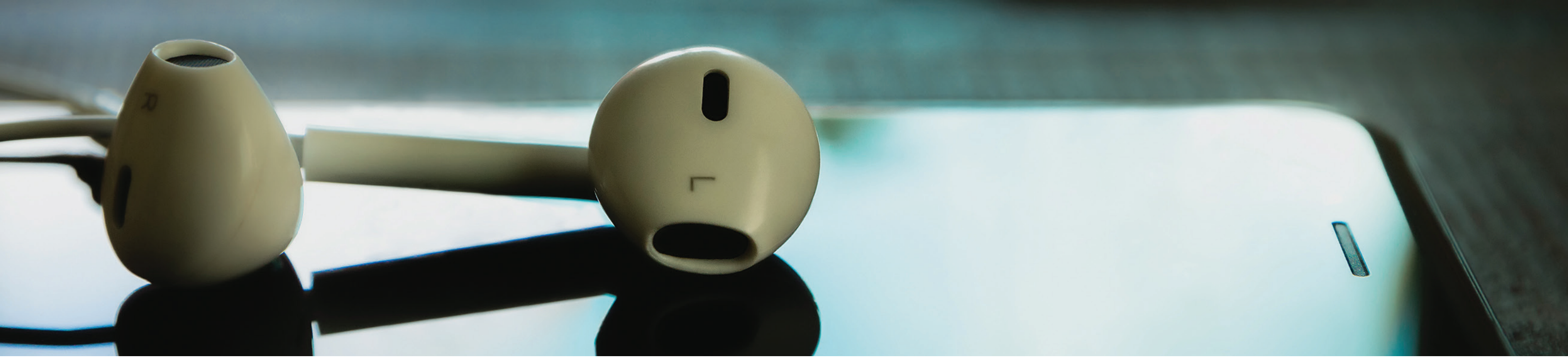
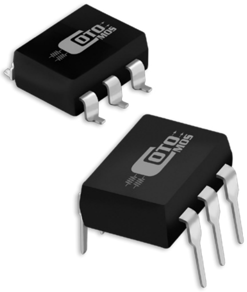


DUAL-RAIL BATTERY SWITCHING USING COTOMOS® RELAYS IN

PORTABLE HEADPHONE AMPLIFIERS AND PORTABLE POWERED SPEAKERS



Most modern high performance audio amplifier circuits run on "dual rail" power supplies, often +/-15Vdc, with circuit ground defined as the center point between the positive and negative power supply. A dual-rail amplifier has a high power supply rejection ratio (PSRR) that a single rail (single battery) amplifier lacks and doesn't require input/output DC blocking capacitors.

One choice to produce a dual-rail power supply for portable equipment is a DC-DC switching converter. However, converters are expensive, large, dissipate heat, and can leak switching frequency noise. In the case of portable headphone amplifiers, which are amplifiers designed to sit between a portable audio source and headphones, another popular method is a "virtual ground" or VG. A VG uses an amplifier chip to create a mid-voltage point between a single power rail and ground. VGs were popularized by small single op-amp "CMOY" headphone amplifiers[1]. Unfortunately this method has been shown to introduce significant harmonic distortion, crosstalk, inter-modulation distortion (IMD), and noise[2].

The remaining method discussed here is simply to use two batteries, one for each power supply rail. The common midpoint of the batteries is ground – often referred to as a "real" ground to distinguish from the virtual ground concept. Two batteries work extremely well as a dual-rail power source except for one problem. What happens if one battery suddenly goes away, leaving one power rail "up" and the other down? A battery can disappear from the circuit surprisingly easily: loose 9V battery contacts or a broken connection wire; internal protection chip low battery cut-off in the case of lithium "9V" rechargeable cells; even internal shorts in NiMH or lithium rechargeable cells can be the cause. The result is a large amount of DC voltage at the headphone amplifier output, which otherwise has nearly zero DC. DC voltage applied to headphones causes a "pop" and can result in actual headphone driver damage.

The circuit presented in Figure 1 using the Coto Technology CT128 (or CS128) CotoMOS® relays solves the dual-rail battery problem. The optical MOSFETs in each CT128 are wired between a battery and each power rail supplying the amplifier. A key circuit feature here is series wiring the control LEDs in each SSR, which ensures that both power rails go "up" or "down" at exactly the same time. A single SPST switch contact is sufficient to make or break the circuit.

The large 4.5 amp rated current of the CotoMOS® CT128 relay means that it is capable of driving larger loads than just headphone amplifiers. Powered portable speakers are a perfect application.

To protect against a disconnected battery, a comparator is added with the open collector output used to return the CotoMOS® series LED string to the negative incoming supply. A resistive divider samples the total rail-to-rail voltage and compares the result to the comparator's internal 400mV reference. The divider values in this case are set to produce 400mV when both batteries are at their minimum 7Vdc level for NiMH technology, or a total of 14Vdc rail to rail.

