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Light Emitting Diodes

I remember when I put my hands on a light emitting diode (LED) for the first time . . . it was about 28 years ago. I don't remember what I paid for it. Undoubtedly, a great deal more than they cost now. The light output was pretty small, about 2 mCd (miniCandelas) as I recall. None-the-less, it was a truly amazing device. No heat, very small power requirements (approx 2 Volts at 20 milliamperes . . . only 40 milliwatts). LEDs were relatively rare in consumer products then. Pocket calculators used them for displays, some wrist watches had LED displays too. You couldn't leave them on all the time due to their relatively high power drain . . . a button on the side of the watch would illuminate the digits to display current time. Car radios and home stereos used them for "stereo" indicator lights. Some high end power amplifiers had LED bar graphs to display peak power output. Nowadays, LEDs are everywhere. They're inexpensive, available in a variety of colors and much brighter. LEDs with light outputs on the order of 15,000 mCd are not uncommon. These devices will throw a spot of light on the wall 20 feet away!

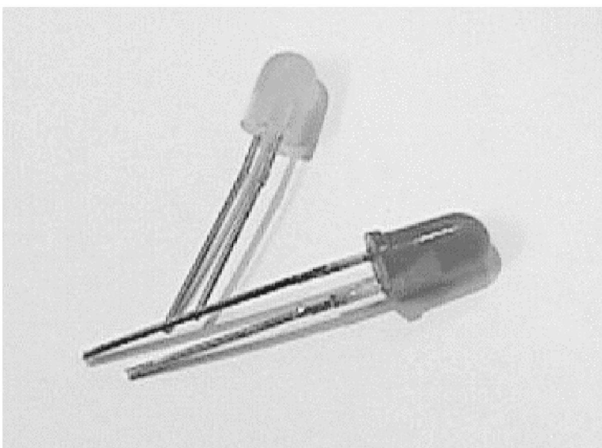

Figure 1.

LEDs should not be confused with laser diodes although they are cousins. Unlike an incandescent lamp LED's are much more efficient. About 97% of the energy used to power an incandescent lamp comes off as heat or other radiation other than visible light. LEDs tend to be more efficient by a factor of 10 or better.

Unlike incandescent lamps that are rated for an operating voltage our solid-state lamps are current devices. The voltage required to drive a red LED into conduction is something on the order of 1.7 volts; green ones seem to check in at about 2.3 volts. However, irrespective of how much current you push though it, an LED's operating voltage doesn't vary much.

For example, I powered the larger of the two LEDs shown here with my bench power supply. There was visible light output at 3 milliamperes of input current where the voltage across the lamp was 1.5 volts. Increasing the current to 20 milliamps (rated current) raised the voltage to only 1.6 volts. Stuffing 100 milliamperes to it (5 times overload) got me a lot more light with only 1.7 volts dropped across the lamp. Hmmm . . . if we hook these guys right up to 12 volts the current goes out of sight and smokes the little feller.

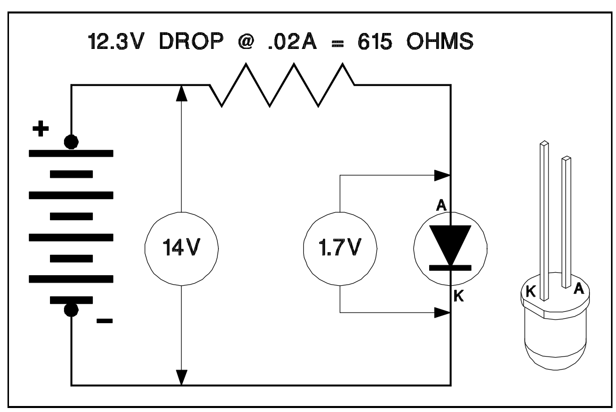

Figure 2.

The schematic in Figure 2 shows how to get an LED illuminated. A resistor in series is used to limit the current to the lamp's rated value. In this case, we've designed for a 20 milliamp rated lamp running from a 14 volt bus. The resistor sets the lamp's operating current in accordance with an Ohm's Law calculation:

(1) R = E / I

(2) R = (14 - 1.7) / .020

(3) R = 615 Ohms

Where:

R = calculated value for the dropping resistor.

E = voltage to drop across the resistor (in this case 12.3 volts) and . . .

I = the operating current for the LED (0.020 amps).

A second consideration in sizing the resistor is to calculate the energy dumped off as heat:

(4) W = E * I

(5) W = 12.3 * 0.020

(6) W = 0.246 Watts

Where:

W = power dissipated in the resistor in Watts

E = voltage drop across the resistor (12.3 volts) and . . .

I = current through the resistor (0.020 amps).

