Make a Voltage Controlled Resistor and Use It

by **Biotele** on August 21, 2007

Table of Contents

Intro: Make a Voltage Controlled Resistor and Use It

This is a three-in-one Instructable:
1. Make a Voltage Controlled Resistor
2.Use it to make a Voltage Controlled Oscillator
3.Use it to feed a signal into a laptop's microphone input.

The voltage controlled resistor is a very useful element in electronics. The one in this instructable takes a minute to make and does not require too much electronic knowledge to operate. It is made out of an LED and a Cadmium Sulfide (CdS) photocell. The LED changes light intensity with change of voltage/current. The photocell is a resistor that changes resistance with change in the intensity of light striking it.

To build a voltage controlled resistor, you need to glue the LED to the photocell then paint the whole assembly black to shut out ambient light. That's it!

The voltage controlled resistor can also be used to:
.Control devices like the volume of an amplifier
.Control gain in automatic gain control circuitry
.Feedback signals to control motors and robotics.
.Amplitude Modulate (AM) a signal.

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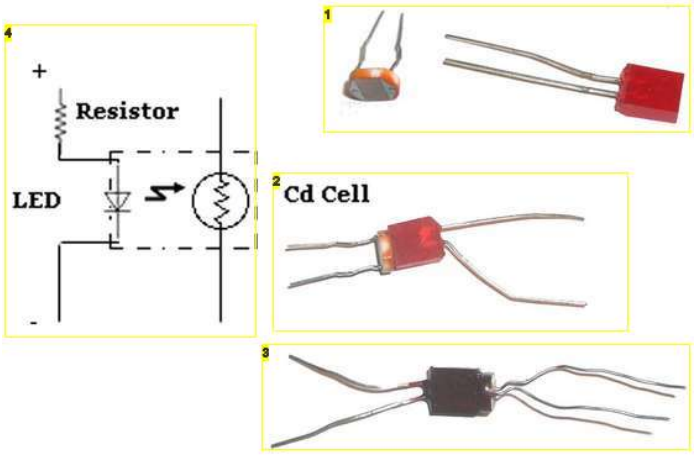


Image Notes
1. You need a CdS photocell and an LED.
2. Glue the LED to the photocell. Use crazy glue.
3. Paint the whole thing black to shut out light. You can dip it in liquid tape.
4. This is the schematic of the device

step 1: Application: Voltage Controlled Oscillator

A voltage controlled resistor can be used to change the frequency of an oscillator. When a voltage controls the frequency of an oscillator, it is called a voltage controlled oscillator or VCO for short.

VCOs are used in FM modulation, mainly. In this case, it used to make a two tone siren which you can see in operation in the video below

(Note: the flashing LED is part of the voltage controlled resistor assembly, I did not paint it black to show how it operates. My hand is changing the pitch of VCO because it is shutting out the ambient light that affects the exposed photocell)

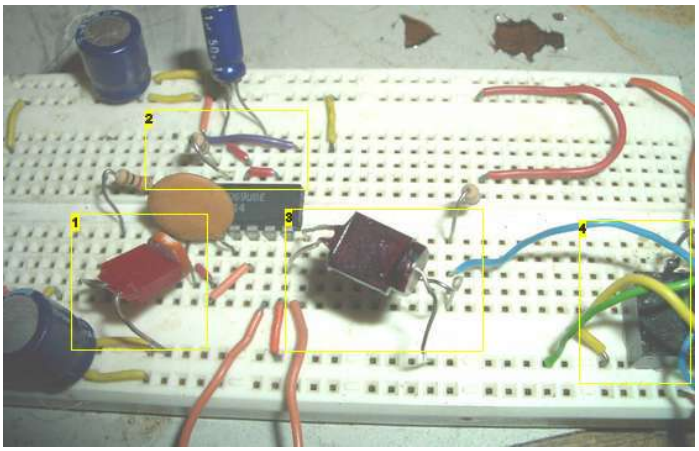


Image Notes
1. The voltage controlled resistor that controls the VCO
2. The low frequency oscillator that drives the voltage controlled oscillator
3. Another voltage controlled resistor (this one is painted black) that I use to buffer the output of the VCO to microphone input of my laptop. This is covered in the next steps
4. The plug for the patch between the laptop's microphone input and the circuit

step 2: VCO Schematic

The schematic below shows the two oscillators from the previous video. The first oscillator controls the second oscillator which is the VCO. The first oscillator is a fixed frequency oscillator and produces a low frequency square wave which the VCO translates into an alternating sequence of low and high pitched sound.

