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APPLICATION NOTE 4622

High-Speed Op Amp Enables Infrared (IR) Proximity Sensing

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Abstract: This simple IR transceiver generates IR modulated at 10kHz, then amplifies the reflected signal with a single op amp (MAX4230), which is also configured as a 2nd-order bandpass filter to demodulate the 10kHz IR signal.

This design idea appeared in the August 6, 2009 issue of *EDN* magazine.

IR proximity sensors are widely used for sensing the presence of an object, its distance from a reference, or both. Applications include speed detection, sensing of the hand in automatic faucets, automatic counting or detection of objects on conveyer belts, paper-edge detection in printers, and many others. The latest-generation smart phones, for instance, can turn off the LCD touch screen to prevent accidental activation of buttons when the screen is pressed against your chin or ear.

To sense an object, the proximity sensor transmits IR (infrared) pulses toward the object, and then "listens" to detect any pulses reflected back (**Figure 1**). An IR LED transmits the IR signals, and any reflected signal is detected by an IR photo-detector. The strength of this reflected signal is inversely proportional to the distance of the object from the IR transceiver. Because the reflected IR signal is stronger when the object is close, you can calibrate the output of the photodiode detector to determine the exact trigger distance of an object (the threshold distance for making a decision on whether the object is present or not).

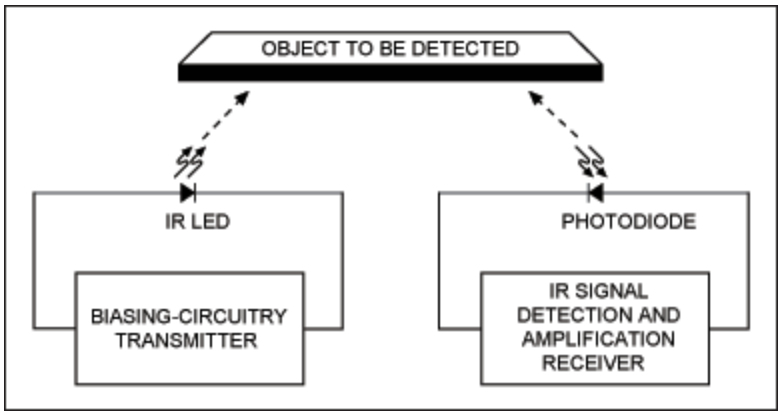

Figure 1. Basic principle of an IR proximity sensor.

The photodiode detects IR reflected from the object, but it detects IR produced by the ambient conditions as well. You must filter out this IR noise to prevent false detections. A common method is to modulate the LED's IR signal with a convenient frequency, and then detect only IR with that modulation, which identifies it as having been reflected by the object.

The IR proximity sensor of **Figure 2** has simple transmitter and receiver sections. The transmitter consists of a 940nm IR LED (IR11-21C), which is turned ON and OFF using a 10kHz oscillator frequency. By varying the LED current you control the level of transmitted power, and hence the detection range. To save power, the transmit pulses have a small duty cycle (typically 10%).

