Rail-to-Rail Amplifier Extends Resolution and Range of Light Sensor

Application Note | **May 8, 2007** | **AN1315.0**

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Light sensors are appearing in every sort of consumer application, aiding in aspects like power conservation. Since a wide range of products are portable, they utilize battery power and are therefore configured for single-supply operation. Single-supply operation introduces limitations on analog circuitry. One of the most obvious trade-offs is reduced input voltage range. Upgrading to a rail-to-rail amplifier will restore this sacrifice.

For example, consider the circuit in Figure 1. The light sensor affects a current at the inverting input of the amplifier. The non-inverting input of a standard amplifier is typically biased half-way between the supply rails. In a 3V single-supply configuration, the non-inverting input would be biased at 1.5V. The output voltage of the circuit is in Equation 1:

$$V_{OUT} = V_{REF} - IR \quad \text{(EQ. 1)}$$

Notice the response curve of our example light sensor, the EL7900, in Figure 2. The sensor produces varying amounts of negative current (drawn into the sensor) for varying illumination. Since this characteristic has a single polarity, it behooves the designer to adjust the reference voltage on the non-inverting input (Figure 1) to accommodate a greater range of input values from the sensor. The output voltage is only reduced by the sensor's signal, so V_{REF} should be raised.

How far can this reference voltage be raised? That depends on the topology of the amplifier used. Standard op amps have an input voltage range limited by the bias circuitry supporting the input differential pair. This reduction may be 0.5V to 1.5V approaching one or both power supply rails. With the shrinking power supplies offered by portable devices, this reduction can severely limit performance.

Rail-to-rail op amps, like the EL8178, include dual input pairs to allow the input signal to travel the full power supply range (and a bit beyond.) For maximum resolution on the light sensor, the non-inverting terminal is biased at the supply voltage. This accommodates the complete response (Figure 2) of the light sensor, improving the output dynamic range as much as 45%.

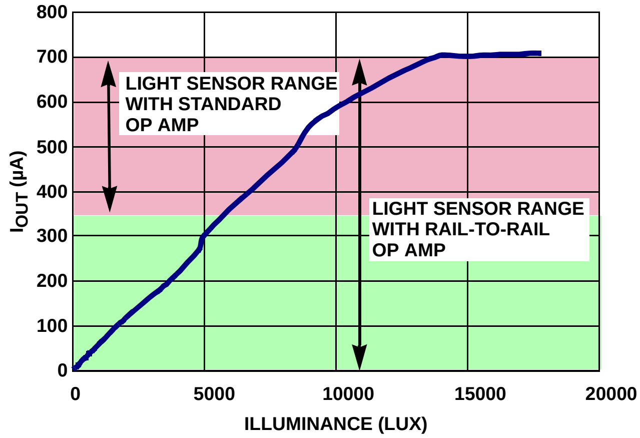

FIGURE 2. OUTPUT OF LIGHT SENSOR vs ILLUMINANCE OF LIGHT

NOTE: Ranges use Circuit 1 in Figure 1 with R = 4.7kΩ

TABLE 1. CIRCUIT CHARACTERISTICS WITH STANDARD OP AMP AND RAIL-TO-RAIL OP AMP

	OP AMP WITH/ STANDARD INPUT (EL5144)	OP AMP WITH/ RAIL-TO-RAIL (EL8178)
Supply Voltage (VS+)	3.3V	3.3V
V_{REF}	1.5V up to 1.8v	3.3V
V_{OUT}	Limited by (VS+ - VREF)	Full power supply range

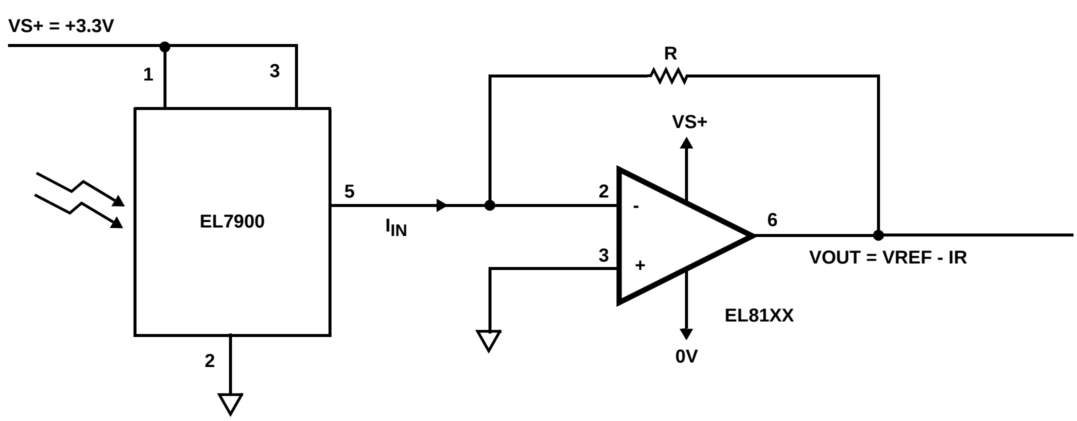

FIGURE 1. LIGHT SENSOR CIRCUIT