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Notes about mosfets for Speaker Solid State Relays

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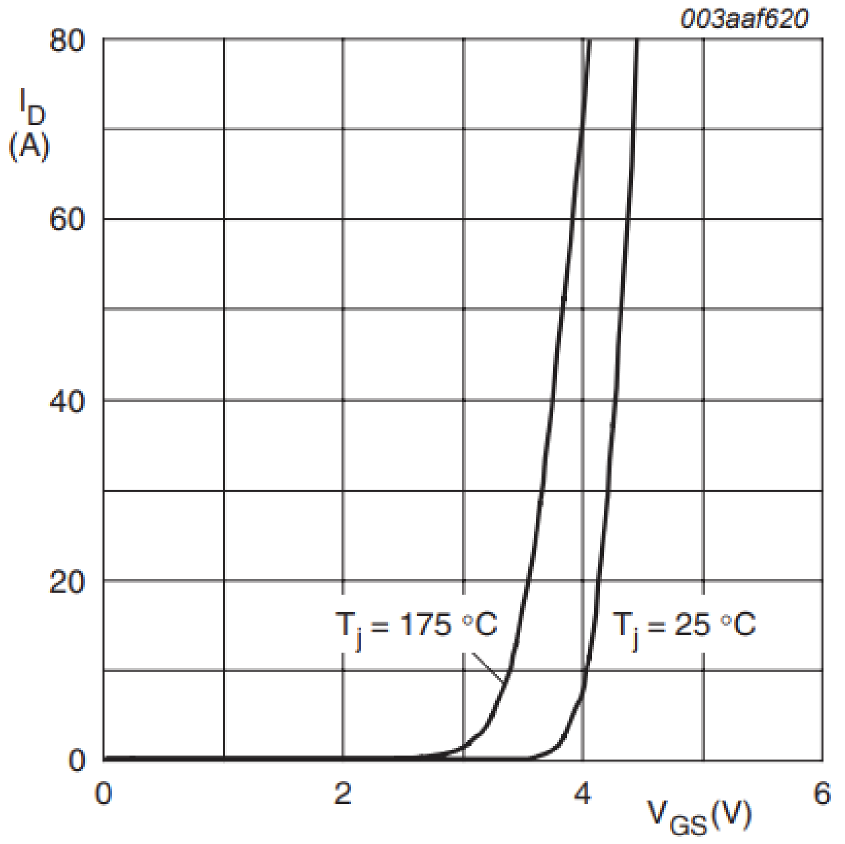
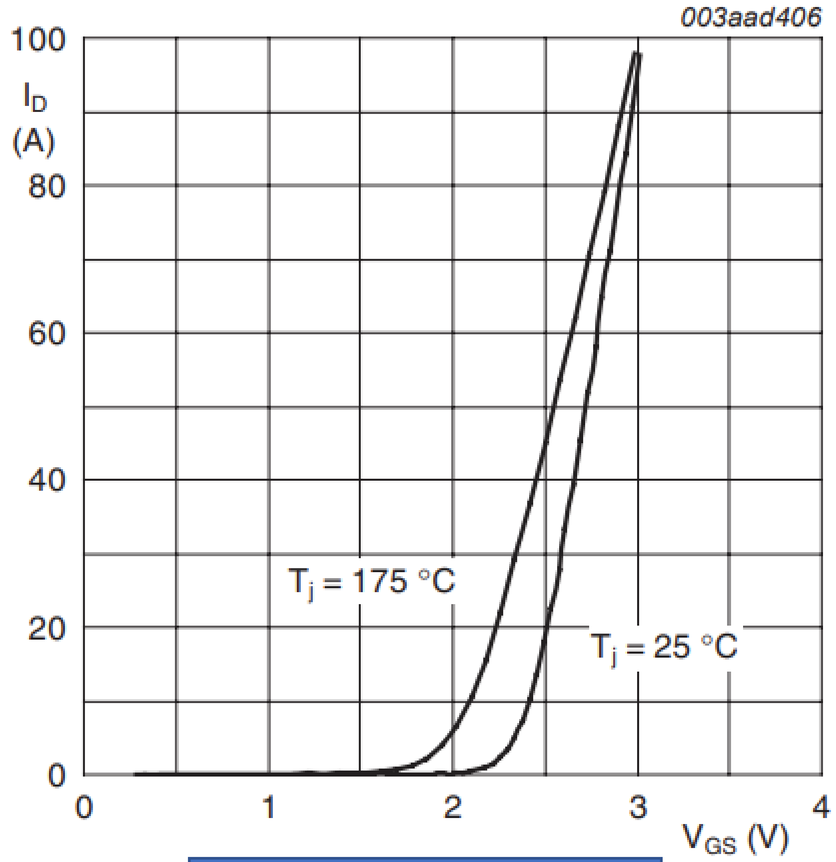
Notes about using mosfets for loudspeaker solid state relays (1)