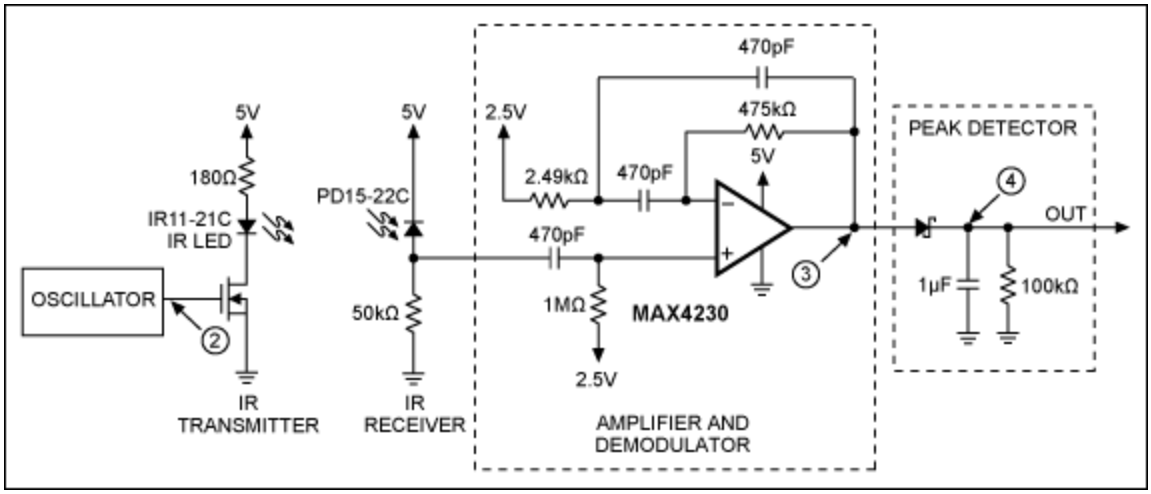

Figure 2. This simple IR transceiver detects the presence of an object, and provides an approximate distance from the transceiver.

The receiver circuit demodulates and amplifies IR signals detected by the photodiode (PD15-22C), whose peak sensitivity occurs at 940nm. The photodiode output is AC coupled to the op amp's noninverting input. AC coupling allows the 10kHz signal to pass, but the 300Hz cutoff frequency set by the coupling capacitor prevents DC noise and background IR from reaching the amplifier.

Low noise, high bandwidth, and rail-to-rail input/output capability make the op amp shown (MAX4230) a good choice for demodulation and amplification in this circuit. In addition, its excellent RF immunity prevents the annoying 217Hz audio buzz commonly found in GSM cell phones. For the IR receiver, the op amp is configured as a gain-of-100, 2^{nd}-order bandpass filter centered at 10khz. Thus, while amplifying the incoming IR signals, the op amp also demodulates them with its bandpass filter.

With no input IR signal present, the op amp is biased at 2.5V. With a 10kHz IR signal incident, its output varies around 2.5V with a dynamic range of 5V. The output drives a simple diode detector, which rectifies the 10kHz signal and provides a DC signal proportional to its amplitude. This analog signal (OUT) is proportional to the distance of the object from the IR transmitter. It can be used directly, or fed to an ADC for further processing. Circuit operation is illustrated by waveforms taken at various nodes in the circuit, for objects at 1.2 inches and 1.4 inches from the IR transceiver (**Figure 3**). Note that these waveforms are keyed by number to the various circuit nodes.

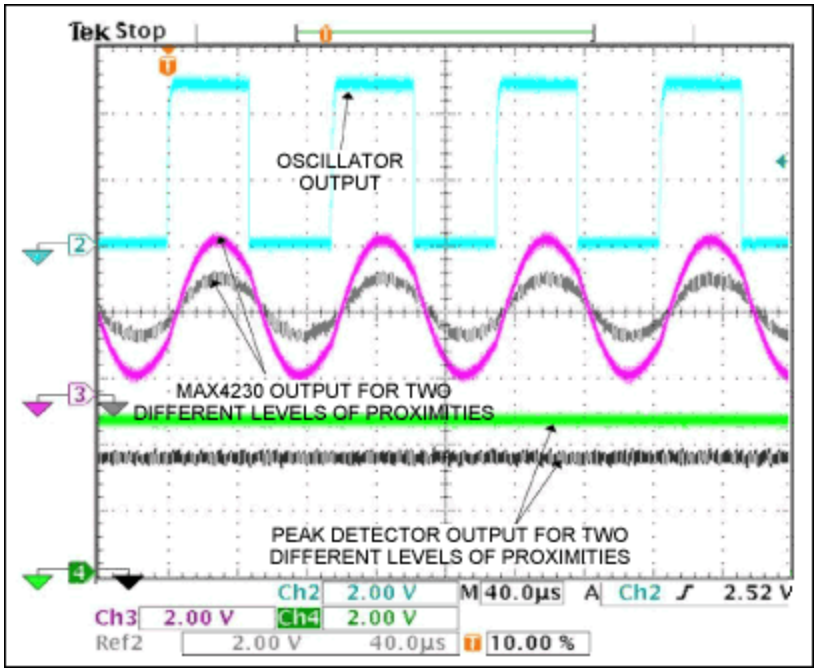

Figure 3. These waveforms from the Figure 2 circuit represent objects at 1.2 inches and at 1.4 inches from the IR transceiver.

Related Parts		
MAX4230	High-Output-Drive, 10MHz, 10V/µs, Rail-to-Rail I/O Op Amps with Shutdown in SC70	Free Samples

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