

# Interfacing Sensors with a Microprocessor



## Application Bulletin 214

This application note addresses a method for monitoring multiple sensor channels with a single analog-to-digital channel. The application might be an eight-channel reflective or a transmissive bar code reader. By using an A/D converter an analog level of the sensor can be measured. This analog voltage can provide more information than a digital sensor.

This system would be controlled by one of the single chip microprocessors like the Motorola 68HC11. Referring to Figure 1 on the next page, let's review the details of operation. The sensors will be configured to operate one channel at a time. This is accomplished by illuminating the LEDs with a microprocessor and connecting the sensors in parallel. The LEDs will be illuminated one by one, and the resulting phototransistor current will be measured by the microprocessor analog-to-digital converter.

This type of operation consumes very little current. Each LED is only on long enough to collect a sensor reading. The microprocessor can also be programmed to have sleep periods and operate only long enough to check all the sensors. The net average current consumption would be less than 25 mA without modulating the CPU on time. This approach is ideal for applications requiring battery operation or those trying to minimize power supply requirements.

When connecting several sensors in parallel as shown, the leakage current of each sensor and its associated solder connections must be very low (200 nA). The ambient light incident on all the sensors must also be low. If these conditions are not met, the leakage currents or off currents (noise) may exceed the on current (signal). Minimizing the off state current will also produce the greatest dynamic range for the sensing system.

The OPAMP shown is one of a CMOS series produced by National Semiconductor. It is a single supply device with an output that can be driven rail-to-rail. Any OPAMP with equivalent characteristics is acceptable. You may even find it desirable to use one with a balance adjustment which can be used to adjust OPAMP offset and any quiescent noise or leakage out of the sensing system.

Another consideration is the analog-to-digital range and resolution. If the sensor conditions vary, attempt to balance them by adjusting each LED current-limiting resistor. Keep in mind that if you have an eight-bit A/D you will have 256 different possible sensor levels. Make sure the sensor off state falls at the low end of the A/D and the on state falls near the upper end by picking good A/D reference voltages and carefully selecting the proper gain of the final amplifier or buffer. This will probably require prototyping and testing of your circuit to select the proper values.

With regard to LED current, the 7445 shown in Figure 1 is rated for operation with 80 mA of sink current. However, try to limit the LED current to about 40 mA. Normally a lower LED drive current is recommended but this system will be pulsing the LEDs at a low duty cycle, so heating and LED degradation will not be a long term factor in most applications. If you have problems with ambient light, operate the LEDs at a higher current level. Also, if you find you can work with 10 mA or less and you have the extra CPU outputs, you may want to drive the LEDs directly from the CPU and save a chip. Check the specification of your CPU. Most CPUs have a particular eight-bit port which is rated to sink more current.

Timing is another consideration. If the 68HCC11 is clocked at 8 MHz, the A/D will complete a single conversion in 32 clock cycles or 16  $\mu$ s. A few more instructions will be needed to turn on the LED and to allow the signal to stabilize so a channel read time of about 30  $\mu$ s will be needed. All of these factors can be adjusted and fin tuned for a particular design.

The 68HC11 includes a serial port option. The port can be used to communicate with another computer or CPU for sensor status and control.

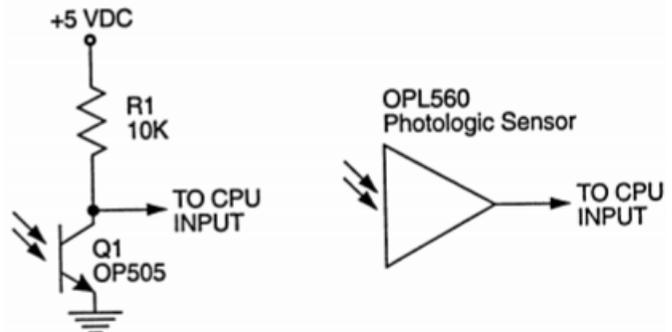


Figure 2

### General Note

TT Electronics reserves the right to make changes in product specification without notice or liability. All information is subject to TT Electronics' own data and is considered accurate at time of going to print.

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