The two oscillators are both based on a single CD4069 Hex inverter chip. CD4069 is a very versatile chip that can be used for a myriad of digital and analogue applications. For example, Two inverter of an CD4069 can make a simple cheap and rugged square wave generator /digital clock (as in this example). One inverter of the CD4069 can be used as a buffer and to drive a heavy load (in this case it drives a computer microphone input decoupler covered in the next step).

The two oscillator are RC type of oscillator, meaning the resistance (R) and capacitance (C) set the frequency of oscillation.

the frequency is = 1/(2*pi*R*C)

A high resistance or capacitance produces a low frequency and vice versa.

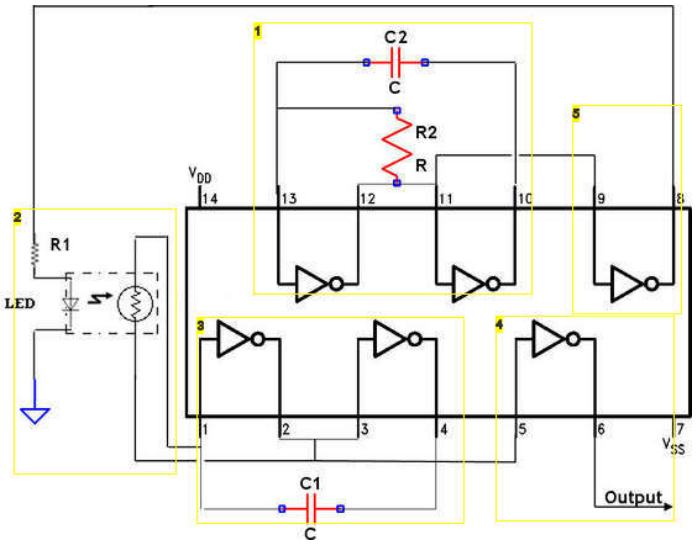


Image Notes
1. This is the fixed frequency oscillator that drives the VCO. It produces a low frequency square wave that makes the VCO switch between a low pitch tone and a high pitched tone.
2. This is the voltage controlled resistor assembly
3. The VCO is the same as the fixed frequency oscillator above. The only difference is that R2 is replaced by the voltage controlled resistor. When the cadmium photocell is illuminated, it's resistance is low and the VCO pitch is high. When the LED turns off the CdS photocell's resistance goes high and the VCO pitch goes low.
4. This inverter is used as a buffer. The buffer can drive more current then the oscillator itself.
5. This inverter is used as a buffer to drive the LED in the voltage controlled resistor

step 3: A Signal Decoupler

A signal decoupler electrically isolates two devices while passing a signal between them. This is very important in cutting out interference noise and for safety.

In the previous example, I used a voltage controlled resistor to decouple and feed the tone from the VCO into my laptop's microphone input.

This setup reduces the noise that my laptop's microphone input can pick up from the circuit and protects my laptop from the circuit (you can burn the microphone input if you put too much voltage into it) .

I will show two configurations to decouple a laptop microphone input. The two configurations are based on the type of laptop microphone input. There are some laptop microphone inputs that provide power to the microphone and some that don't.

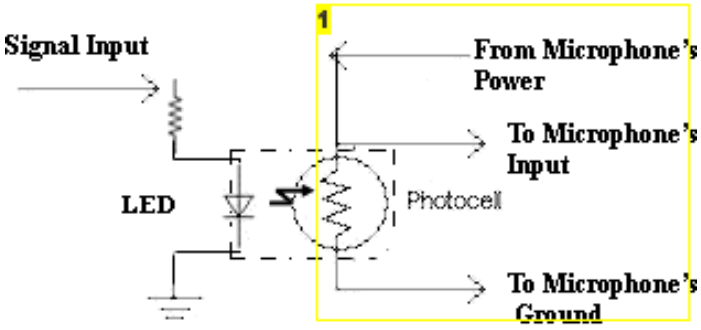


Image Notes
1. This is for the type of laptops that provide power to their microphones. There will be a voltage between one of the microphone wires and ground.

