How low the ON-resistance and the ON-resistance flatness of analog switch can and should be?

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Analog switches are used in a wide range of products today. From power-routing to audio and video signal routing all these different applications require different performance parameters of the switches. This article describes which parameters are the most important and why, and where is the limit for them.

Key parameters for the analog switch

There are two key parameters for the analog switch. Depending on the application it is most important to keep the maximal ON-resistance as low as possible, to achieve almost no energy losses during throughput. The second most important parameter is the ON-resistance flatness. The flatness is defined as difference of the maximal ON-resistance and minimal ON-resistance for the whole voltage throughput domain. Especially the audio applications require low flatness values, because the flatness causes harmonic distortion that should be kept as low as possible.

Realization considering

For the switches in power management solutions the single transistors NMOS or PMOS are used. The NMOS has very low resistance for signals near ground (negative supply), and the PMOS has very low resistance for signals near positive supply. In power management circuits the switches connected to ground are NMOS transistors, while the switches connected to input or output voltage are PMOS transistors.
To realize analog switch as standard linear product for different application the ideal solution is to put NMOS and PMOS parallel. Than the switch will have low resistance in the whole throughput domain from ground to supply (see Fig 1).

Figure 5. R_{ON} vs. V_{COM} and Temperature (V_{DD} = 5V)

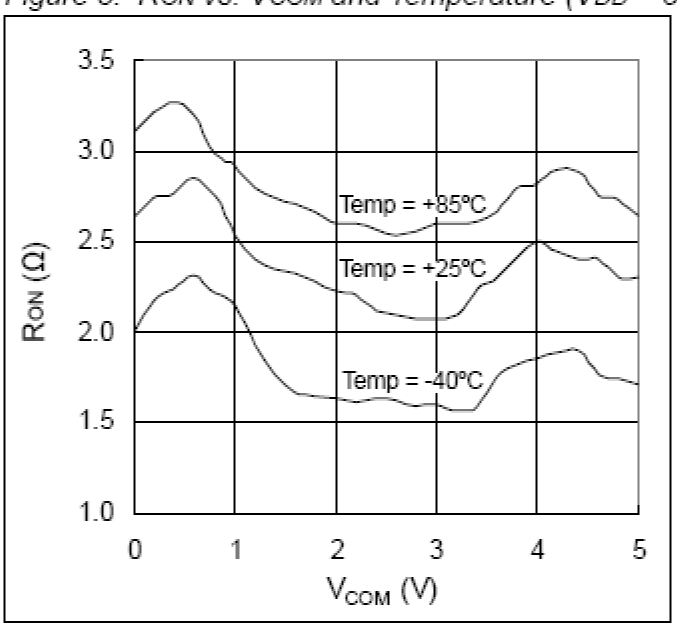

Fig. 1 AS1744: RON

The energy loss when the current flows through resistor is E=I*R. So, if bigger currents flow through switch, we should try to choose switch with minimal resistance. But how low can it go?
Also the flatness of the switch should be minimal, to achieve small harmonic distortion. But how low can it be?

Very low switch resistance and flatness
To achieve very low resistance and flatness for analog switch, two parameters are important. For both PMOS and NMOS, the size should be big as possible, and its voltage thresholds should be low as possible. Double bigger transistor should have double smaller resistance, but it costs also double price in production. The smaller thresholds would improve flatness. The resistance peak (maxima) on the left side is caused by the NMOS threshold and the resistance peak (maxima) on the right side is caused by the PMOS threshold. But also the technology processes with lower transistor thresholds are more expensive.
Also, different parasitic resistances from package (like bond wires), connections and contacts, and spetial transistor layout parasitic resistances, one must to take into account during designing of analog switches. In practice these parasitic resistances can be few hundreds of mOhm, so they can be even bigger than transistors resistances as well.

Figure 5. NC ON-Resistance vs. VCOM, 5V

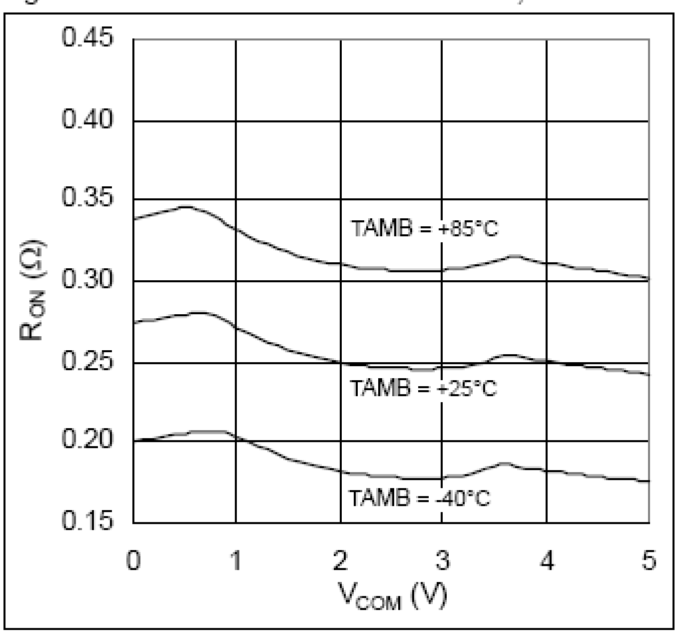

Fig 2: AS1746: RON

In Fig 2 the resistance of very low resistive analog switch AS1746 is presented. With the fact that different parasitic resistances are about 150 mOhm, the typical whole resistance of 250 mOhm is best result that could be reached. Also the flatness of less than 50 mOhm is very low, because only the difference of the parasitic resistances of NMOS and PMOS transistors could be much bigger, what would make big difference in left and right maxima, and the flatness would be much bigger.

Which solution to choose in application?

For the power routing applications or very high quality audio applications, the AS1746 with very low resistance and flatness is the right solution. This solution makes energy losses and also harmonic distortion minimal.
However, in application where these two things are not so important, the cheaper AS1744 would be the better solution. In many applications the audio quality difference would be so small, even if typical resistance is about 10 times bigger, that it would not bring any advantage to use more expensive solution.