thin enamel coated copper wire and fold it in half. Now, pass the folded end through the core most of the way so that the two free ends stick out about 40mm from the core. Glue these to the core side-by-side and let the glue set. Hot melt glue makes this simple and fast, but make sure you only use a tiny dot of glue.

Now, wind 20 turns onto the ferrite core in a bifilar fashion (well, you have to really as you are using two-core wire!) and once finished, spread the turns evenly around the core and glue the other end (the folded end) of the wire to the core to stop it unwinding. The best way to do this is to put a tiny

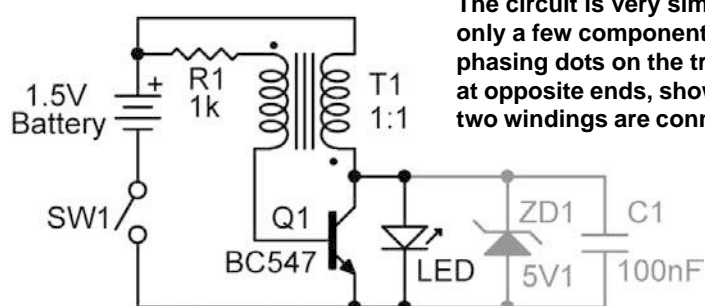
squirt of hot melt glue into the hole of the ferrite core. This stops the windings moving or unwinding. Try to keep the turns as tight as possible against the core, but small gaps between the wire and the core are ok.

Now you need to cut the folded end of the wire so that you have two separate windings on the core. Trim the wire ends to about 20mm in length and remove the enamel coating. You can do this by carefully scraping it off with a sharp knife. Heating the wire ends with a soldering iron and solder will weaken the enamel and allow it to come off more easily. Some brands of enamel will even come off completely when you do this, making this step much easier. Once the wire ends are stripped, use a multimeter to find the two ends of each winding. They become windings A and B. Wire ends A1 and B1 start at the same place on the transformer, as do A2 and B2.

Now, place the four wires from the transformer into their appropriate holes on the circuit board and solder into place. Hold the transformer in place with a dot of glue. Remember that you must get the wires in the correct holes, or the circuit will not work.

## The smoke test

Now to test your handywork. Get yourself a 'flat' AA battery that has a reasonable terminal voltage (at least 1 volt) and connect it to the circuit via the terminals marked + and - on the board. The LED should light immediately. If not, the most likely problem is that the switch is off (doh!) or the transformer is connected the wrong way. To fix the latter problem, unsolder the wires from the A1 and A2 positions and swap them over. If that doesn't fix it, check the windings to make sure that you didn't swap one end of the A and B windings somehow.



The circuit is very simple and uses only a few components. Note how the phasing dots on the transformer are at opposite ends, showing how the two windings are connected.

The circuit board, shown larger than actual size.

