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New Low Resistance Analog Switches Permit Speaker Switching in Cell Phones

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APPLICATION NOTE

INTRODUCTION

CMOS Analog switches have been available from the semiconductor industry for more than 30 years. The venerable MC14066 is an example of a still popular device in the "4000" family. The MC14066 exhibits ≈ 500 Ω series resistance (R_{ON}).Switches of this style are still popular and useful for controlling high impedance audio and similar signals. In the past few years the industry has begun to offer switches in the 10−20 Ω R_{ON} range, and in 2003 switches with R_{ON} values of ≤ 1.0 Ω became available. The NLAS4684 and NLAS4685 are two examples of switches with R_{ON} ≤ 1.0 Ω, capable of switching an audio output signal that is directly connected to a speaker.

In the cell phone marketplace, it is virtually mandatory to include a jack for external microphone/speaker connections. Many places in the world do not permit operation of a cell phone when driving, except in a hands−free mode. It is very common to see people walking and talking into a lapel mounted microphone, with the earpiece placed in the users ear. It is potentially dangerous to have the ring tones that are generated at high levels directed into the earpiece. The use of a mechanical switch to disable the speaker and direct the signal to the earpiece is therefore ruled out. This design gets further strained, when one adds all the new features consumers are demanding. MP3 stereo audio playback and FM−stereo radio are two such desirable features. The commuter riding the metro or suburban train would want to have MP3 to have music playback, of his choice, and FM radio for news. With a rechargeable battery, and a high power microprocessor on board, all that is needed to add MP3/FM functionality is an external memory card and software, and possibly an FM tuner chip. For MP3/FM the user will likely demand stereo playback. Both MP3 and commercial FM radio require a stereo audio amplifier. If the designer had to switch the routing between the stereo earpiece and the internal speaker, there are two choices:

a. two stereo audio output amplifiers
b. one stereo amplifier and an electronic switch

At first blush, it might appear that two amplifiers might be the desirable way to go. with The advent of some new switching technology will show this is not the case. If the designer were to use two stereo amplifiers, he needs to steer the signals at low level to the appropriate amplifier. He also needs to Enable/Disable the appropriate amplifier, to reduce the standby current. ON Semiconductor supplies a small stereo amplifier capable of > 100 mW output, that can be used for this purpose. The NCP2809 is delivered in a Micro−10 surface mount package that is 3x5 mm, occupying 15 mm^2 of board space. A second amplifier would occupy an additional 15 mm^2 of space. The signals need to be routed to the appropriate amplifier, and a pair of NLAS4599 devices in 2x2 mm packages could be used. In addition, an inverter is needed to permit the Enable/Disable function to be done with one line from a micro−controller.

On Semiconductor offers two new low impedance switches that exhibit less than 1.0 Ω R_{ON}. The NLAS4684 is a dual analog switch with a typical R_{ON} of 0.5 Ω. It is available as a flip−chip or bumped die device. In this form it occupies only 3 mm^2 of board space.

Circuitry: the following diagram shows a cell phone based on two stereo amplifiers and no switch low R_{ON} switch versus one stereo amplifier and the NLAS4684.

