Design and Testing of a Frequency-Band Selectable Sigma-Delta Modulator

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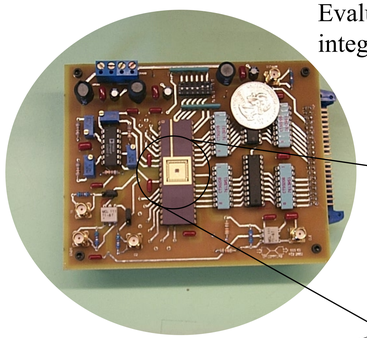
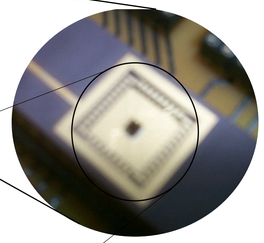
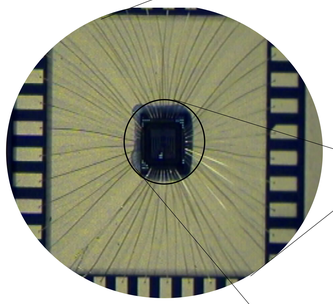


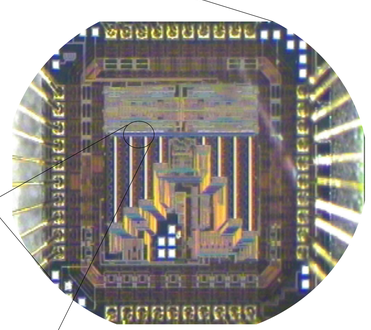
Evaluation board with integrated circuit in place.

Small silicon chip in center of integrated circuit.

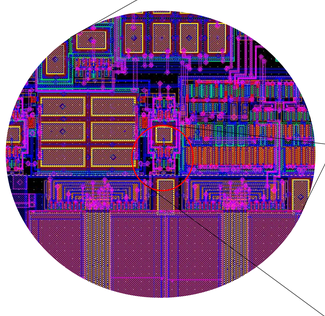


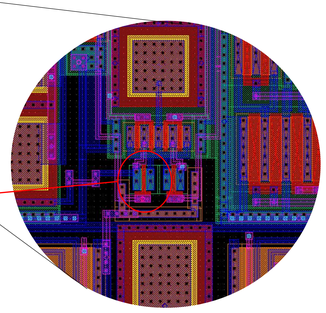


Silicon chip with gold wires connecting it to the integrated circuit package. The chip is 1.6 x 1.6 mm.



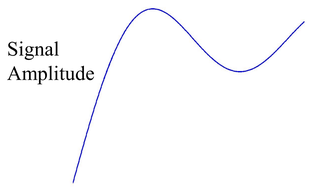
Photograph of silicon chip. Gold wire connections are visible and measure 60 x 60 µm.



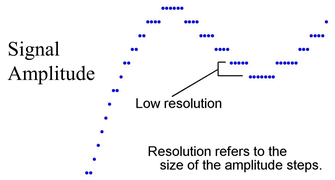


Highest magnification shows an individual transistor with a gate that measures 0.6 x 3 µm.

Analog to Digital Conversion (ADC)



ADC

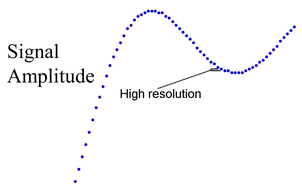


Analog signal from real world is defined at all points in time and amplitude.

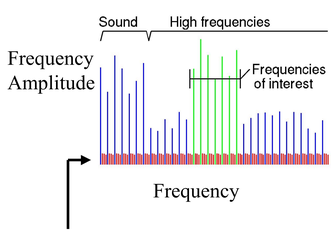
Discrete digital data is evenly spaced in time. Only a limited number of different magnitudes can be represented.

A fundamental problem in ADC is the appearance of quantization noise due to low resolution of the converter. If only a few levels of amplitude are used this leads to low resolution and lots of quantization noise. Quantization noise sounds like static when listening to recorded music.

Sigma-Delta Modulation (SDM)



<u>Advantage of SDM</u>
Sigma-delta modulation produces the highest resolution of all types of ADC's because they produce the lowest quantization noise. SDM's account for the high quality of sound produced by CD players.



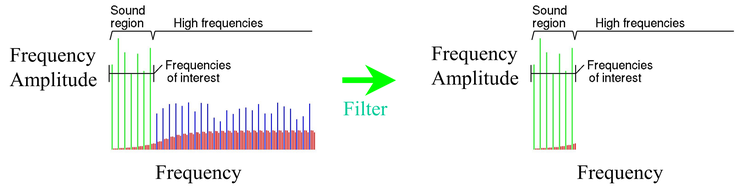
<u>Disadvantage of SDM</u>
The use of SDM's is limited to the conversion of low frequency signals such as sound. High frequencies may be of interest, but standard SDM's are incapable of converting signals above a certain frequency limit.

Quantization noise (indicated in red) is shifted from the sound region that is converted in a SDM up to the high frequencies. Following this the high frequencies, including the quantization noise, are filtered out leaving just the desired signal.

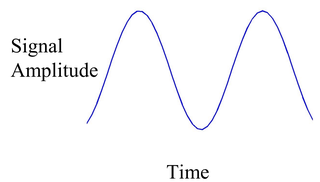
Goal of this design

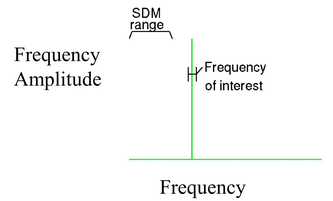
Expand the ability of an SDM so that it works on signal frequencies higher than sound and allow the user to select the frequency to convert.

<u>How it operates</u>
Frequencies of interest are shifted into the region where the SDM is effective and the quantization noise is still shifted out of the region. Following filtering, only the desired high frequency signal remains.

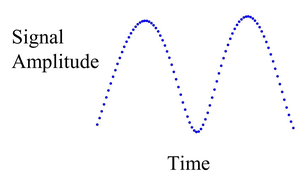


Results of Testing





The analog signal is shown above and the converted digital signal below. The frequency spectrum is shown at the right. The signal is shifted into the convertible range and the noise shifted to high frequencies by our SDM. The SDM output is filtered to produce the digital spectrum at the lower right. After shifting the frequency back to its original band the digital signal below results.



Shift frequency back