Silonex
The art of micro-engineering

Audio switching applications for resistive optocouplers

Electronically switching audio signals can be a complex. There the obvious problems of interfacing between your control logic which is running off a 5 V supply and something that is probably controlling a larger voltage swing. In addition, the various imperfections of the switch element need to be considered, as they can degrade your audio signal. Variations in ON resistance with signal voltage can cause distortion when the switch is on and non-linear parasitic capacitance. OFF resistance can do the same when it's off. There is the problem of the control signal coupling through into the audio path (charge injection) introducing switching clicks, most noticeable when the audio level is low, and also Fourier products caused by cutting into the waveform when the level is high (also apparent as clicks).

Audiohm optocouplers offer a unique set of features for controlling audio signal switching. The main features are:

1. Very high isolation between control port and audio circuit.
2. Simple drive circuit: straight from 3 or 5 V logic circuits.
3. Relatively low drive requirement (<60 mW)
4. Low switching spurii (clicks), both in terms of charge injection and Fourier products.
5. Good distortion performance.
6. Large signal voltage range: up to 500 V.

If we compare their performance with other methods:

Device	Signal voltge	Isolation voltage	Drive complexity	Drive Power	On resistance	Off resistance
Junction FET	15...60 V	10...55 V	high	a few mW	10...500	>100 M
MOSFET	20...1K V	+/- 20 V	high	a few mW	1...100	>100 M
Relay	>200 V	>500 V	low medium	>140 mW	<100 m	>100 M
CMOS switch (4000B)	<20 V	<20 V	V.low	µW	100...500	>100 M
Analogue switch (SSM2402)	+/- 20 V	+/- 20 V	V. Low	90 mW	50	N/A
Audiohm coupler	60...500 V	>1 KV	low	3...60 mW	10...500	1...>100 M

Device	Charge Injection	Fourier Clicks	On Distortion	Off Distortion	Cost
Junction FET	Medium…good*	Low	Medium*	Low	Low
MOSFET	Medium…poor	Good*	low medium*	medium	low
Relay	Good	Poor	V. low	V. low	High
CMOS switch (4000B)	Medium	Poor	Medium	Low	Low
Analogue switch (SSM2402)	Medium good	V. Good	Low	High	High
Audiohm coupler	V.Good	V.Good	V.Low	Low..medium	medium

*depends on drive circuit

Switch configurations

Resistive optocouplers can be used in series (**Figure 1**), shunt (**Figure 2**) or series/shunt (**Figure 3**) configurations. The multiway selector (**Figure 4**) is a variation of the series/shunt configuration and behaves similarly if the source resistances are low. In most normal solid state audio circuits the optimum source and load resistances are going to fall somewhere in between the **R**on and **R**off of the couplers. There is likely to be an asymmetry in the ON and OFF switching times of the series and shunt configurations.

Figure 1

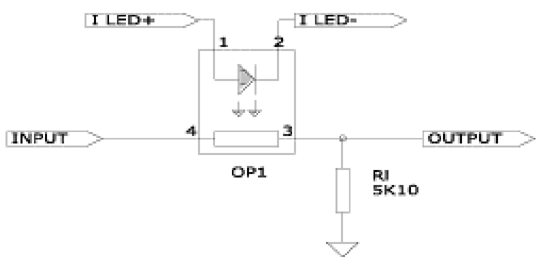


Figure 2

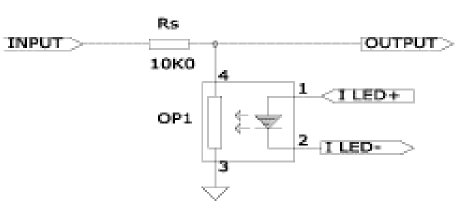


Figure 3

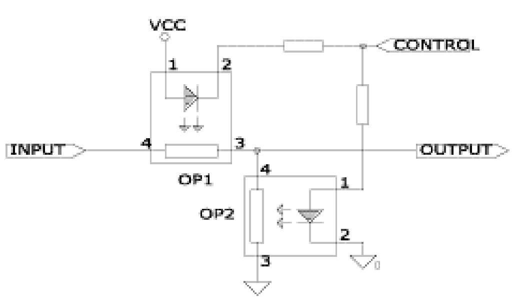
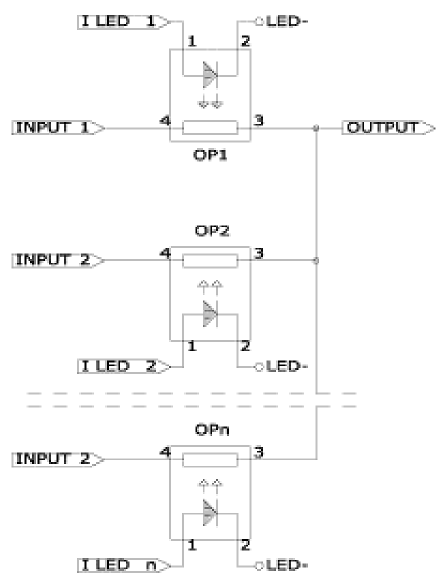