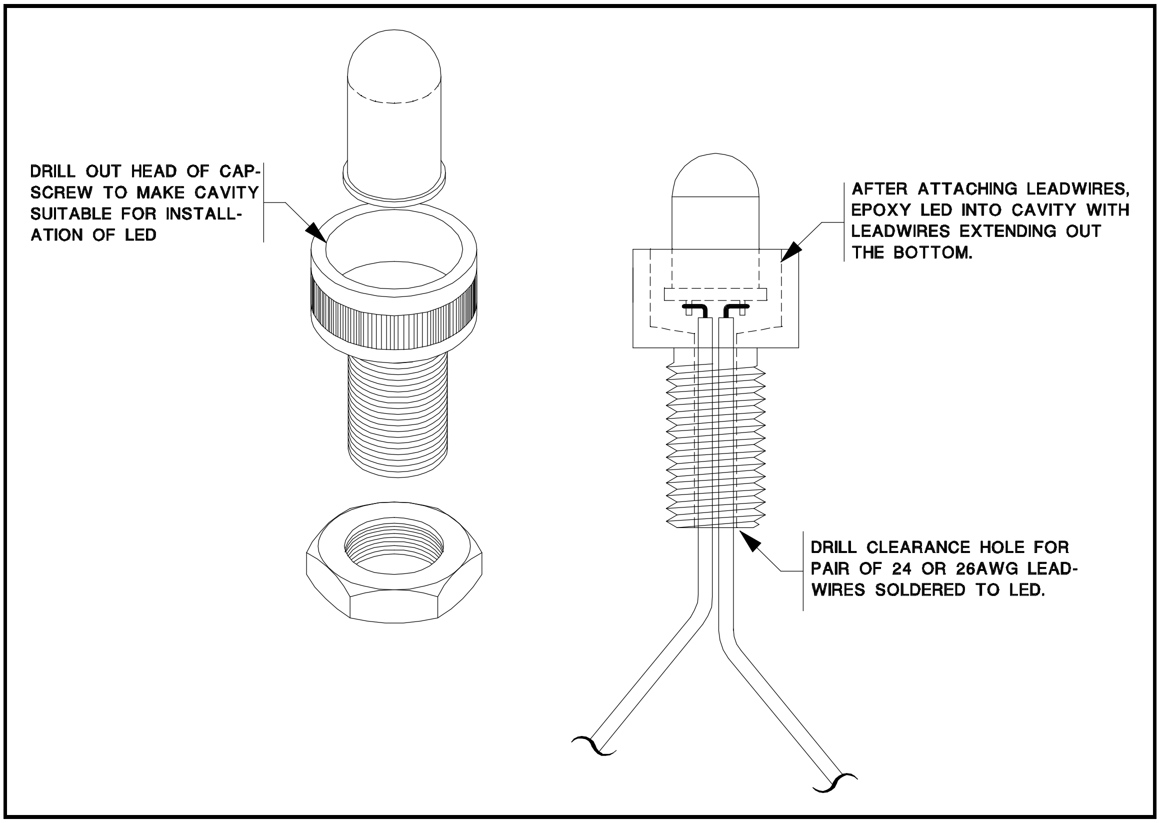

Figure 3. LED Mounting Suggestion.

If you try to purchase a 615-ohm resistor, you'll find that the nearest standard value is 620 ohms. 1/4 Watt (or 250 milliwatt) resistors are also a standard size. In this case, we've calculated that almost exactly 250 milliwatts of heat will be dumped off causing the resistor to operate right at the top of it's rated capability. Here, I would select the next larger resistor rating of 500 milliwatts so that we don't work it so hard.

Note the "A" (anode) and "K" (cathode) markings on both the schematic and pictorial representations of the LED. Before the LED's leads are cut, one lead is generally longer than the other. Further, the long lead may be adjacent to a small "flat" molded into the LED's base flange. The long lead next to the flat is the cathode connection (or minus supply lead) for the LED. Now, let's talk about some common myths I've heard circulated recently about LEDs.

Myth 1: "LEDs are electrically fragile. Take care not to exceed their rated current by even a small amount or you'll smoke it."

Generally not true. The LED I just measured on the bench was temporarily subjected to 100 milliamps of forward current with no observable effects. A few months ago, I mounted a super-bright LED (rated for 60 milliamperes) on a wall pluggable power supply and biased it up to 125 milliamperes . . . twice it's rated current. I left it plugged in 24 hours a day for about 4 months . . . approximately 2,800 hours. When I get around to it, I'm going to double the current again and see what happens. But suffice it to say that the little feller tolerated a 2x "overload" quite nicely.

