Electronic Valentine Heart

LEDs are red my dear…

Design by F. Wolling

Although this month's Mini Project is not exactly stunning from a technical point of view, there are a number of unusual sides to it, mainly regarding why and how it came to be published in this issue. Read on…

Unusual aspect no. 1: This is the first Valentine circuit ever to be published in Elektor, and no, the highstreet flower shops are not to blame if that is the first you associate with Valentine's Day.

Valentine's Day is reportedly the day we 'celebrate' the beheading of a priest called Valentinus on 14 February 270. The execution orders came from an oppressive emperor called Claudius Goticus (a.k.a. Claudius II). According to some sources, Valentinus was a bishop and the 14th of February a popular Roman holiday. The legend of Saint Valentine tells us the martyr was executed for illicit marrying of Christian couples, the occasions being marked by Valentinus presenting lots of flowers to the newly weds.

The oldest literary evidence for Valentine's Day being associated with (secret) love may be found in 14th century writings, as well as in some of Shakespeare's sonnets and plays.

Unusual aspect no. 2: The designer of this circuit, Florian Wolling, was 14 years old when he sent us his article proposal — making him the youngest external author ever to make it to publication of a Mini Project.

Unusual aspect no. 3: Originally, this project did not stand a chance of getting published in *Elektor Electronics*. Just like all contributions and other article proposals we receive from free-lance authors, Florian's papers were 'evaluated for publication value' during a meeting of editors and design staff. Although the project met with praise for the meticulous way the circuit, the circuit board and the documentation had been designed and presented, and despite the fact that the small heart-shaped LED ornament was 'charming', the manuscript was rejected for publication because the complete

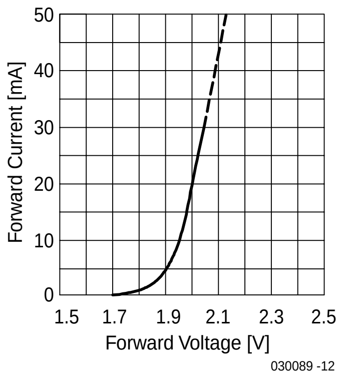
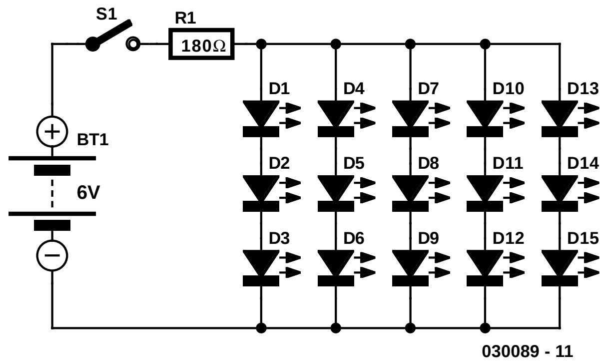


Figure 1. Typical U/I characteristic of a red LED.



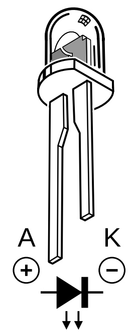


Figure 2. The circuit: one resistor and 15 LEDs.

project was found rather too simple for our demanding readership. However, when writing a letter informing Florian about the rejection of his project, still encouraging him to send further projects in the future, one of our fellow editors suddenly recognised the simple arrangement of LEDs on a board as the perfect circuit for Valentine's Day. Having discovered that such a circuit had not been 'done' before in our magazine, and because Elektor editors are always open to novelties, the LED Heart was added to our forward planning schedule. So, here it is, although one more thing should be noted…

Unusual aspect no. 4: The Elektor designer assigned with the technical preparation of Florian's project (mainly to make it meet our design standards), could not resist doing his bit of post-engineering. Admittedly, there's not you can change drastically when looking at one resistor and a bunch of paralleled LEDs, but improvements and fine tuning are always possible. The difference between Florian's LED Heart and the Elektorised version boiled down to the components used. Apparently, Florian was encouraged to use SMD LEDs by our two-part article 'SMDs — Don't Panic!' In the January and February 2003 issues of *Elektor Electronics*. The resulting project, he thought, would make a excellent gift as well present a convincing exercise to win over those readers still hesitant about their own skills in handling these tiny components. The latter aspect has been crossed out, however, because the Elektorised version of the project employs normal size components, not only with an aim to make the project easier to reproduce for beginners, but also to prevent component sourcing problems. Because all components except the LEDs are soldered at the rear side of the board, only the LED faces are visible from the front, allowing the front side of the board to be painted or sprayed in whatever way you like. For our own prototype, we happened to have some red paint left…