- Power mosfets come in 3 gate voltage thresholds: Logic, Intermediate (from some manufacturers) and standard level. Logic level devices are fully ON and meet stated Rds(on) specs with c. 2.5-3 volts applied to the gate wrt the source, and Standard level devices with 4.5-5 Volts (figures for 25 C – at higher temperatures, the gate threshold voltage drops – see the next slide)
- Logic level is preferable in all cases, but at higher drain-source voltage ratings, logic level devices are not readily available because the device gate oxide thickness (an important determinant of gate threshold voltage) has to be thicker to withstand the higher drain voltage, hence standard level devices only are available.
- Therefore, for amplifier voltages above 60V where logic level devices become scarce, you must use a standard level device but it must be low Rds(on) – say <5 milli-Ohms.
- This will ensure that with the 5-8 V supplied by the VOM127 or TLP191 gate drivers, the Rds(on) of the individual mosfets will be below 10 milli-Ohms, which is still 20% to 50% lower than a good high powered relay when new. Electro-mechanical relay contact resistance degrades over time, and especially so when switching a load. This is not the case with mosfet SSR.
- The peak drain current should be rated for the *worst case expected short circuit current*. For most amplifiers incorporating short circuit protection, this will be with a in the region of 2 Ohms
- Never use a mosfet beyond its absolute maximum ratings – if for example the amplifier supply voltage is likely to occasionally be as high as 65V, use the next available voltage group which will be 75V

Typical Gate Threshold Voltages for Power Trench mosfets



Standard Level – 80V Vds rated device



Logic Level – 30V Vds rated device

Notes about using mosfets for loudspeaker solid state relays (*cont.*)

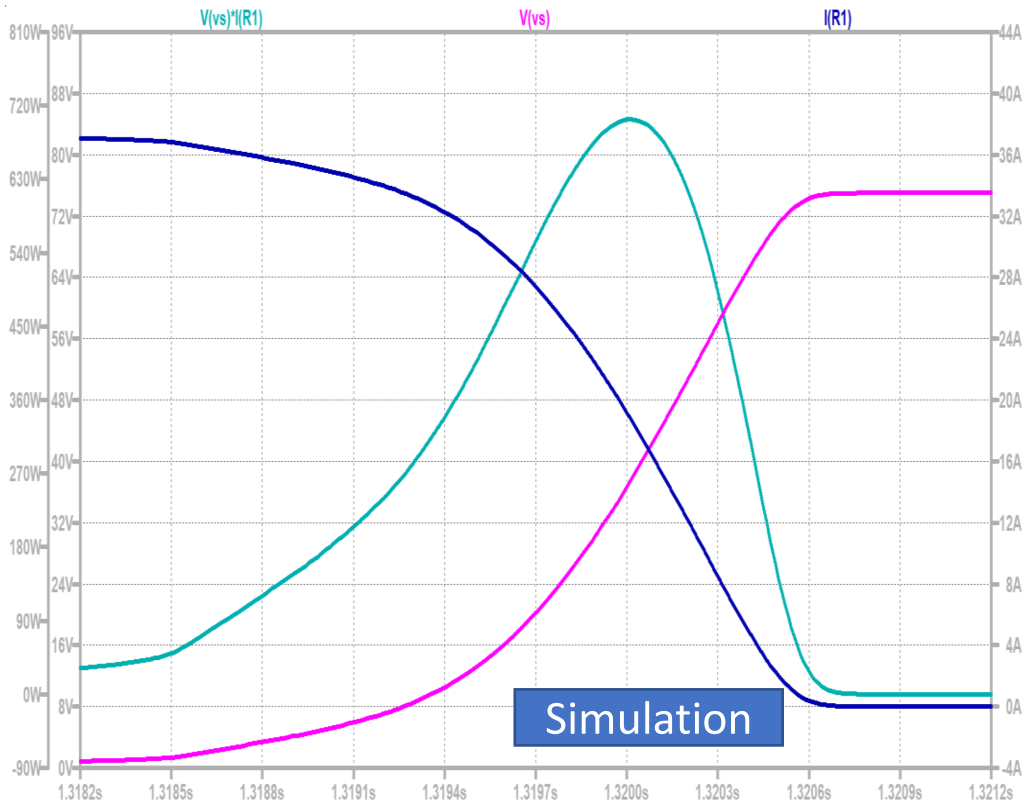
- For the most part, the SSR mosfets will deal with single switching events at medium to low powers
- Under *worst case fault conditions*, as for example when an amplifier output device fail short to either of the supply rails, the SSR may be called upon to momentarily conduct and then switch currents of 10~15A on a large amplifier
- In the case of an amplifier output short to ground, this figure can be 5~10x higher if the amplifier does not incorporate current limiting. Since most amplifiers incorporate some sort of current limiting and fusing, these kinds of current levels are unusual in practice.
- Mosfet based SSR's can be used in amplifiers that do not incorporate current limiting, but special techniques must then be used to speed-up the switching time to < 100us. The 2~5ms using standard photovoltaic drivers is usually not quick enough to protect the amplifier output devices. You can see an amplifier that uses this technique here

