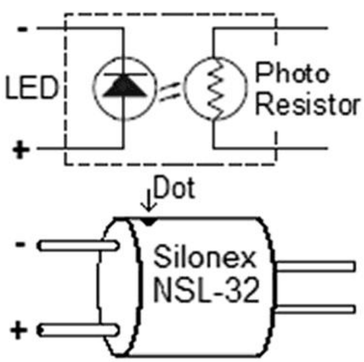
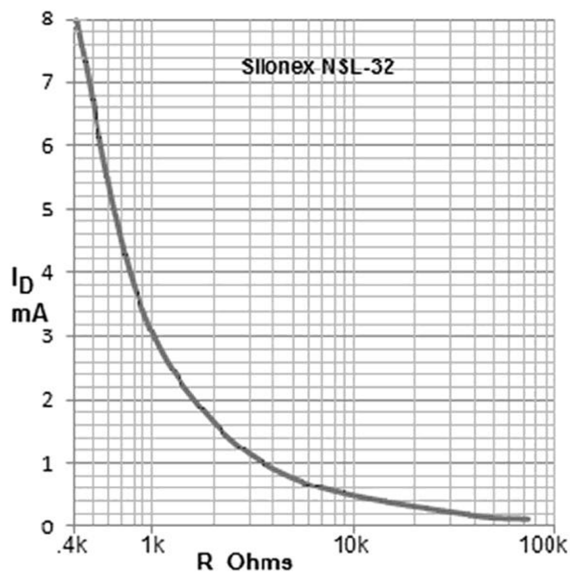
Chapter 8: Photo-Resistor-Coupler Applications

Most opto-couplers use an LED and a photo-transistor or photo-diode to transfer signals between electrically isolated circuits. Photo-resistor opto-couplers use an LED and a photo-resistor. The value of the photo-resistance can be varied by the LED current.

Opto-couplers can be used in an "on-off" mode as an isolated switch or remote controlled switch. In this mode they can also be used to transfer digital data. Photo-resistor opto-couplers are commonly used as variable resistors in audio and music applications in volume control, compressor, limiter, and tremolo circuits.



The diagram of the NSL-32 is shown above and its typical response is shown on the right.



One major limitation of the photo-resistor coupler is its slow response time, on the order of tens and hundreds of milliseconds. An improved version of the NSL-32, the NSL-32SR3 has a somewhat better response time, a higher off resistance and lower on resistance. Please refer to the appendix for more information.

From the graph above one sees that the resistance is highly non-linear and that greatest range of resistance change occurs at LED currents below 1mA. A voltage controlled current source is typically used to vary the LED current.

The Silonix NSL-32 series is now produced by *Advanced Photonix, Inc* and is available from *Digi-Key* and *Newark*.

Project 12: Photo-Resistor Opto-Coupler Simulation

Manufacturers often provide Spice models for their products but no models appear to be available for Photo-Resistor Opto-Couplers. The simple model presented in figure 8-1 is used in the next three projects to demonstrate the basic operation of the opto-coupler. The model, named ZX1, has characteristics similar to a *Silonix* NSL-32.

Current sources I1 and I2 are used to test the model and are not part of the model. H1 and H2 are current controlled voltage sources. H1 and VS between nodes 3 and 0 simulate a voltage controlled resistor. H2 senses the diode's current and outputs the control voltage for H1. Thus the diode current controls the resistance between nodes 3 and 0. Voltage sources V1 and VS are set to zero volts and used only to sense the currents through them.

Rise and fall times are approximated with R4, R2, C1, and current control switch, W1. W1 is controlled by the direction of the current in H2.

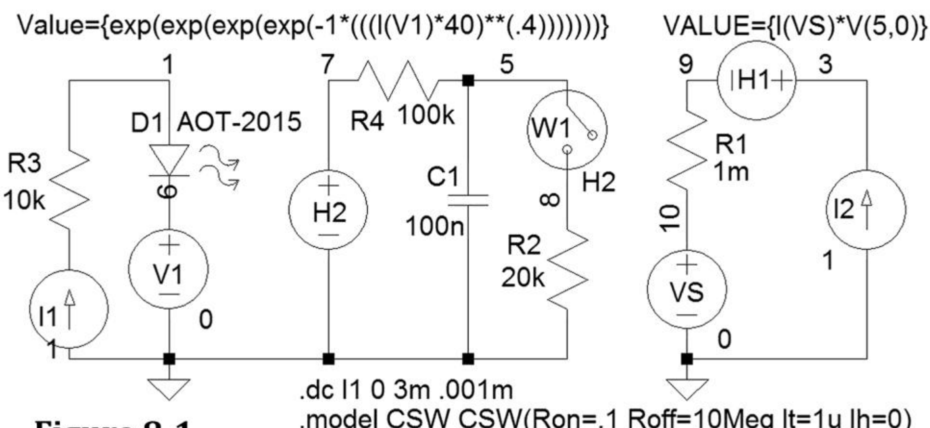
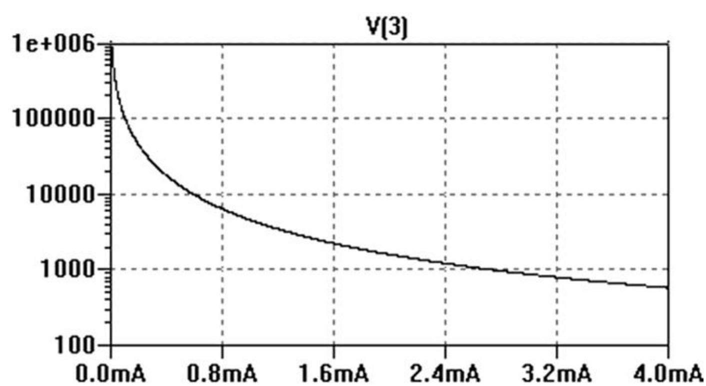