'High Efficiency' LEDs

Light Emitting Diodes (LEDs) have been around for a long time — the first LEDs were mass-produced around 1975. The luminosity of red LEDs is specified by the manufacturer at a current of 10 mA or 20 mA (depending on type). These current eaters are hardly used anymore (at least not in Elektor circuits), because red LEDs with a much higher efficiency are now available. These successor types light happily at a current of just 2 mA (similar green LEDs are specified at 4 mA or 5 mA). Because of their improved efficiency, these LEDs are referred to as 'High Efficiency' types in some professional publications. The classification 'Low-Current' is however more commonly found in catalogues, datasheets and articles. Such LEDs are perfectly suitable for low currents of the order of 1-3 mA and are clearly visible in indoor applications when operated at just under 1 mA (as in the project described in this article). Besides, who would use the Electronic Valentine Heart in the glare of the February sun?

Circuit and component calculations

As most of you will know, there are few, if any, applications of LEDs that do not include some form of current limiting resistor. After all, LEDs are simply diodes that light when a forward bias voltage is applied across them. They also 'exhibit' the typical diode characteristic shown in **Figure 1**. If you apply a slowly rising voltage starting at 0 V to a LED, such that the device conducts (+ to anode; – to cathode), you will notice that nothing happens for quite a while — no current appears to flow. However, once the voltage exceeds a critical level, current starts to flow, rising very quickly when the voltage is increased further. This so-called threshold voltage occurs at 0.6 V with normal silicon diodes and at 1.6 V with most LEDs (as in Figure 1). A value of 1.7 V will be noted when testing low-current LDs in this way. Without a current limiting resistor, a small increase of the voltage beyond the threshold voltage would mean imminent destruction of the LED because the forward current rises extremely fast and soon exceeds the 'safe' level.

With a resistor in series with the LED, things look different because according to Ohm's law, the resistor becomes the main current determining factor. In the circuit of the Electronic Valentine Heart (**Figure 2**) five strings of series-connected LEDs are connected in parallel. Each string consists of three LEDs. The voltage across each of these strings equals three times the forward conducting voltage of a single LED. Assuming a device voltage of 1.7 V we get

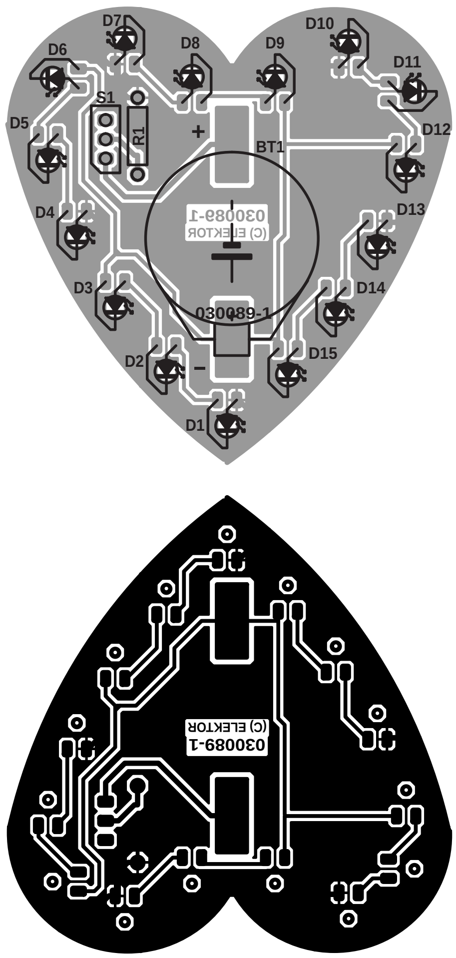
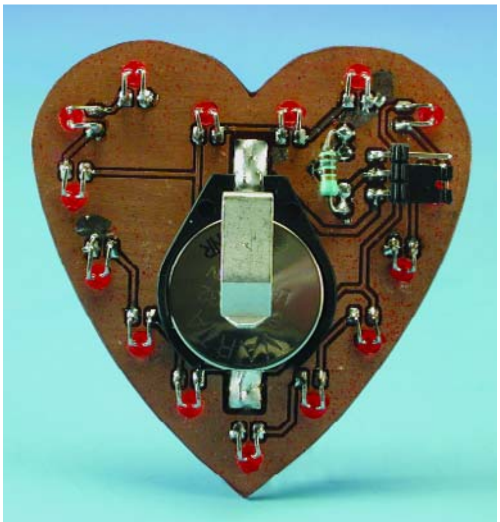