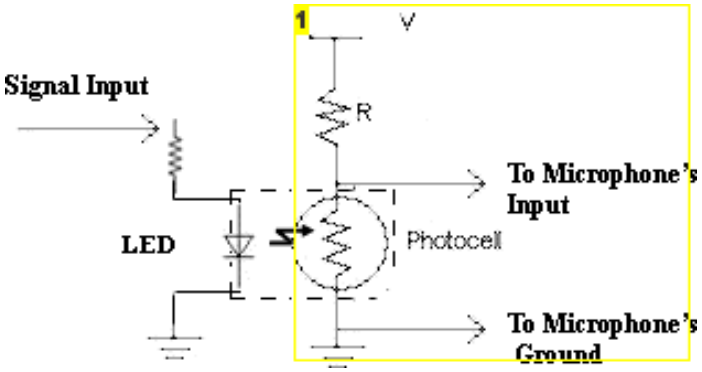


Image Notes
1. if the laptop does not provide power to the external microphone then you need to add an external power supply. Note, if you use the power from the circuit you are decoupling then you are not decoupling the circuit because there is a direct path between the laptop and ciircuit. However, the decouple does reduce interference noise.

step 4: Some Technical Details

An LED is a current device, meaning it responds to current change change not voltage change. The Voltage across an LED is always fixed (red LED have a voltage of 1.2V, white LEDs have higher voltages). So technically this device covered in this instructable is a CURRENT CONTROLLED RESISTOR.

However you can add a voltage to current converter to drive the LED. The simplest voltage to current converter device is a resistor.

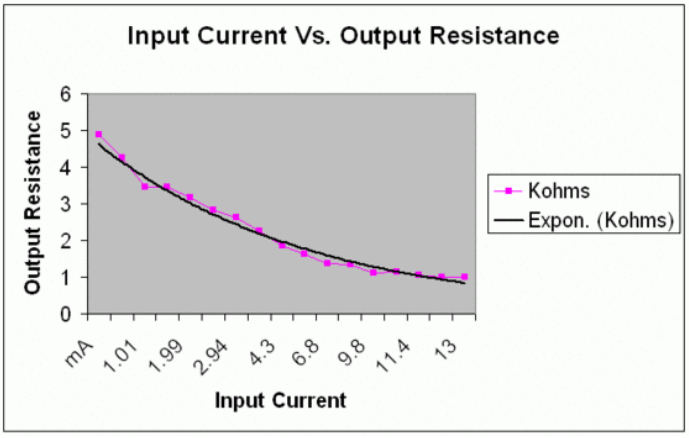
A resistor converts voltage to current by means of OHMs law, so that the output current I=V(across R)/R.

The voltage across a resistor in series with an LED is Vinput-VLED (in a red LED it's Vinput-1.2V).

It is always a good idea to put a resistor in series with an LED because it protects the LED from over current which burns out the LED.

Another detail, the output light from an LED is not linearly proportional to the input current but changes exponentially.

I plotted the input current vs. the output resistance of the voltage controlled resistor in this instructable below. It clearly fits an exponential trend line.



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Make a Rotating Microphone by noxidgerg

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USB Headphone Hack! by babblin5

Cheap & easy opto-isolated TTL-to-110V light control module by jcomtois

LapTop BreadBoarding by dsauer

A USB Power Controled Plug Strip. With Isolation. by toymotorhead

Pulse Width Modulated LED Torch by mathews

Poor mans slingbox by wasteotime

Comments

42 comments **Add Comment**

ionia23 says: Sep 14, 2009. 4:31 PM **REPLY**

It must be me.

Correct me if I'm wrong, but with this design, as the LED light increases the photocell will decrease resistance. Simply put, bright light shining on the photocell will allow current to flow from the AC source to whatever you plug into this adapter.

It won't work the way you'd expect it to. Say you were trying to use this as a trigger for a light.

Led's require little current so you could take a speaker wire pair, connect it to your control wires on this box, and get an incandescent light to flash in time with the music.

Wouldn't work. No LED light = Outlet is live. LED light = Outlet is off.

That would have to be reversed.

PLEASE correct me if I'm wrong or mssed something. I really want to be wrong about this.

burzvingion says: Oct 15, 2007. 5:04 PM **REPLY**

It is slightly misleading to call this a voltage controlled resistor. A more proper term would be opto-isolator . While it will work well in a variety of applications, a faster and more accurate alternative might be to use a digital potentiometer. They are available in various configurations, maxim has quite a few app notes on them.

