Modeling the [quantization] distortion (© Kurt L. Kosbar)

http://www.siglab.ece.umr.edu/ee341/dsp/adda/adq.html

Bits are expensive. It not only *costs* more to buy an A/D converter that generates more bits of precision - it will also take time, power, transistors, design effort, etc. to build a DSP system that uses more bits. All these constraints push designers to use the *minimum number of bits* possible.

The down side to a small numbers of bits was [shown in the demonstration above] - **distortion**. If you are going to work with digital signals, you need some way to objectively measure the distortion that the A/D introduces. Once you have an objective measure, you can start *reduce* the number of bits in the digital number until the distortion increases to an unacceptable level.

The Success and Failure of **Dominico Quantizino**

At first glance, analyzing the distortion of stair-step nonlinearities, seems pretty cold and boring. However there is a human side to even this topic.

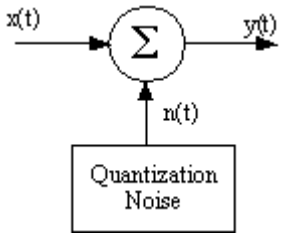
The story starts in a small Italian Restaurant shortly after the turn of the century. A young patent clerk, Dominico Quantizino, was having dinner with a young lady, Maria someone-or-other (her last name has been lost to history). After a suitable amount of wine their conversation wandered to the topic of free-will versus destiny.

Dominico was convinced that everything from the movement of individual atoms, to the behavior of complex organisms like people could be predicted by a complex set of equations. This means a sufficiently smart person/god could predict what everyone will experience in the future, and how they will react to that experience.
Maria considered this a very cold and calculating view of the world. She argued that people are driven by unpredictable thoughts and emotions, and can exercise a free-will. According to Mr. Quantizino's diary, this was a very heated discussion, so heated that they continued it the next day - at breakfast.

This same dairy tells us that shortly after this discussion, Quantizino reviewed the patent application for a new device called an Analogo-to-Digitalo Converter. Other patent clerks claimed the device would be useless, because it would introduce complex distortion into the signal. They thought this distortion would be too complex to analyze and characterize. Quantizino at first agreed with them, but then recalled the discussion/argument/etc. he had had the previous night. In a stoke of insight (which may or may not have been predictable) Quantizino realized that even though a stair-step nonlinearity was a **deterministic function**, you could model it by a **noise source** and an adder…
Quantizino showed that there are some simple mathematical models that describe this noise source, and allow engineers to predict the SNR at the output of the A/D converter. This concept of **modeling a complex, but deterministic, function as a random device** made Quantizino famous. Everyone called this type of distortion "Quantizino's Noise", which of course we have now changed to "Quantization Noise".

There is no record that Quantizino ever acknowledged Maria's contribution to his fame. She became so upset with men, that she considered becoming a nun. When she found this life equally upsetting, she finally found her true calling as a day-care worker. Her first assignment was to watch the children of an Austrian Barron, by the name of Von Trapp.

Thanks to Mr. Quantizino, we now think of quantizers like this:



There is a simple way to figure out what **quantization noise** looks like - just subtract the input from the output

- Input to A/D, the desired signal: x(t)
- Output from **A/D**, or signal **plus** noise: y(t) = x(t) + n(t)
- Quantization Noise: n(t) = y(t) - x(t)