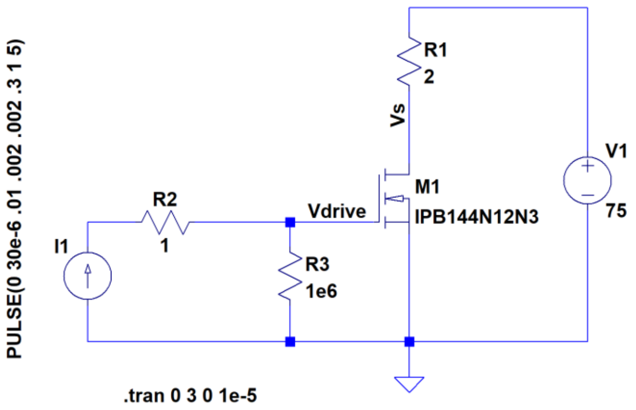
The simulation on the right shows the peak currents likely to be encountered momentarily in a scenario where the amplifier output at the speaker terminals is shorted out – generally a worst case situation.

The rise/fall time of the driving source was set to 2ms to simulate the worst case mosfet gate drive using a standard photovoltaic driver like a VOM127 or TLP191.

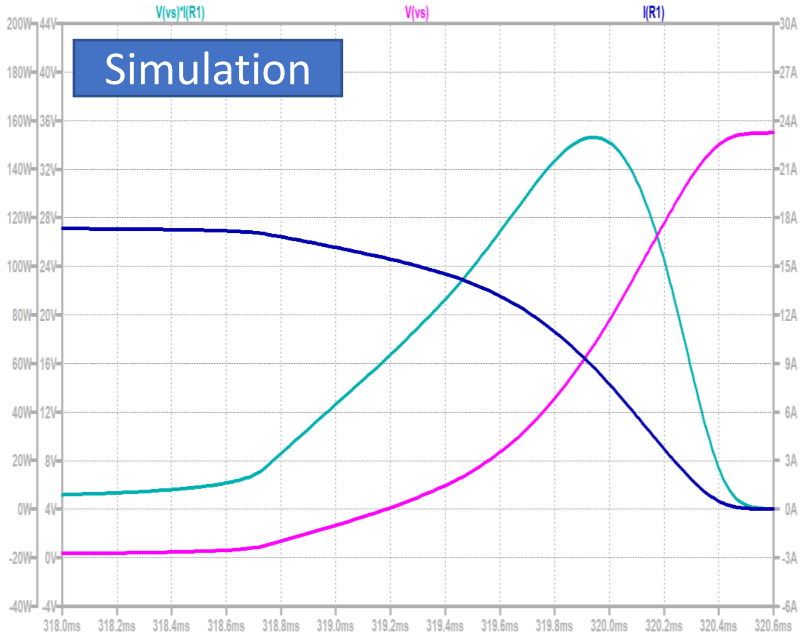
In this example, an amplifier powered off ±75V rails and assuming no rail droop (*highly unlikely in practice under this type of fault condition*) peak currents in the region of 75A can be expected, leading to peak one shot mosfet dissipation of 720 Watts.

Note that high power is dissipated only during the switching event. When fully ON, little power is dissipated because the mosfet Rds(on) is only a few milli-Ohms. For a single shot event, the average power computed over 1 second is therefore very low and in this example only about 2.5W assuming a single switch off event.