Polymorph says: Aug 28, 2008. 2:17 PM **REPLY**

It would be more accurate to call it a -current- controlled resistor, in that the current vs light output from an LED is fairly linear over a wide range. While it is true that the resistance vs light of a CdS photocell is not linear, for audio applications you rarely want linearity.

jackever says: Jan 30, 2008. 9:46 AM **REPLY**

It is not misleading!!
You are right in that it is an opto-isolator but it is a voltage controlled resistor. Think about it:
1 change the voltage applied
2. the resistance of the photo cell changes
What is your criteria for a V.C.R.?? This soluton has been used even before LED's with incandecet bulbs. It was invented by Alexander Graham Bell. And is very cost effective, and simple. How does much does a digi-pot cost and the supporting parts to develop the digit input??

burzvingion says: Jan 30, 2008. 8:35 PM **REPLY**

My apologies. I did not intend to imply that it would not work, merely that it may not be optimal for certain applications. Particularly where a quick response time or linear response curve are desired.

jackever says: Jan 31, 2008. 7:12 AM **REPLY**

Thanks. Every application has its own options and optimal solutions.
I need to check my spelling- Incandescent- not incandecet . also to many does's.

alex-sharetskiy says: Mar 16, 2008. 6:20 PM **REPLY**

you should use a high intensity LED instead of the red

Biotele says: Mar 17, 2008. 4:15 AM **REPLY**

The red LEDs where the only ones that I had that were rectangular. Rounded LEDs are harder to glue.

Changing the type of LED changes the transfer function. The cadmium cell best respond to green light.

Polymorph says: Jul 13, 2008. 10:37 AM **REPLY**

I've done this for years, you just sand the end of the LED flat. You aren't even worried about it being smooth since it is glued onto the photocell.

Biotele says: Jul 14, 2008. 2:23 AM **REPLY**

What do you use them for?

Polymorph says: Aug 28, 2008. 11:27 AM **REPLY**

A number of things, anywhere I need a variable resistor and it is easier if it is isolated (versus using a FET as a variable resistor).

I've used it as part of an AGC circuit. Used several to modify a Radio Shack digital echo box into a nice Effects box that would vary the echo depth, timing, volume, etc. so it would act as a multi-effects guitar pedal. Made VCO with a 555 timer. Remote wired volume/balance/tone controls. Etc.

CdS photocells are most sensitive to green/yellow light, so I usually use a yellow LED (less forward voltage than a green LED).

Biotele says: Aug 28, 2008. 1:19 PM **REPLY**

they are perfectly suited for AGS in the audio range and they are less of a headache to design than jfet in the feedback loop of an op-amp.
They can be used as digitally controlled variable resistors with a voltage hold circuit. I even linearized them by using a reference CdS in a feedback loop matched with the working CdS (I glued the CdSs side by side and used one LED for both).

Polymorph says: Aug 28, 2008. 2:02 PM **REPLY**

And they have a faster attack time (ie, change to low resistance with light) than decay (ie, change to high resistance with less light) that is well suited to AGC.

I like your idea for linearization.

thermoelectric says: Aug 28, 2008. 12:55 AM **REPLY**

Glue to the photocell!

alex-sharetskiy says: Mar 17, 2008. 4:35 PM **REPLY**

i agree that they are harder to glue, but you get a lower resistance as a final product.

also, what wattage are those photocells?

Biotele says: Aug 23, 2008. 5:31 PM **REPLY**

you can easily fry them at moderate voltages, I guess a 1/4 watt.

Derin says: Apr 22, 2008. 7:25 AM **REPLY**

be careful with cadmium it is both toxic and recognised as calcium

alex-sharetskiy says: Aug 23, 2008. 5:45 PM **REPLY**

recognized as calcium in your body?