Myth 2: " . . . yeah . . but hook 'em up backwards and they're toast . . "

I dug a half dozen pieces out of the junk drawers and was able to apply 30 volts of reverse voltage for a minute or so to any device without killing them. By-in-large, the common LEDs in green, yellow, red and near combinations are quite robust. The exceptions to this are the newer blue devices. I'm told that the physics of their construction does make them more fragile than the their older predecessors.

Given that a 20 mA lamp becomes visible at less than 3 milliamps of bias; will stand a 2x overload for thousands of hours; and doesn't crash with 30 volts of reverse voltage suggests that the garden variety LED is rather rugged. So, if you can't find a 620-Ohm resistor in stock but can find a 470-Ohm device, go for it.

Mounting an LED has two challenges: (1) transition from solid conductor leadwires into more flexible and vibration resistant stranded conductors and (2) mount the device so that it's appearance is appropriate to an aircraft instrument panel. Figure 3 suggests one way to accomplish both goals. Drilling out a piece of standard threaded fastening hardware (in this case, a capscrew) can provide a sturdy pocket where small, stranded leadwires can be soldered to short stubs of the LED's original solid leadwires. An appropriate amount of 5 minute epoxy can be used to retain the LED and wires in a single, rugged assembly. The fixture is mounted on the panel by means of a single hole and mating nut on the back side.

There are probably many variations on this theme. If anyone would like to share their own preference for an elegant LED mounting method, I'd be pleased to add it to this article.

Figure 4.

A few weeks ago, a builder on one of the Internet list-servers asked me about my recommendations for selecting and using LEDs on the instrument panels of airplanes. It had been some time since I'd surveyed the market for ready to mount LED indicator products so I took a quick trip to a local Radio Shack store to see what was hanging on the pegs. I found several interesting items. The Radio Shack 276-084 (Red) and 276-085 (Green) indicator lamp assemblies (Figure 4) are supplied with stranded wire leads and built in resistor for operation in a 12-volt DC system (look close in the picture and you'll see a little lump under a heat shrink sleeve on the black lead where the resistor resides. These devices are easily mounted by means of a nut that threads onto the fixture's body from behind.

Figure 5.

The RS276-011 lamp assembly (Figure 5) is also supplied with wire leads and a built in resistor for 12V operation. This device snaps into a drilled hole.

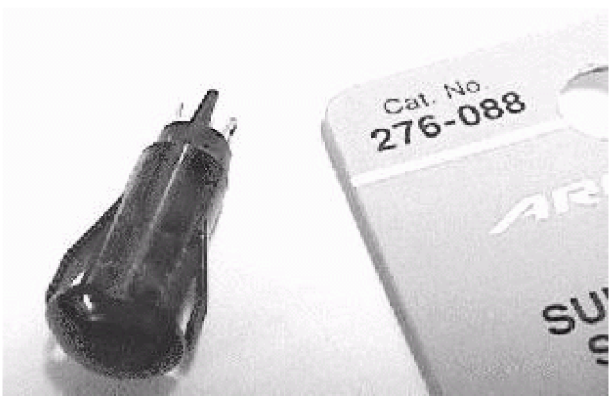

Figure 6.

Another interesting product is the RS276-088 lamp assembly shown in Figure 6. This device also features a built in resistor for 12V operation and is self-mounting by simply pressing it into a drilled hole. This device has solder lugs as opposed to wire leads.

The last two items I've illustrated are available from Radio Shack in red only but they are the brightest of the four products I looked at. The RS276-011 is most attractive to me from the standpoint of installed appearance and high on-off contrast ratio for sunlight viability. Certainly there are many other LED indicator products on the market. Here are some things to look for:

(1) Ease of mounting. The loose lamps in Figure 1 have solid leadwires and no built in means for installation. There are some holders for loose lamps that make 'em easier to mount but you still have to deal with the solid wire leads.

(2) Ease of wiring. All except the loose lamps shown in this article have interconnection features friendly to installation in aircraft. Lamp assemblies with built in resistors have added incentives for selection.

(3) Viewability and finished appearance. All of the products reviewed would look good installed. My personal preference would lean toward the RS276-011 device. In my opinion, it's tapered, polished black bezel looks pretty sharp. It's intensity seems adequate too.

I've found a number of ready-to-mount products in the catalogs that are good looking, easy to mount (single hole), small (.2" diameter), multiple colors and a measley 2-10 mCd of light output! These are quite adequate for indoor lighting visibility but pretty dim for the daytime cockpit. I'll revise this article as other devices appropriate to aircraft panels are discovered. In the mean time, you can easily put your hands on high intensity red, yellow, amber and green LEDs that are guaranteed to get your attention under any cockpit lighting conditions. If you want to go all solid state, it can be done.