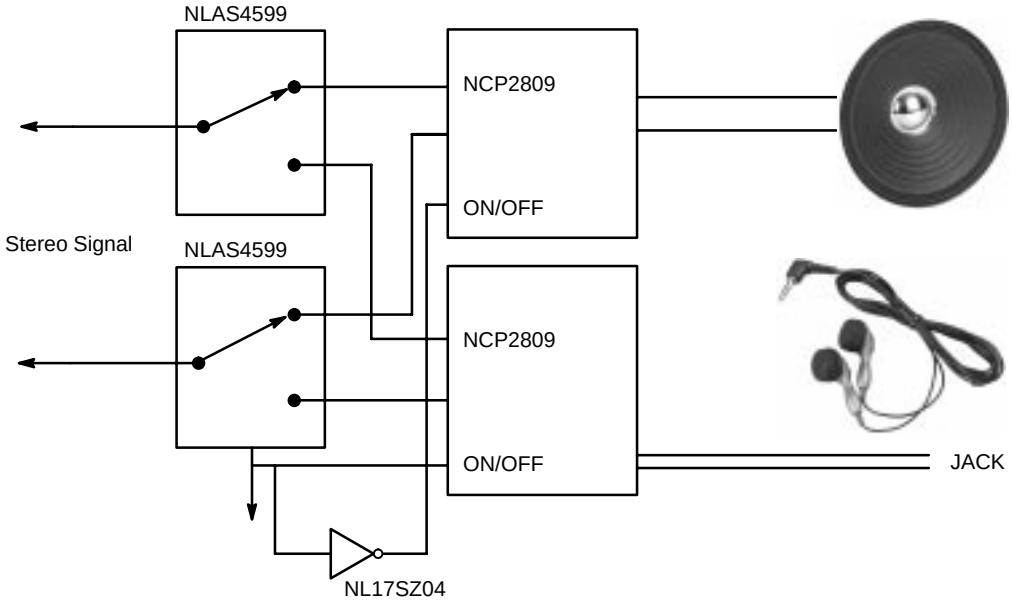

Figure 1. Two Stereo Amplifiers to Switch Earphone/Speaker

Alternative: A new analog switch that exhibits ≈ 0.5 Ω series resistance can be used. This will insert less than 0.5 dB loss to the system when using 8−16 Ω speakers. The circuitry in Figure 2 is amazingly simple. It is almost as if we have a mechanical switch that is electrically controlled. The new embodiment reduces the number of parts to one amplifier such as the NCP2809, one NLAS4684 analog switch. Cost and almost more importantly board space is considerable reduced. The new circuit accomplishes the same function with 3 fewer parts board space, cost and complexity. The table following shows that the new approach saves 2 standard switches, one stereo amplifier and one inverter, while only adding the new 0.5 Ω NLAS4684 switch. The switch is fabricated in 0.5 μm silicon gate CMOS, and is only 1.5 x 2.0 x 0.5 mm. It has only one control line. It hooks "transparently" to the audio output, inserting almost no loss. This new approach saves > 20 mm^2 of board space, while saving approximately 20% of the cost, compared to the dual amplifier approach.

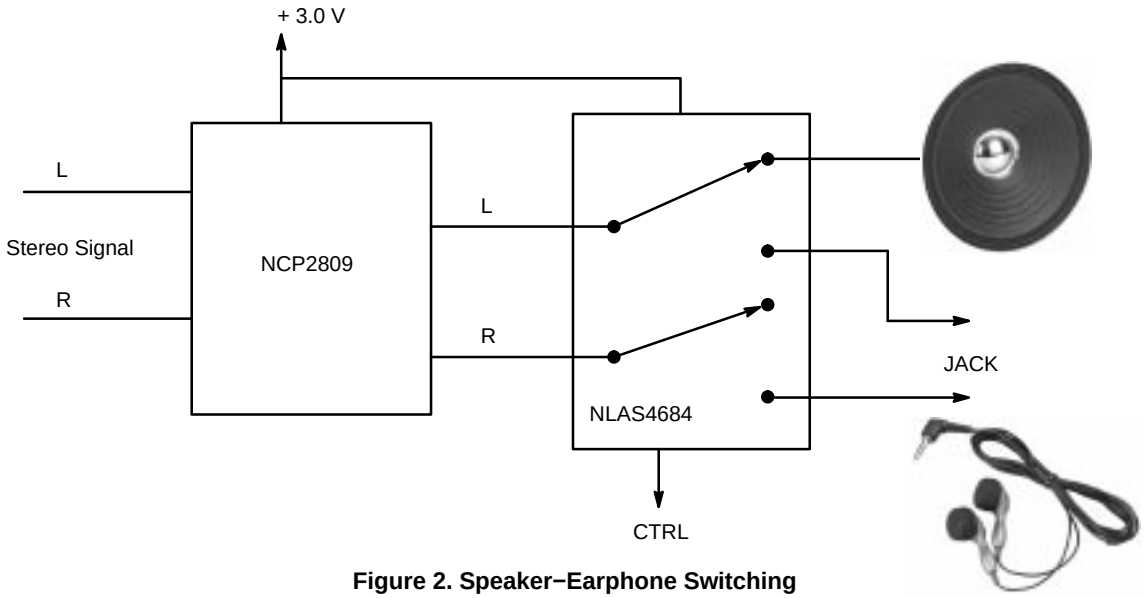

Figure 2. Speaker−Earphone Switching

Comparison of Figure 1 and Figure 2

	Quantity	Device Type	Function	Total Area sq−mm
	Figure 1			
	2	NLAS4599	SPDT−Sw	9
	2	NCP2809	Stereo Amp	30
	1	NL17SZ04	Inverter	2.5
Total	5			41.5
	Figure 2			
	1	NLAS4684	D−SPDT	3
	1	NCP2809	Stereo Amp	15
Total	2			18
Savings	3			23.5

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