Solid State Loudspeaker Relay

Design and PCB Layout for a 40 A SSLR for use with amplifiers with supply rails up to a maximum of +-50 V or +-75 V and rated for up to 500 W RMS continuous. The completed relay measures 23 mm x 14 mm x 20 mm. This design uses SMD mount components and utilizes a double sided PCB.

Andrew C Russell

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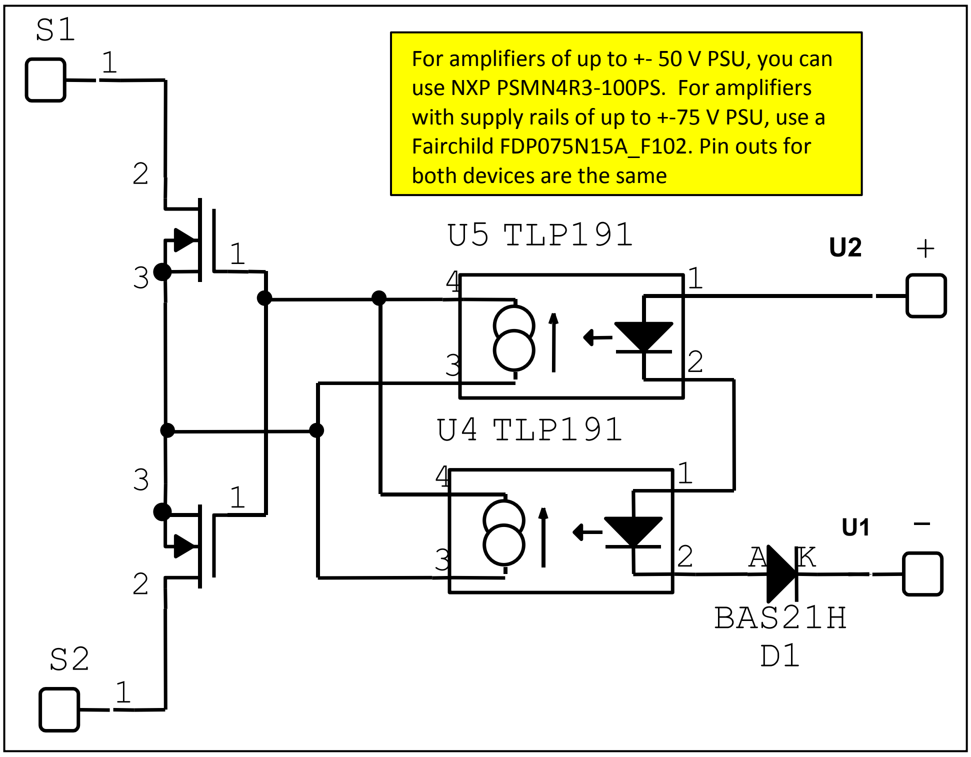

This design uses <u>two</u> photo-voltaic couplers in parallel to drive the mosfet gates, speeding up the switching time, and thus the dissipative energy handing capability of the SSLR during switching.

Figure 1 - Solid State Loudspeaker Relay

Here is a simple Solid State Loudspeaker Relay (SSLR) that can be used to replace electro-mechanical relays (EMR). SSLR's offer a number of key benefits over conventional relays:-

- **<u>No</u>** wear out mechanism when operated within specified ratings
- Can handle large fault level currents repetitively (40 Amps/500 mJ for this design)
- Cost effective – though not quite as cheap as an EMR (the design here can be build for $8-00)
- Very compact – the board layout presented here is 23 mm by 14 mm wide and 18 mm high – considerably smaller than a standard 16 A EMR like a Tyco RT series footprint for example

Specifications

Activation current	**20 mA**
Engage time	**<150 us for 20 mA drive current**
Disengage time	**<250 us**
Supply Voltage min	**5V (see application section below)**
End to End Drain Break down Voltage U6-U3	**150 V using Fairchild FDP075N15A_F102; 100V using NXP PSMN4R3-100PS**
Maximum repetitive load switching capability	**40 A;**
Maximum Inductive energy handling capability	**500 mJ maximum**
Max SSLR Power Dissipation on ON mode	**1.5 Watt for mosfet Tcase = 100 °C**
Max continuous audio handling capability	**500 W RMS for mosfet Tcase = 100 °C**
Dimensions	**14 mm Wide x 23 mm Long x 20 mm High**
ON Resistance (Activation current = 20 mA)	**<15 mΩ with FDP075N15A_F102 <10 mΩ with PSMN4R3-100PS**
OFF Isolation (40 V pk-pk into 8 Ω Load, 20 kHz)	**Typically -80 dB; 65 dB minimum**

Application

Refer to Fig. 1. To use the SSLR, connect U2 to your +ve supply voltage, and U1 via a current limiting resistor to the activation switch which will typically be a bipolar transistor or a mosfet being driven from a delay and/or protection circuit.