If the two batteries are above 14Vdc the divided voltage will be greater than 400mV, the comparator output will pull down and the CotoMOS® LED string will be on, turning on both relays simultaneously. Power goes out to the amplifier circuit. If the total incoming voltage drops below 14Vdc the comparator output will go high impedance, cutting off both CotoMOS® relays simultaneously.

The dual battery CotoMOS® circuit presented here using the CotoMOS® CT128 can be considered a second generation technology circuit. For a similar first generation circuit see the "O2 Headphone Amplifier" by NwAvGuy in the references[3]. This extremely popular dual-battery, do-it yourself (DIY) headphone amplifier uses a battery protection circuit with a discrete MOSFET on each power rail. Since one was N-channel and the other P they had to be fed from two different comparators in series to invert one gate signal. One comparator pulled down (fast) while the other pulled up (slower). The net result of the circuit is still one power rail up for a small period of time while the other is going down, rather than an exact simultaneous switch.

In the SSR-based circuit presented here, both SSRs switch simultaneously from one comparator output. Both SSRs will be "turning on" or "turning off" together, with matching timing specifications. The CotoMOS® CT128/CS128 is exceptionally well-suited to this application due to an exceptionally low "on" resistance of just 0.0125 ohms when DC-wired and a maximum required LED "on" current of just 3mA. Many other solid state relays have "on" resistances in the 10 – 100 ohm range (much too big for switching batteries) and have less battery-friendly LED "on" currents of 10mA or more. The large 4.5 amp rated current of the CotoMOS® CT128 relay means that it is capable of driving larger loads than just headphone amplifiers. Powered portable speakers are a perfect application.

Another concern with high performance audio amplifiers is production of harmonics by any element in the circuit. A distortion analyzer has been used to verify that the COTO CT128 does not generate any additional harmonic distortion in this power switching application.

1. https://en.wikipedia.org/wiki/CMoy
2. http://nwavguy.blogspot.com/2011/05/virtual-grounds-3-channel-amps.html
3. http://nwavguy.blogspot.com/2011/08/o2-details.html

To learn more about Coto Technology's CotoMOS solid state relay offerings (including the CT128 / CS128 relay) and how our applications support team can help you with your latest design, please contact us at Cotomos@cotorelay.com or visit our website at www.cotorelay.com

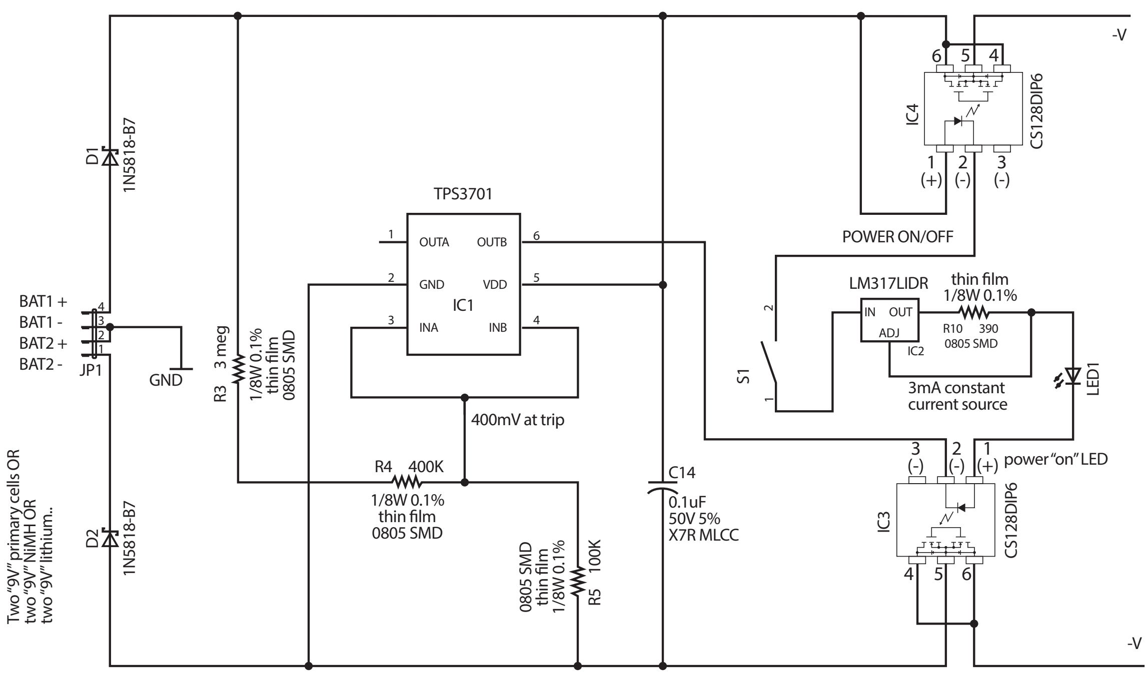


Figure 1: A circuit using the CotoMOS CT128 solves the dual-rail battery problem.