Figure 4

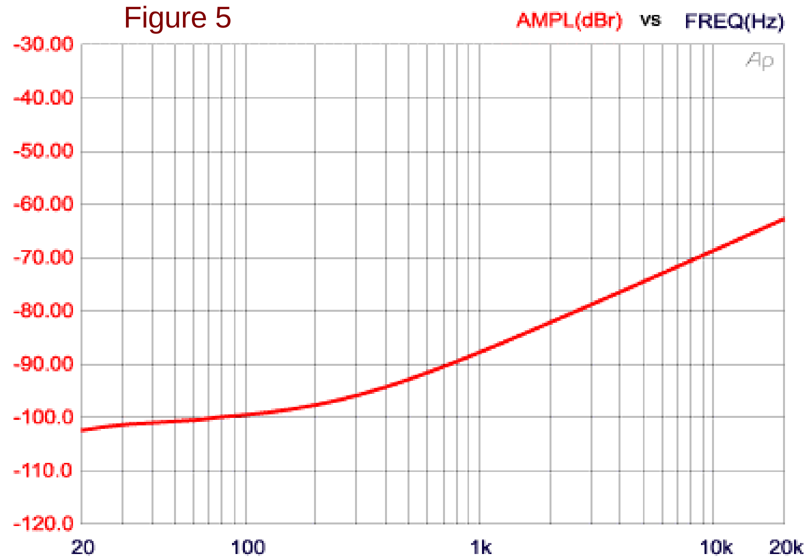


Series switch

To get the best **OFF** attenuation, a coupler with high **R**off, for example the **NSL-32SR3**, is required. Used in the circuit of **Figure 1** with R_L = 5 K10 and I_{LED} = 10 mA, the following results were obtained:

ON insertion loss: 0.25 dB
OFF attenuation: 88 dB@ 1 KHz, see **Figure 5.**
T_{ON}: <1 msec
T_{OFF}: 15 msec
ON distortion @ 1 KHz +14 dBu <0.0007%

Figure 5



At frequencies above a few hundred Hz, the OFF attenuation is determined mostly by the cell parasitic capacitance, and decreases with frequency. To minimize this effect, R_L should be kept as low as possible, commensurate with an acceptable insertion loss and distortion performance. T_{ON} will increase and T_{OFF} will decrease.

Shunt switch

In this configuration a coupler with low R_{ON} e.g. the **NSL-32SR2** gives the best OFF attenuation for a given LED current. With **Rs** = 10 KW and I_{LED} = 10 mA, the performance was:

ON insertion loss (High Z load): 0.1 dB
OFF attenuation: 52 dB 20....20KHz
T_{ON}: 200 msec
T_{OFF}: 2 msec
ON distortion @1 KHz +14 dBu <0.001%

In the shunt switch the cell capacitance is not significant until **Rs** >200 K. Large values of **Rs** give greater OFF attenuation at the expense of extended switch T_{ON}, which may be unacceptable. Under such circumstances a faster responding coupler, for example the **NSL-32SR3**, used at a higher current may give better results. The output needs to feed into a high impedance buffer amplifier to minimize insertion loss.

Series/shunt switch

This configuration achieves better OFF attenuation and symmetrical switching times, at the expense of an additional coupler. A practical implementation of a circuit is shown in **Figure 6**. The drive can be from any device that can swing within 0.25 V of the rails at 5 mA. The zener diodes in series with the LEDs ensure that only one of the couplers can be on at any one time. The **NSL-32SR3** is again the preferred coupler. Fast turn-off minimizes the time when both couplers are conducting, as a considerable load can be placed on the circuitry driving the audio input.

Figure 6

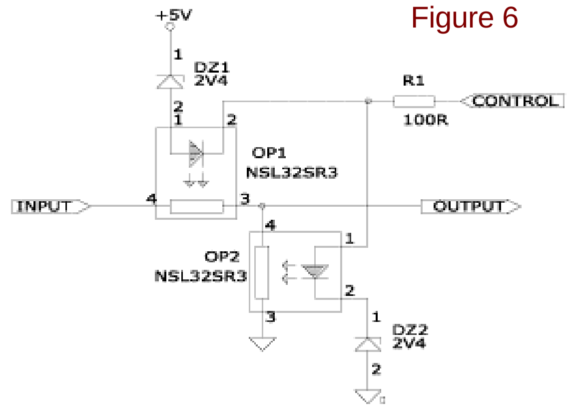
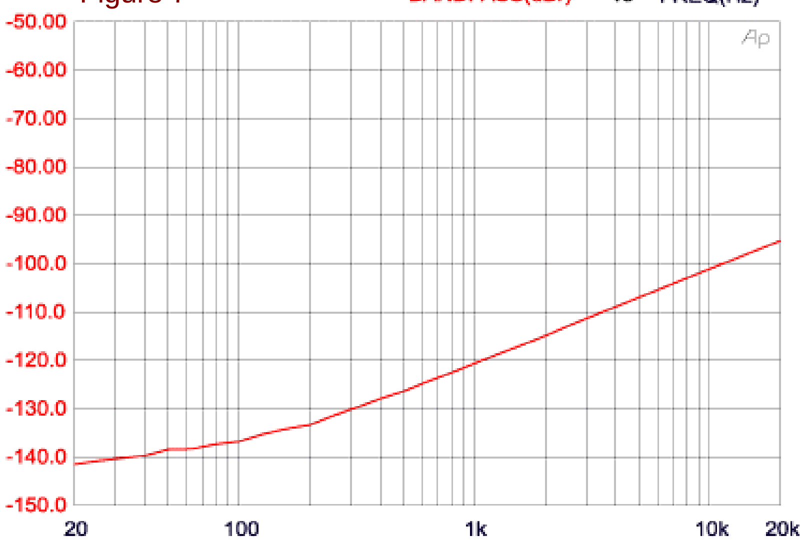


Figure 7



As shown the performance is:

ON insertion loss: 0.1 dB
OFF attenuation: >110 dB @ 1KHz, see **Figure 7**.
$T_{ON} = T_{OFF}$: 3 msec
ON distortion @ 1 KHz +14 dBu 0.0007%

If longer switching times are wanted for a subjectively smoother transition, then the circuit of **Figure 8** can be used. Here the coupler LEDs are driven by an integrator configured around 1/6 of a 74HCU04. The ON and OFF times of the switch are set by the product of Rt and Ct, and with the values shown are approximately 15 msec.

Figure 8