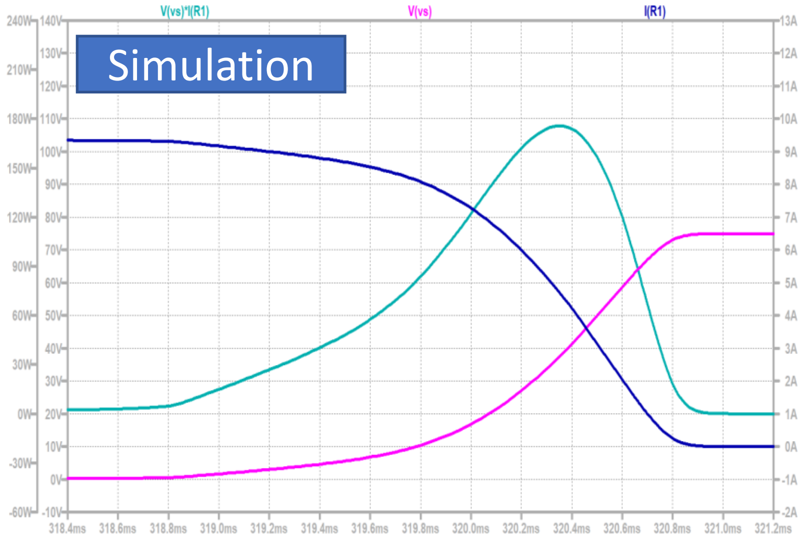




In this example, the supply rail is 35V, and the switched speaker load 2 Ohms. The peak switching power encountered by the mosfet in the region of 160W (the same low Rds(on) mosfet was used for this simulation).

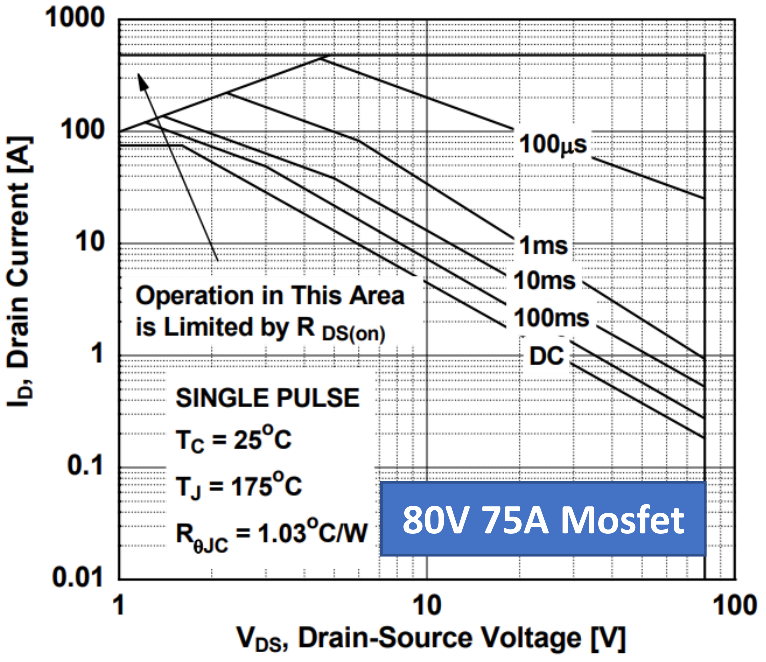


In this example, the supply rail is 75V and the speaker load 8 Ohms. The peak switching power encountered by the mosfet in the region of 180W. The average single shot power computed over 1 second is < 0.25W (the same low Rds(on) mosfet was used for this simulation).

