Circuit Bodging

Laser Tripwire Sensor

One very important application of electrical engineering is security systems. Although fear of a Big Brother style continuous surveillance system might be justified in some places, we would once again like to remind you that technology can be used for Good as well as Evil. In this issue of Maxwell we present: a laser tripwire. It’s been done in the movies, and now it’s been done in Maxwell.

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There are a multitude of reasons why you might want to protect an area from intruders. Perhaps you want to protect your fancy furniture from party guests. Perhaps you want to stop thieves from stealing your things. Perhaps you want to make your roommate jump three feet into the air when he goes to the kitchen to get a drink. Whatever your reasons, electrical engineering is applied in many situations to detect and deter would-be trespassers.

One obvious discussion point is that a laser sensor as simple as this one is easily circumvented. The laser’s beam is easily visible, even more so if one introduces a dust or powder in the air. A replacement light source can take the laser’s place while an intruder passes through the laser’s light beam. The circuit also ignores the colour of the light, so an alternative light source is impossible to detect. Cutting the power to the circuit will also defeat it. However, this is not meant as a foolproof security system, but more as a proof of concept and a fun little circuit to play around with.

First we will need to choose a sensor to measure the light falling onto it. There are many choices on how to approach this, a photodiode is frequently used for this kind of application. Unfortunately these do need a fair amount of circuitry to get a useful output from the sensor.

An easier method is the light dependent resistor, or LDR.

An LDR’s resistance is logarithmically and inversely proportional to the amount of light striking it. This gives it useful properties for our sensor design.

However, building an ohm-meter around the LDR to measure its resistance would be a rather convoluted and unnecessarily complicated exercise. What we’re going to do is design a simple circuit around the LDR to turn on a transistor at a certain trip level to provide a logical ‘1’ or ‘0’ to the next stage of the circuit.

First, we must turn the resistance into a voltage. We achieve this by using it in a voltage divider. As the resistance of the LDR changes, so does the voltage at the output of the divider, so when the LDR’s resistance drops because light is hitting it, the output voltage of the divider goes up.

When the voltage is high enough, T1 will turn on and allow a current to flow through it. Because T1’s emitter is connected to 0V, the voltage across it is low and this, in turn, keeps the power low. A 2N2222 in this configuration can sink a fair amount of current before it starts to exceed the power rating threshold.
When the LDR’s resistance is low the transistor will conduct, causing Vcc to be low, a logical ‘0’. When the light source [our laser] is removed the transistor no longer conducts, and as such Vcc rises, delivering a logical ‘1’ at the collector. When you build the detector, adjust the trimmer R1 to set the sensitivity.

The next step is to create a circuit that will ‘remember’ if the sensor has been tripped. This is achieved by implementing a basic S/R latch with NOR gates. Take note that the symbol in the schematic is non-standard, but does represent a NOR gate, and not a NAND as might be assumed.

The simple S/R latch has one illegal combination, namely both inputs being high. If this occurs both outputs drop low. At this point the latch no longer obeys the rule that the outputs must be each other’s inverse, however this is a useful combination for our circuit: while S1, the Reset button, is pressed, the sensor is disarmed.

When the sensor’s LDR is illuminated sufficiently and the output was not yet high, the output of IC1A will be high, illuminating the “armed” indicator LED. When the sensor is tripped the latch will switch outputs and IC1B will output high. IC1A drops to logical ‘0’ and the indicator LED turns off to indicate that the alarm cannot detect further intrusions until the reset switch is pressed. This is a moot point, however, because depending on the user’s configuration - alarms will be going off and lights will be flashing and everybody in a 200 metre radius will be aware of the fact that something is going on.

Now we have a system that will detect the light beam being obstructed and continue to provide a high signal until it is reset. What we must do now is use this digital signal to activate any alarm signals we might want to use.

In the schematic below, the signal from the latch activates relay K1, which will make it possible to connect any alarm or light or siren we want. This is done by once again using a 2N2222 as a current sink. However, the logical high signal could conceivably be connected to a microcontroller for inclusion in a larger security system - but that is beyond the scope of this article.

Another option is to replace the relay with a buzzer, creating a quick-and-dirty alert. Please note that the relay is not necessary if you’re just going to use an LED - this can be connected directly to the logical signal in series with an appropriate resistor.

As always, the reader is encouraged to experiment with and improve the circuit, as it can be implemented in various ways, but please remember it cannot replace a commercial alarm system. So there you have it, a laser tripwire for your home security system that will stop your enemies dead in their tracks by scaring them to death! 🤓