Figure 3. The heart-shaped board (insert LEDs from track side).



$$3 \times 1.7\ V = 5.1\ V$$

The LEDs are connected to the battery by way of a 180-Ω resistor. Although the battery voltage is 6 V nominally (2 × 3 V), we should use the value 5.9 V to account for the load on button cells. If the voltage across the LED strings is 5.1 V, the resistor is accountable for the voltage difference between the two voltages at its terminals. The difference works out at 5.9 V – 5.1 V = 0.8 V. From this value we can calculate the current as

$$0.8\ V / 180\ \Omega = 0.00444\ A = 4.44\ mA$$

This current is supplied by the battery, flowing through the resistor and the LEDs. Because all LEDs are of the same type and the voltage across each string is also equal, it is safe to assume that the current is equally divided across the five LED strings. Hence, the current through each individual LED equals

$$4.44\ mA / 5 = 0.89\ mA$$

Not a lot, you may think, but sufficient for a low-current LED to light with reasonable brightness. If the circuit was modified such that all LEDs are connected in parallel, the current consumption from the battery would be three times as high (assuming the same LED current is maintained). The load on the battery would then become about 13 mA, which is rather heavy on the button cells used. Besides, the difference in brightness between individual LEDs would be far more noticeable than with the series-connected version.

If you would like to know more about LEDs and how they can be used in large clusters, you should get a copy of our article ‘LED Arrays’ from the April 2003 issue of *Elektor Electronics*. The Internet is also a good source for additional information on LED calculations, see ‘Web Pointers’ at the end of this article.

COMPONENTS LIST

R1 = 180Ω
D1-D15 = LED, red, low-current
S1 = 3-way SIL pinheader, angled, with jumper (alternative: miniature slide switch)
Battery holder = SMD button cell holder (e.g., Farnell # 302-9785)
Two button cells type CR2032
PCB, available from **The PCBShop**

Printed circuit board and construction.

The printed circuit board designed for the project is single-sided. The 3-mm holes in it enables the LED faces to be seen from the front side. For this to work the LEDs have to be inserted from the solder side of the board, their terminals being cut, bent and then soldered to the copper pads on the board. The other three parts in the circuit (battery holder, resistor and a 3-way SIL pinheader) are soldered in SMD fashion to the track side of the board. The battery holder is actually the only SMD component. Instead of the soldered battery holder you may, of course, use a separate holder (for example, containing two AA cells) and connect it to the board via wires.

When soldering the LEDs onto he board, make sure you get their polarity right. As indicated in the circuit diagram, the cathode is the shorter of the two wires. This (negative) connection is marked by the bar in the diode symbol.

Our prototype is switched on by relocating a jumper on the 3-way SIL pinheader. For a more sophisticated approach to on/off switching, a miniature slide switch is recommended.

Finally

If you have been wondering all the time why the Electronic Valentine Heart does not blink just like most other LED ornaments, brooches and trinkets, well, it happens to be *Unusual Aspect no. 5*. There’s nothing to stop you making the LEDs blink, though, just consider borrowing the flip-flop element from our ‘LED Christmas Decoration’ (December 2003).

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Web Pointers

ourworld.compuserve.com/homepages/Bill_Bowden/led.htm
http://linear1.org/ckts/led.php
www.electronics2000.co.uk/calc/calcled.htm
www.hamradioindia.com/HRI-Calc/LEDcalc.htm