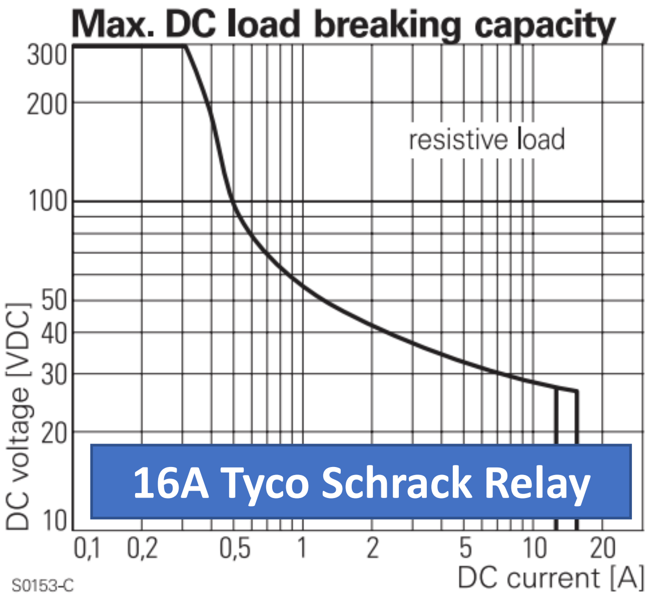


The graph on the right is typical of a power mosfet designed for high power switching applications, in this case an 80V device rated at 75 Amps with an Rds(on) of 5.3milli Ohms. These types of 'switching' mosfets have poor SOA when operated in the linear or DC mode.

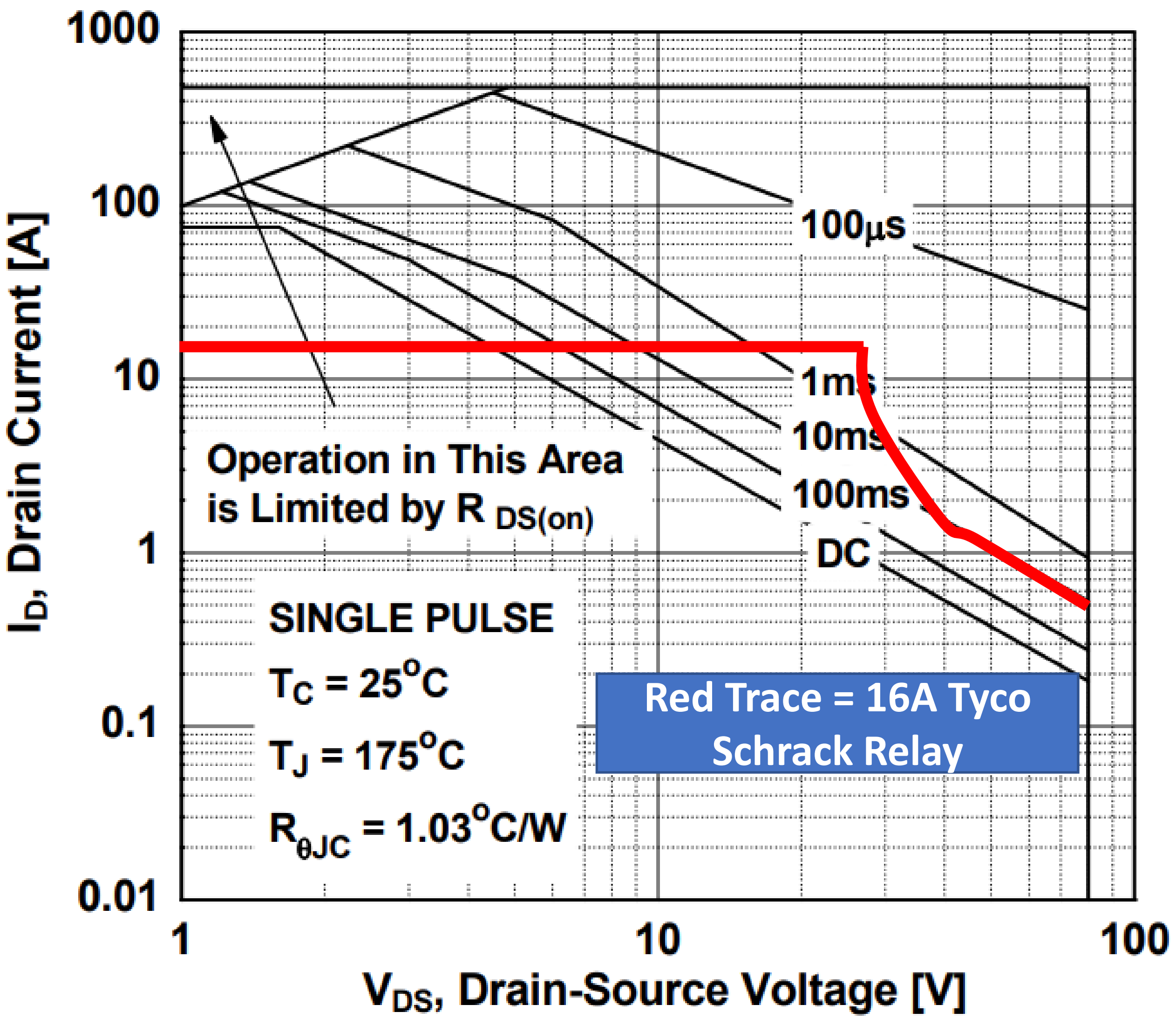
To reduce power dissipation and remain within the SOA, the devices must switch quickly, or the peak current flowing through them must be limited to safe levels.