The current limiting resistor is essential in order to prevent damage to the SSLR, and can be calculated from

R_{limit} = [Vs- 3]/0.02   where Vs is the supply voltage to the SSLR

So, by way of an example, if your supply voltage is 12V, then R_{limit} = [12- 3]/0.02 = 450 Ω – use 470 Ω which is a standard E12 value.

You can calculate the required resistor wattage from $R_{wattage}=I^2R$ so for the above example, we get $R_{wattage} = ((12-3)/470)^2*470$ which gives 0.172 W, so use the next highest standard rating which is 0.25 W.

Table 2 gives the resistor and wattage values for some popular voltages for your convenience.

Vs	R	E12 Value	Resistor Power Rating	Use This Wattage Minimum
5	100	100	0.04	0.125
9	300	270	0.13	0.25
10	350	330	0.15	0.25
12	450	470	0.17	0.25
15	600	560	0.26	0.5
18	750	820	0.27	0.5
24	1050	1000	0.44	1
30	1350	1200	0.61	1
36	1650	1500	0.73	1
48	2250	2200	0.92	1.5
55	2600	2700	1.00	1.5
60	2850	2700	1.20	2
65	3100	3300	1.16	2
70	3350	3300	1.36	2
75	3600	3900	1.33	2
80	3850	3900	1.52	2
85	4100	3900	1.72	2

Figure 2 - Series Current Limiting Resistor Values

Construction

- Firstly, use 70u thick copper PCB material – although the tracks carrying heavy current are short and thick, you still need to minimize the series resistance.
- Start by assembling the SMD components on the bottom side of the PCB (U4 and U5 Toshiba TLP191 photo diode couplers) and then D1 (BAS21H diode) on the top side. Note carefully the orientation of the TLP191 devices – the elongated solder pad is pin 1 of the device.
- Next, solder the Mosfets in place. The yellow rectangle on the solder mask shows the orientation of the heatsink which is towards the + and - supply pins.
- Finally, solder the pins in place. The + and – connections use 0.9 mm diameter pins and S1 and S2 use 1.5 mm diameter pins. The pins should be about 10 mm long. The best approach here is to drill all holes to 1 mm diameter, and then drill S1 and S2 to 1.5 mm.

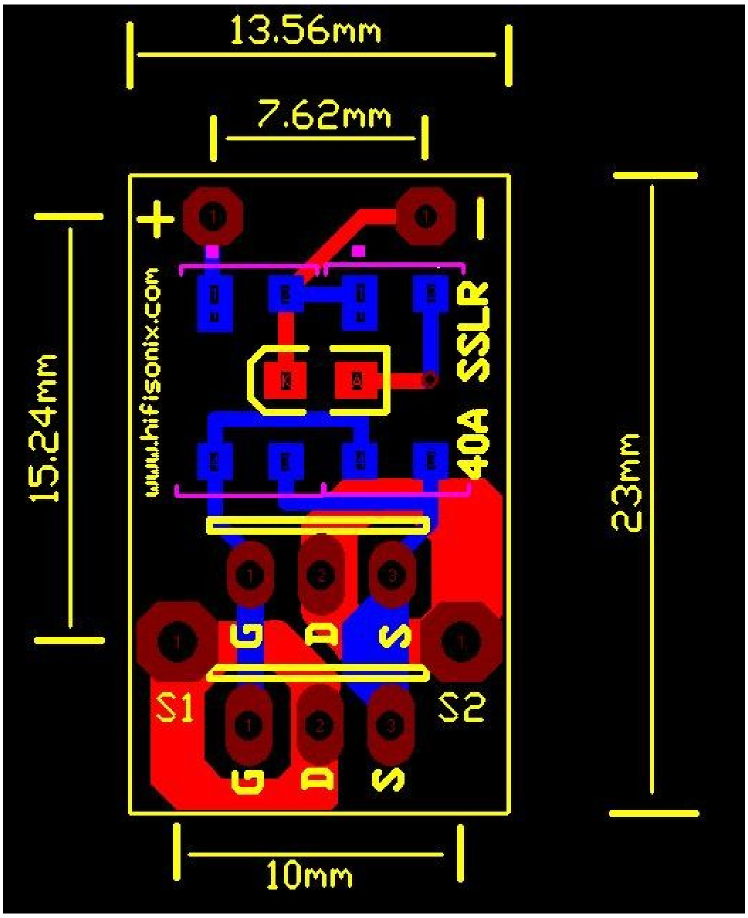

Figure 3 - PCB Layout and Pinning with Dimensions

When mounting the SSLR onto your main PCB assembly, push the SSLR down flat so it rests on the TLP191 devices – i.e. they act as spacers.

