An alternative principle is to use depletion-mode nMOST devices. Leaving out an ion implant allows nMOST devices to obtain a negative threshold voltage. This allows rail-to-rail input stages with supply voltages down to 1 V. It is not considered any further however, as no standard CMOS can be used.

Let us first decide when we need such an input. What are the circuit configurations which allow a rail-to-rail input range?

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- **Why rail-to-rail?**
  - 3 x Current mirror rtr amplifiers
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  - Other rtr amplifiers and comparison
The first reason to require a rail-to-rail input range is to be able to maintain the same Signal-to-Noise ratio for smaller supply voltages. Indeed signal swings decrease with the supply voltage. A rail-to-rail swing at the input is the highest that can be obtained.

For maximum output swing, a fully-differential operation is a must as well.

At the output, it is easy to provide a rail-to-rail swing. We simply take two output transistors Drain to Drain. For a capacitive load, rail-to-rail is guaranteed.

At the input, however, we do not need rail-to-rail operation.

To illustrate this last point, let us take this well known symmetrical opamp.

For a capacitive load, it is obvious that the output can reach rail-to-rail output voltages. At the extremities, the output transistor goes into the linear region and the gain is reduced leading to distortion. It is still rail-to-rail, however.

At the input, it is clear that a voltage is lost of $V_{GS1} + V_{DSat0}$ for the input range, which is rather large.