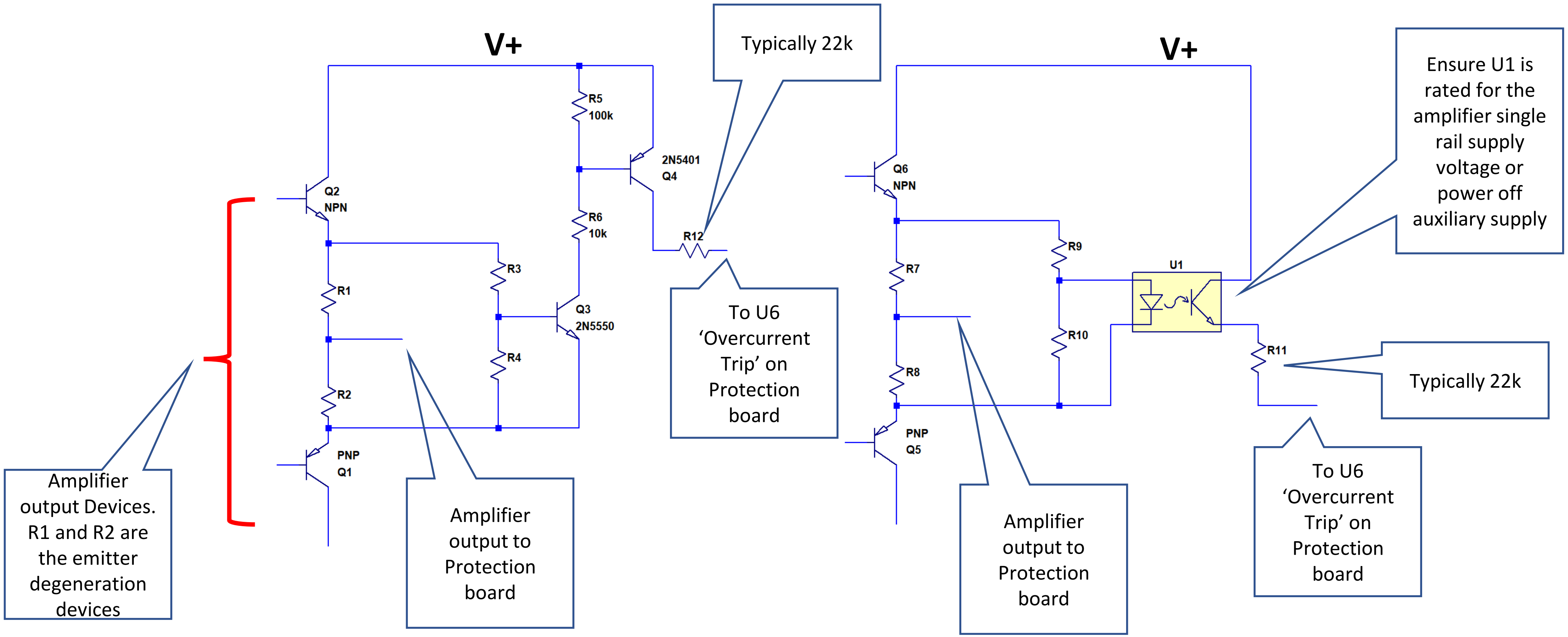
The graph on the right is for a good quality Tyco Schrack 16A industrial grade relay. The relay SOA is better than the mosfet used above, but there is a *hard stop at 16A*. Currents above this figure will damage the contacts, leading to a drop in current handling capability and early failure during some future switching event. The mosfets in contrast will easily switch 100A provided it is done quickly to minimize the peak power dissipation during the switching event. Further, the mosfet switches do not wear out.



This graph overlays the 16A relay SOA on an 80V 75A rated mosfet. At currents up to 16A, the relay SOA is better than the mosfet.



Using the Current Overload Detection Input (terminal U6) – Some Ideas



R3 and R4 selected to ensure Q3 turns on at the desired current trip threshold

R9 and R10 selected to ensure U1 turns on at the desired current trip threshold