Light Emitting Diodes and Your Race Car

The purpose of this document is to discuss how to use commercially available Light Emitting Diodes (LEDs) to replace the warning and signal lights currently in your race car.

First, you may ask - Why bother? The light I have works just fine. Here a few reasons why you might consider making the switch:

1. Incandescent bulbs rely on a filament to glow and emit light. This filament is quite fragile and not designed to operate in the high vibration environment of a race car.
2. Have you ever had a light bulb in your house fail on turn on? It's a bit spectacular, as the filament breaks and leaves the bulb full of white smoke. Why does this happen, and what is the applicability to racing? The filament in an incandescent bulb goes from ambient temperature to a temperature hot enough to give off light in a very short period of time. During this time, the filament actually flexes under the electrical and heat load. Failure is caused by the filament being flexed beyond its limits. This can happen to a filament bulb in a race car, as well. Your oil pressure just went to zero, and the pressure switch closed, sending current to the bulb. If the filament fails, chances are very high that you won't see the flash and bingo! Broken motor!
3. Incandescent bulbs have a relatively short life span.
4. They take a fair amount of current to light. (Rain Lights take 15w.) That's electricity that could be used by your ignition. If your battery is marginal, the first place that you will see the effects is at high RPMs. (This assumes that you are running a total loss system; if you use an alternator, no problem).

By using LEDs, the above mentioned problems go away:

1. There is no filament in an LED, just the semiconductor material. It is mounted on a substrate that is not bothered by the vibration.
2. See Item #1. Additionally, LEDs light quicker than incandescent. A study by Hewlett Packard (I think) showed that at 60 MPH, an LED tail light added 7 feet of reaction time to a panic stop situation by virtue of its quicker "on" time
3. LEDs have a rated Mean Time Between Failure (MTBF) of 100,000 hours or higher.
4. Probably the biggest reason to use LEDs – they take very little current. The Ultimate Rain Light draws 200mA of current at full brightness- that's about 2.5 watts, instead of 15 (or 21, depending on who makes your light).

So. If these reasons are sufficient to cause you to think about changing, what else is necessary?

Nothing comes free. The LED that you see in figure 1 needs some preparation before using it in your car. The biggest problem against a direct hookup is that the LED has a much lower voltage rating than the battery puts out. Red, yellow, and green nominally like 1.8vdc; orange is a bit higher at 2.4vdc, while blue and white like 3.8vdc. More than that and your LED will work exactly one time.

figure 1

So you say, how do I make this work? You must put a device in the circuit with the LED that uses the rest of the voltage, namely a resistor. The description below describes how to determine the size needed.

A commonly available LED for this purpose is the Radio Shack, Jumbo Red LED part number 276-086 that costs about $2.49. Specifications for this LED are shown in Table 1.

5000 MCD Jumbo LED (276-0086)	**Specifications**
MCD	5000
Size	10 mm / T 3 1/4
View Angle	30°
Voltage	1.9 VDC / 2.2 VDC (max)
Absolute Maximum Ratings	
Power Dissipation @ Ta = 25 C:	100 mW
Forward Current, DC (IF):	50 mA
Reverse Voltage:	3 V
Operating & Storage Temperature:	-55 to +100 C
Lead Temperature (Soldering, 5 sec., 1/16" from body)	260 C
Electro-Optical Characteristics (Ta = 25 C)	
Max. Forward Voltage (IF = 20 mA):	2.4 V
Min. Reverse Breakdown Voltage (IR = 100 microA):	3 V
Luminous Intensity (IF = 20 mA)	
Minimum:	2300 mcd
Typical:	5000 mcd
Typ. Peak Wavelength (IF = 20 mA):	660 nm
Spectral Line Half-Width (IF = 20 mA):	20 nm

Table 1

From the specifications sheet we see that the maximum forward voltage for this LED is 2.4 Vdc at 20 milliamps. With a typical battery voltage of 12.6 Vdc, we can see that we need to lose an additional 10.2 Vdc or our LED will become an SED – Smoke Emitting Diode.

We'll be using Ohm's Law which is:

$E = IR$
where E is voltage, I is current and R is resistance.

We know what E and I are so a little algebra gives us this formula:

$R = E / I$

R = 10.2 Vdc / 0.02 Amps
R = 510 Ω

To find out how much power this resistor will dissipate we use:

P = IE

P = .02 Amps x 10.2 Vdc
P = .204 Watt

Which is just under 1/4 watt, a standard resistor size[1]. Perfect!

figure 2

The color bands (figure 2) on this resistor will be GREEN BROWN BROWN GOLD. We won't get into color coding of resistors in this article.

Check out this link for a color code calculator:
http://webhome.idirect.com/~jadams/electronics/resist/resist_calc.htm?result=500

Put Away the Calculator and Warm Up the Soldering Iron

Now it's time to put this all together. Look at the LED and you'll see that one of the two leads is longer than the other. This one is called the ANODE and is the positive (+) lead. The other, shorter lead, is the CATHODE and is the negative (-) lead. You'll also notice that these leads are very small and fragile. Do not bend or handle them more than necessary. Notice the soldering heat information in the specifications. You are allowed 260°C for 5 seconds, 1/16" from the body. (Don't you just love it when they mix metric and British units in the same line? Anyway 260°C is about 500°F and 1/16" is 1.58 millimeters.)

You should have no trouble soldering the resistor to the LED without damaging the LED but just to be sure, get yourself a heat sink. A simple alligator clip (figure 3) will do, put it between the resistor and the LED. This is simple insurance and it'll only cost you about 40 cents. Much cheaper than that 3 dollar LED.

figure 3

[1] Radio Shack 900-0211 - 510 Ohm 1/4 W 5% Carbon Film Resistor

Carefully solder one lead of the resistor to the longer, ANODE lead of the LED. When finished you should have something that looks very similar to figure 4[2].

figure 4

Next, solder your wires to the resistor and the other lead of the LED. Figure 5 shows how that should look.

figure 5

Finally, put heat shrink tubing over your wires and a larger piece over both of the solder connections at the LED. You guessed it, figure 6 shows you how that should look. We'll get to that black ring in the picture in just a bit so stay tuned.

figure 6

The red wire goes to your power source. The black wire connects with your pressure and temperature switches. Don't forget to cover all bare wire with heatshrink tubing. Also be sure to properly support the wires and resistor and don't let them hang from the leads on the LED. Like

[2] The solder connection shown in figure 4 uses a high tech system made by the company Raychem. It's called a solder sleeve and can be made without using a soldering iron. If you can obtain some of these solder sleeves do use them. Otherwise just use solder, a soldering iron, heat shrink tubing, care and a liberal dose of patience.

we said before these little wires are very fragile and will not live long in the harsh race car environment without a little help from you.

That black ring in figure 6 is the LED panel mount. We have another picture of it in figure 7.

figure 7

This thing is also available from Radio Shack[3] . Just drill a 9/16" hole in the panel where you want your light, put in the mount and then install your LED.

figure 8

When you're all done you should have something that looks a lot like the steering wheel in figure 8. Makes you feel like Michael or Mika just looking at it.

[3] Radio Shack 276-092 / $0.99 for a package of 3