Figure 8-1

The result of the simulation of figure 8-1 is on the right. The vertical axis is the voltage drop across the simulated resistance by the 1 ampere current source so that the vertical axis represents resistances in ohms.



A ".subckt ZX1" file is developed next from this simulation.

Four exponentiations are used to obtain a non-linear response that is similar to the response of the NSL-32 photo-coupler. In the file below, the sources I1 and I2 are removed. Node 0 on the input side is relabeled node 2 and node 0 on the output side is relabeled node 4.

This file may be copied, saved as "ZX1.sub", and copied into *LTspice's* sub circuit directory (\LTC\LTspiceIV\lib\sub). A 4 pin symbol file, "ZX1.asy" needs to be copied into the "Optos" directory (\LTC\LTspiceIV\lib\sym).

```
********* + - R  R
.subckt ZX1  1 2 3 4
VS 10 4 0
R1 9 10 1m
R2 8 2 20k
H2 7 2 Value={exp(exp(exp(exp(-1*(((I(V1)*40)**(.4)))))))}
V1 6 2 0
D1 1 6 AOT-2015
H1 3 9 VALUE={I(VS)*V(5,0)}
R4 5 7 100k
C1 5 2 100n
W1 5 8 H2 CSW
.model D D
.lib C:\Program Files (x86)\LTC\LTspiceIV\lib\cmp\standard.dio
.model CSW CSW(Ron=.1 Roff=10Meg It=1u Ih=0)
.ends.model  D  D
.lib C:\Program Files (x86)\LTC\LTspiceIV\lib\cmp\standard.dio
.ends
*Note: the .lib paths may need to be changed for some pcs.
```

The table below compares three photo-coupler characteristics to the spice model derived here, which is designated as ZX1. It can be seen that the characteristics vary widely between devices. These characteristics can also vary by more than 50% for any particular device, especially for low currents.

Photo-Coupler Comparison				
Resistance	ZX1/ZX1A	NSL-32	NSL-32SR3	VTL5C2
Ω	µA	µA	µA	µA
1MEG	6	?	2	?
100K	105	100	6	200
10k	600	500	30	600
1k	2800	3000	200	3000
100	*	*	4000	*

Project 13: Voltage Divider

The circuit in figure 8-2 demonstrates an application of the resistor opto-coupler as a voltage divider (volume control).

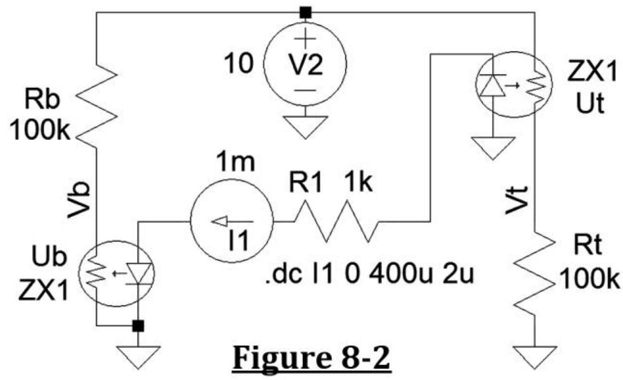
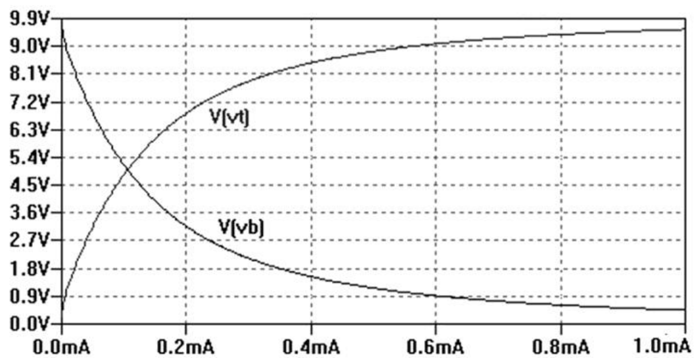


Figure 8-2

Both couplers are driven by the same current source. Their operation as the top resistor Ut, and the bottom resistor Ub, of the divider is compared.

The simulation result on the right shows the two curves intersecting at 5V, where the coupler resistor values are 100k ohms. This is the basic idea for a balance control or cross-fader.



The graph below shows a 200ms transient analysis response of the ZX1. A 90mS, 1mA, current pulse is applied to The ZX1 (.1mA to 1mA). The time it takes to go from 100k ohms at 0.1mA to 4.8k ohms at 1mA is about 6ms. The time it takes to go from 4.8k ohms at 1mA to 100k ohms at 0.1mA is about 180ms.