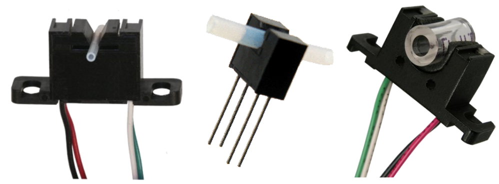
Fluid & Bubble Sensing—OPB350

Application Bulletin 235

This bulletin covers the basics of how to use the OPB350 fluid and bubble sensor.



The **OPB350** is a fluid and bubble sensor is intended to provide the designer a low cost easy means to identify:
1. Presence of a tube transmissive to Near Infrared light in the slot
2. Presence of a fluid in the tube
3. Presence of a bubble in the tube
4. In some instances type of fluid in the tube

Typical applications for this product may include:

There are several non-invasive ways to know if a tube filled with fluid has an air bubble. The two most common ways are ultrasonic and optoelectronic. They both use electronics to detect changes in viscosity, transmissivity or movement of fluid in the tubing.

Optoelectronics sense the presence of the tube, bubbles, and in some cases the type of fluid in the tube. Under controlled conditions this can be a simple process using a microprocessor or comparator to interpret the output signal level of the optoelectronic sensor.

Optoelectronic devices consist of a light-emitting diode (ultraviolet, visible or near infrared) and photosensor (photodiode, phototransistor, or photologic® device). The LED emits light at a specified wavelength that is sent through a tube that contains air or another gas. The internal walls of the tube reflect some light, reducing the amount of light received by the photosensor. When fluid is in the tube, the amount of photons picked up by the sensor changes, changing the output of the photosensor.

Several factors affect optoelectronic performance. To get the most out of them here are a few tips to keep in mind:
LED power may be different depending on the production lot. This can be compensated for by adjusting the current through the LED.

Sensitivity of the phototransistor may vary depending on the production lot. This variation can be adjusted by changing the output power of the LED or load resistor.

As temperature decreases the output power of the LED increases while the sensitivity of the phototransistor decreases. This phenomenon assists in keeping the overall signal constant as temperature changes.

Different types of tubes provide different amount of light through the tube (optical transmission of the tube). Therefore, the designer should specify the type of material used for the tube.

While LED's age light emission decreases over time. (You can expect 5% to 20% degradation over 100,000 hours.)

Identification of different materials or fluids can be accomplished by monitoring the output current of a phototransistor across a resistor utilizing either a microprocessor or comparator circuit (see Figure 1 for a comparator circuit). Some of the typical states that can be identified are: presence of a tube, air in the tube, saline solution or some Hematocit levels.

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With the ability to vary the current drive on the LED, or change the sensitivity of the photosensor measurements technique, critical measurements of minor optical transmission changes of the fluid can be identified to recognize different fluids such as Hematocrit %.

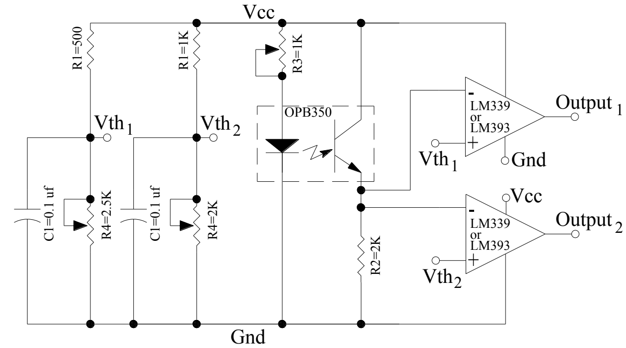
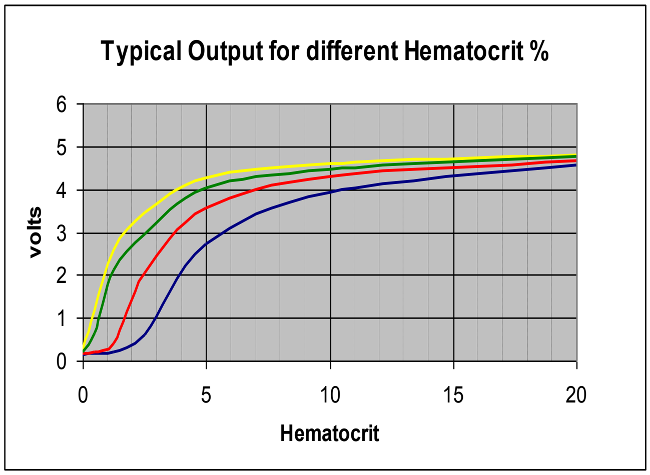
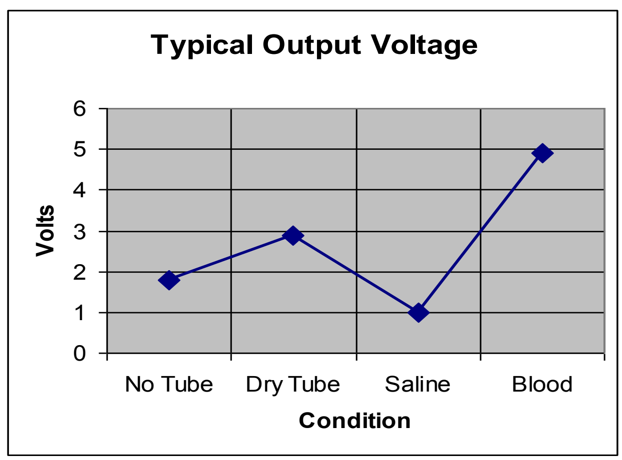


Figure 2 shows some expected output levels of a phototransistor with different percentages of blood in a fluid (Hematocrit %). The yellow line on the graph is with the lowest LED current and the blue line shows the highest LED current level. The user will have to evaluate different tube types to provide a suitable signal level. Keeping in mind the TIPS mentioned earlier, the designer can provide a stable fluid sensing system.



Solution to the variable characteristics of the sensing system are:

- Keeping the material used for the tube consistent allows the transmission properties to be consistent.
- With the ability to use a microprocessor or other sensing device to monitor the output phototransistor, during initialization, the designer can adjust the current drive of the LED to provide the initial expected output level. Normally the device is without a tube. This initial output level is used as the reference point for all other states. See figure 3 for some typical output ratios.
  - Example 1: Dry Tube = 2.9V, No Tube = 1.9V giving a ratio of 2.9/1.9 = 1.53
  - Example 2: Saline Solution = 1V, No Tube = 1.9V giving a ratio of 1/1.9 = 0.53
  - Example 3: Blood = 4.9V, No Tube = 1.9V giving a ratio of 4.9/1.0 = 2.58
  - By adding the output initialization state to include a clear tube condition, you can compare the % change in output, and identify that the proper tube material is being used.
- The temperature coefficient of the LED goes in the opposite direction of the phototransistor thus reducing the effects of ambient temperature change.



Normally in medical applications this characteristic can be ignored.

The typical LED life expectancy of an LED driven at 20 mA is over 100,000 hours of continuous operation with an expected degradation of between 5% and 20%. This is over 10 years of continual operation. With the use of the initialization program, the LED degradation problem is can be ignored. Lowering the LED drive current reduces the degradation of the system providing an extremely stable configuration.

In conclusion, when using an optical device in an apparatus, the designer can provide a monitoring scheme, capable of being vary stable over an extended period of time. When using an optical device the designer can identify a multitude of conditions such as, presence of the tube, presence of a bubble or foam, type of tube material, or even the type of fluid within the tube.

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