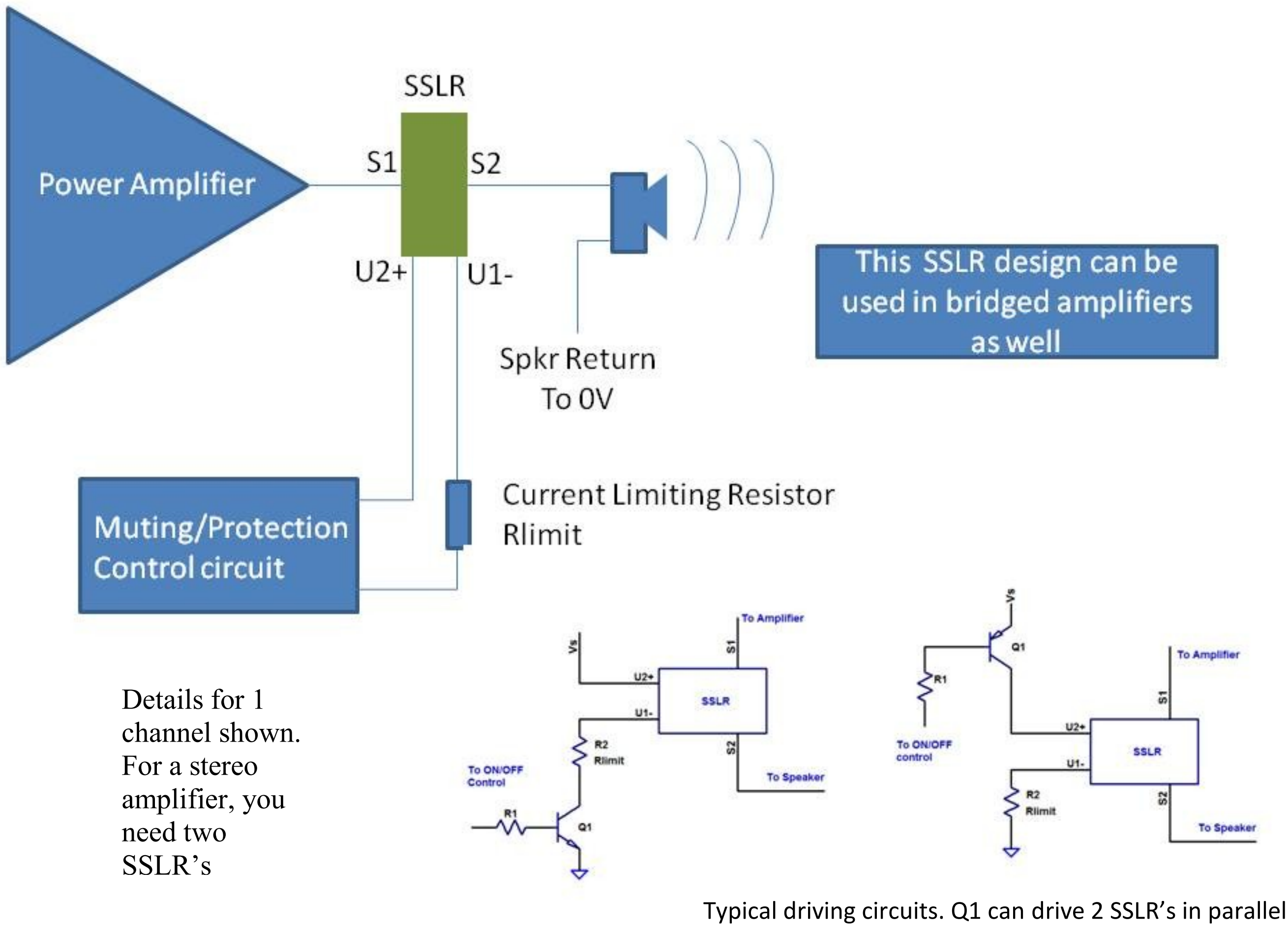

Figure 4 - How to Connect the SSLR

You can download the PCB Gerbers here:- [Solid State Loud Speaker Relay PCB Layout] and the data sheets for the [PSMN4R3-100PS] and [FDP075N15A_F102]

As a general comment on the mosfets, you can use basically any device that meets the following criteria:-

- Same pin out (usually not a problem for TO-220 packaged devices)
- Rds(on) of 10 mΩ or less per device
- You *must not* use mosfets with a lower Vds breakdown than your absolute maximum rail to rail supply voltage – they will fail
- Total gate charge of <200 nC, the lower the better

Mosfets with low Rds(on) in TO-220 above 150 Vds rating are not readily available, so above this voltage, you will probably need to use TO-247 or T0-264 which means they will not be compatible with the PCB layout presented here

For more information on SSLR's, you can also refer to this [document], which discusses a speaker *ground return* line switching technique.

Solid State Loudspeaker Relay Document History

December 2012	Initial Release
January 2013	Added NXP Mosfet option, corrected grammatical errors, clarified text, drawings