PRODUCT HOW-TO: Differential line driver with excellent load drive - EDN

EDN

Differential signaling is the undisputed champion for conveying analog signals, audio or otherwise, across distances with minimal noise pickup. One of the big concerns during the design of differential drivers is the capacitance at their output. This capacitance comes from actual capacitors added to the line as well as the parasitic capacitance of the cable itself.

Differential drivers can be built around either conventional op amps, or the preferred solution of a fully differential op amp. However, both of these amplifier types have limited capacitive drive capability.

Another issue with op amps is the low-impedance termination at the end of the cable will often cause significant die temperature rise above ambient. One approach which mitigates these problems is to include a high-speed, high output-current buffer inside the op amp feedback loop. An example of this is shown in *Figure 1* .

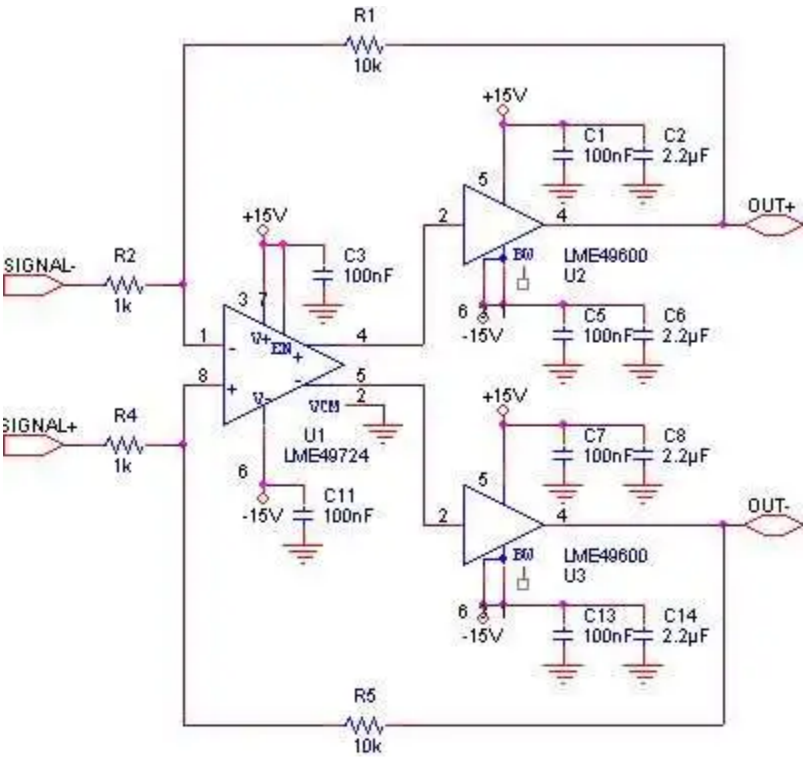

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Figure 1. A differential amplifier with buffered outputs.

The circuit of Figure 1 is built around a fully differential op amp U1, the LME49724 (LME49724 information page). A fully differential op amp has a differential input similar to conventional op amps, but has two complementary outputs. Fully differential op amps use dual feedback paths, maintaining signal balance. An additional pin on a fully differential op amp sets the output common mode voltage, ground in this application.

The two outputs of the LME49724 drive the inputs of a pair of U2 and U3, LME49600 (LME49600 information page) high-speed open-loop buffers. The LME49600 provides up to 250 mA of output current, and has a 110-MHz bandwidth as configured. Resistors R1 and R5 close the loop around U2 and U3 back to U1.These resistors in conjunction with R2 and R4 set the gain to 20dB.

Although the circuit of *Figure 1* could be considered complete, in actual application it will often have capacitors added to its outputs. These capacitors, usually in the 47-pF to 470-pF range, suppress EMI, both radiated and received. Furthermore, the other piece of equipment which receives the differential audio signal will usually have capacitors on its inputs to protect against EMI.

In addition to the capacitors intentionally added to the circuit, the parasitic capacitance of the cable also loads the differential driver outputs. In a shielded twisted pair cable, this capacitance appears as both differential (OUT+ to OUT-) as well as single ended (OUT+ to Ground and OUT- to Ground).

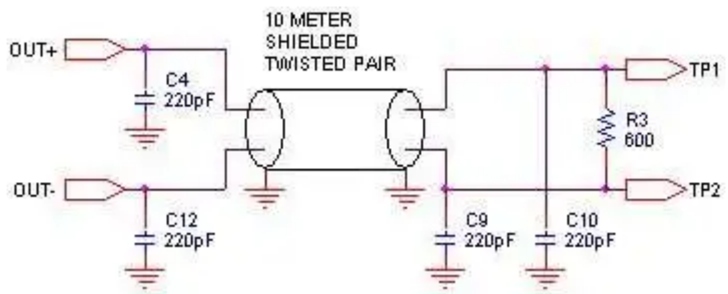

Figure 2. A measurement circuit to reproduce real world conditions.

In order to reproduce real world conditions, the circuit of *Figure 1* was loaded as shown in *Figure 2* . A 10-m piece of cable was attached to the amplifier outputs. This cable has 90 pF per meter of differential capacitance, and 190 pF per meter of single-ended capacitance. Four capacitors, each 220 pF, were added to make the circuit EMI tolerant. The end of the cable was terminated into 600 Ω. The design was tested by measuring at the end of the 10-m cable to simulate the signal as received in an actual application. The THD+N plot as a function of output signal amplitude is shown in *Figure 3* .

Figure 3. THD+N measured at the end of 10-m cable.

About the author:

John Guy is an application engineer who joined National Semiconductor in October 2007. Prior to National, he worked for Maxim and Analog Devices. John obtained a BSEE from San Jose State University in 1992. In his spare time he enjoys woodworking, crafts and constructing esoteric devices. He lives in San Jose, CA, with his wife and two daughters.

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