Upgrade PC Board for NwAvGuy's O2 Headphone Amplifier

V2.0, agdr, 2013, with design input from Sergey888 on diyaudio.com

Description

This DIY PC board slides into the top slot of NwAvGuy's O2 headphone amplifier in the standard B2-080 extruded aluminum enclosure. The board plugs into the O2's U3 and U4 IC sockets in place of the two NJM4556A output chips.

What the upgrade board does:

- **99.3% Lower Output DC Offset Voltage To The Headphones.** The original O2 has a DC offset voltage of about 3mV on each output channel going to the headphones. Half of that is inherent DC offset in the NJM4556A output chips. The other half is an input offset voltage to the NJM4556A chips caused by the input bias current of the chip going through the O2's 40.2K ground return resistors. The new OPA2140 chip solves this problem in two ways, resulting in an ultra-low DC offset of around just 20uV! The original 3mV offset of the O2 is 3000uV, so that is a 93% reduction. The OPA2140 is a DC precision op amp, meaning it has very high input DC offset precision of no more than 120uV. Then the chip is also FET input, as opposed to the current-hungry bipolar inputs on the NJM4556A chip, resulting in nearly zero voltage drop across the O2's 40.2K resistors. The net result is the vanishingly small 20uV DC offset. This low offset becomes especially important on high sensitivity headphones and IEMs where just 60mV of swing can be full volume.
- **Even Lower Distortion**. Replaces the standard NJM4556A paralleled output chips in the O2 with an OPA2140 FET-input op amp looped around a LME49600 power audio output buffer on each channel. The OPA2140 + LME49600 combination has much lower distortion figures in their datasheets, by more than 10 times, that the NJM4556A chips. NwAvGuy noted in his O2 design website write-up that the distortion levels of the NJM4556A chips are the limiting factor in the O2 headamp and swamps the lower distortion of the gain stage NJM2068 chip. In fact, he mentioned there way no point in replacing the gain stage chip with a lower distortion chip since the output stage would bury it. The new lower distortion output combination can allow the low gain stage distortion levels to make it through to the headphones. Lower distortion input chips (that the O2's original NJM4556A) can now be successfully used, such as the LME49720 or two LME48990 on a dip adaptor.
- **Higher Current Output For Low Impedance Headphones**. Each half of each of the O2's NJM4556A chip can sink or source 70mA of current. In parallel, as is the case with the O2 amp, that roughly doubles to 140mA. The new LME49600 low distortion audio buffer chip can sink or source up to 250mA of current, 100mA more than the original O2 chips. The extra current capability can help with low impedance headhpones.

- **Capable of Higher Voltage For High Impedance Headphones**. Although the original NJM2068 and NJM4556A chips in NwAvGuy's O2 headamp are specified for a higher +/-15Vdc power rails than the O2's +/-12VVdc rails, he noted that the resulting power dissipation would be too much for the NJM4556A chips in their small DIP8 packages. The LME49600 chip is in a larger TO263 package soldered to a large area of heatsink foil on the upgrade board. So with the new board the O2 amplifier could be run at +/-15Vdc by replacing the two voltage regulators and one capacitor. The higher voltage is useful for higher impedance headphones where the O2's original +/-12Vdc just doesn't provide enough volume.
- **Optional After-MOSFET Dual Power Rail LEDs**. NwAvGuy's O2 amplfier has one single LED across the power supply rails before the MOSFETs that are controlled by the power management circuit. Although the O2's LED tells when the power switch is on or off, it does not let the user know if the MOSFETs have turned on and if both power rails are working. The upgrade board includes two optional LEDS, one on each power rail, after the O2's MOSFETs which tell when the power management circuit is on or off and if both rails are working. Two small holes are drilled in the O2 front panel to let the LED light be visible. If the LEDs are not wanted they are simply jumpered using zero ohm 1206 resistors. The two new LEDs are in series with the new optional anti-thump resistors, below, so there is no additional current draw.
- **Anti-Thump Turn-Off Resistors.** NwAvGuy only had IC chips as the load after the O2's MOSFETS. Since the ICs are only specified down to a certain minimum voltage level, it becomes possible for one power rail to drain faster than the other on their way to zero volts when the MOSFETs turn off, possibly leading to a turn-off thump in the headphones. The upgrade board includes two optional resistors that allow a small amount of current to flow and allow the power rails to linearly discharge all the way to zero. The new power rail LEDs are in series with these two new resistors to make good use of that small current flow.
- **Power Management Latch Circuit.** In NwAvGuy's original O2 power management circuit it is possible for the batteries to recharge slightly all by themselves once the O2's MOSFETs cut off, causing the PM circuit to turn on again. The result is a motorboating or oscillation sound in the headphones when the batteries are low and the PM circuit tries to cut off. The upgrade board includes an optional latch circuit that wires into the O2's power management circuit. The latch circuit causes the O2's MOSFET's to "latch" off, preventing oscillation, when the do turn off. Turing the O2 off for 30 seconds resets the latch circuit, although it will re-latch again if the batteries are still low and in need of charging.
- **¼" Output Jack For Use With The B3-080 Case.** If the board is used in the taller B3-080 case, a Neutrik ¼" jack can be mounted underneath the board, sitting above the O2's 1/8" jack. The pads for the ¼" jack are hooked directly into the new board's output, so no further wiring is required. It just works!

Board Build Instructions

Installing The Board

To install the O2 upgrade board, perform the following steps.

1. Remove the O2's batteries and unplug the power adapter.
2. Carefully remove U3 and U4, the two NJM4556A chips in the middle next to the batteries.
3. Plug the pins sticking out of the bottom of the upgrade board into the U3 and U4 sockets. All 8 socket positions of U3 are used, but only the top 6 socket positions of U4 are used. The bottom 2 socket holes of U4 are not used.
4. Connect the ground wire. Either a wire from the GND hole on the upgrade board near the batteries to one of the two center battery terminals, or a wire from the upgrade board GND hole near P2 to either of the upper two holes in the O2's P2 socket near the output jack.
5. If the optional LEDs on the upgrade board were installed, drill the two holes in the front panel to let the LED light out. The dimensions are given in the build instructions section.
6. If the optional power management latch circuit is installed, run the two wires to the points on the O2 board shown below and solder.
7. Reinstall the O2's batteries, if they are being used.
8. Slide both the O2 and the upgrade board into the O2's case. The O2 goes in the usual bottom slot while the upgrade board goes in the top slot. If the parts on the upgrade board hit the top of the case, just pull it to bend it up very slightly.
9. Reinstall the O2's front and back covers. Don't forget to re-install the O2's ground wire from the **input jack to a cover screw.**

Operation

Turn on the O2 and test your new board! The two new power rail LEDs should light up about 1 second after the O2's power switch it turned on, when the O2's power management circuit turns on.

Once the batteries run down, the new power management latch circuit will "lock" the mosfets off to prevent oscillation until the batteries are recharged. The latch circuit can be reset by turning the O2 off for 30 seconds, but if the batteries are still rundown it will just re-latch until the batteries are charged.

The two new LEDs will turn off when the batteries get low and the power management circuit turns off. You now have a way to know that has happened. With the original O2 it would just "die" with no real indication the batteries had run down and the power management circuit turned off, rather than some problem had occurred.

If only one of the new LEDs lights and the other doesn't that means an electrical problem has occurred in the O2 and only one of the two mosfets has turned on. If this happens turn the O2 off and troubleshoot the problem, keeping in mind that LED1 is the positive rail and LED2 is the negative, so you already know which power rail has died.