Derin says: Aug 23, 2008. 11:21 PM **REPLY**

yep,it acts like it has calcium,instead it has CADMIUM in it.So that spreads the poison and gives it a permanent home.

alex-sharetskiy says: Aug 23, 2008. 11:34 PM **REPLY**

crap! i'm gonna recycle away my NiCad batteries! <-after i drain the last bit of life out of them

Derin says: Aug 24, 2008. 12:06 AM **REPLY**

oh yay
NICD OUT!NIMH IN!!

alex-sharetskiy says: Aug 24, 2008. 1:20 PM **REPLY**

ya, but NiCad batteries can take a beating when you re-charge them, since i don't like to go on a quest to find my only charger, i usually just charge the batteries with my variable PSU

jcomtois says: Mar 9, 2008. 6:28 PM **REPLY**

Nice concept. This voltage controlled resistor is like an analog opto-isolator, very cool. I just finished a similar "digital" version for controlling 110V outlets. Someone below mentioned driving the LED in pulse-width modulation fashion and it occurred to me that this would be a good way to completely isolate digital noise from an analog circuit because not only are the two circuits electricall isolated, but the CdS cell also has a such a comparatively long time constant.

Biotele says: Mar 10, 2008. 2:44 AM **REPLY**

This is precisely an analogue opto isolator. I could not find ones that are ready made and affordable so I made them myself.

jcomtois says: Mar 10, 2008. 4:53 PM **REPLY**

yep, that's how I got into Instructables. Have you plotted the response curve of any of these? How linear are they?

Biotele says: Mar 11, 2008. 6:15 AM **REPLY**

Yes it is in step 4. It is non linear, of course, which give this device the ability to mix signal like a diode.

jcomtois says: Mar 11, 2008. 5:04 PM **REPLY**

Sorry, I was skimming the site and missed it.

lucianoabcd says: Aug 23, 2007. 11:28 AM **REPLY**

Have you tried reading the mic input with some program (I mean other than a wav recorder!) ??

I've always wondered whether the microphone could be used as a cheap and easy signal input port...

Biotele says: Aug 24, 2007. 4:04 AM **REPLY**

Yes, I used Audacity. One of the main motivation behind this instructable is to use the mic as an easy Analog to digital converter.

lucianoabcd says: Aug 30, 2007. 7:37 AM **REPLY**

I would like to use some dll or ocx from inside a vb or c program...

And going beyond, I'd like to try this as an input system for my pocket pc, lol !!!

Biotele says: Aug 30, 2007. 10:02 AM **REPLY**

You can do that. Some pocket PC don't have a mic input, so you need to hack out the mic and solder the decoupler instead. You need to make sure that the internal mic has a voltage on it, or else you need to supply a voltage to the CdS.

As for the program on pocket PC you can try Bioera

http://www.bioera.net/

Brandon121233 says: Aug 25, 2007. 2:27 PM **REPLY**

Try a program called scope

Biotele says: Aug 25, 2007. 2:39 PM **REPLY**

what I need, is a program like labview but limited to microphone input. That will be ideal.

therian says: Aug 26, 2007. 6:31 AM **REPLY**

can anyone please give resistor or voltage controlled oscillator circuit (not 555 or variable diode one)

therian says: Aug 26, 2007. 6:33 AM **REPLY**

something what can make radio frequency

therian says: Aug 26, 2007. 8:20 AM **REPLY**

like RC oscillator circuit (cant find any)

rc jedi says: Aug 21, 2007. 6:21 PM **REPLY**

i thought of it one time to solve some servo control mixer issues like used in r/c planes, but aren't cds a bit slow? not in human terms but in freq 50hz or faster? if true, could photo transistors in linear mode substitute? thay are faster.

your project has lots of applications, thanks for doing the work, we now have a circuit example to follow!

Biotele says: Aug 21, 2007. 7:02 PM **REPLY**

Excellent point. They do have a low pass response but it's on the first order scale . You can modulate voice frequencies with CdS cells. For robotics where the response time is in miliseconds, it is very well suited.
Yes, a phototransistor has a wider bandwidth but it's not a linear device and cannot be used as a pure resistance so you have to design your circuitry around it which makes it more complicated.

Proteus says: Aug 21, 2007. 3:22 PM **REPLY**

Nice, I like it!
Did you try using PWM in the LED?

Biotele says: Aug 21, 2007. 6:31 PM **REPLY**

You can use any type of modulation scheme with this device, linear or non-linear. That is why it's very versatile.

thadrien says: Aug 21, 2007. 7:57 AM **REPLY**

Very good proof of concept. And comes with some well-suited examples moreover.

Biotele says: Aug 21, 2007. 8:44 AM **REPLY**

Thank you, I have been making and using this type of voltage controlled resistors for years.