Video Fundamentals 14 Digital Quantisation Noise Brian Summers G8GQS

This is a little discussed topic, after all digit's are perfect, aren't they? Well perhaps not.

Analogue

When you consider an analogue signal, it is considered to be indefinitely variable. That is, over time, the voltage level changes smoothly from one value to the next value and setting aside the effects of noise, there are as many different voltage levels as you care to measure. Except, perhaps if you have a very good magic voltmeter that can measure the arrival of individual electrons.

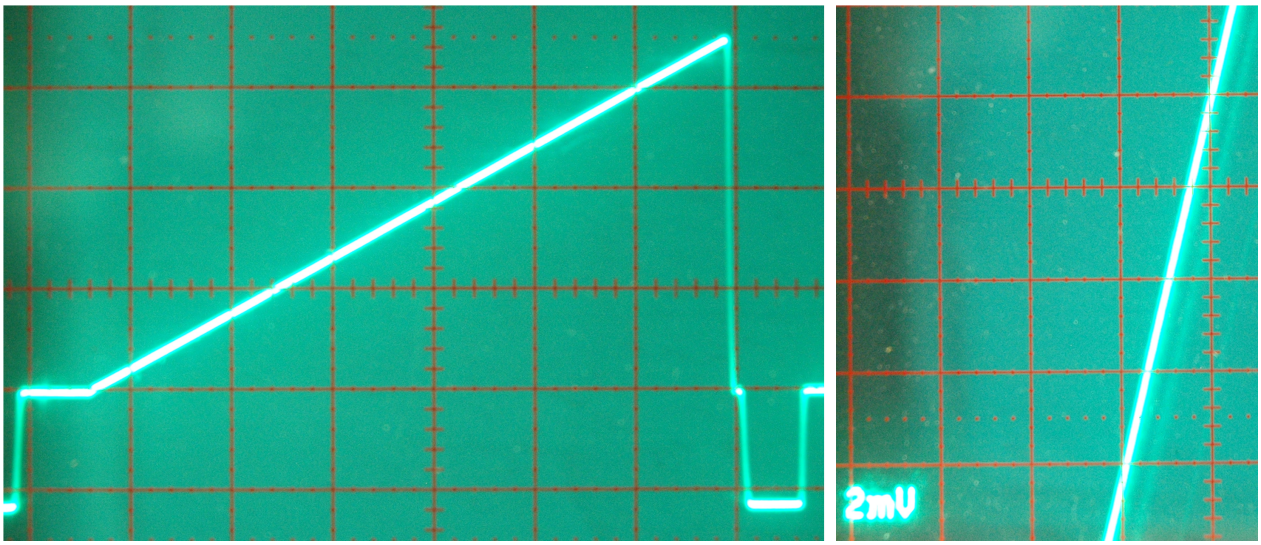
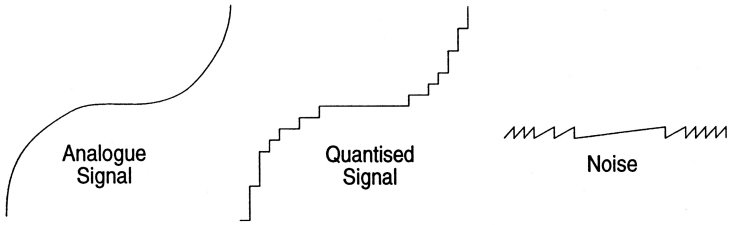


Fig.1: Analogue sawtooth & same sawtooth expanded by 100 times at 2mV cm.

Digital (video)

Now when we come to digitise an analogue signal or create one from scratch, we have to choose how many bits to use. Until recent times 8 bits was the choice, it fits well with hardware and for video gave acceptable results. Latterly 10, 12 or more bits are used especially in camera and other processing systems.

Returning to 8 bit systems, you have to define what number represents each part of your video waveform. The ITU REC. 601 specification defines 16 as black level and 235 as peak white. So there are 220 steps in the picture 700mV signal. This equates to 3.196mV per quantisation step. It does not sound much but it is there as you can see in the figure were the digits try to follow the curve of the analogue signal.



This happens every time you go from analogue to digital or vice-versa. So best to say in digital once achieved. This small step of 3.196mV is supposable less then a “Just Noticeable Difference” as decreed by the standards authority. It is, however, more noticeable after the pictures have been though a hard compression and can often be seen in the gradual level changes in clouds or the sky being a series of “bands” but that is

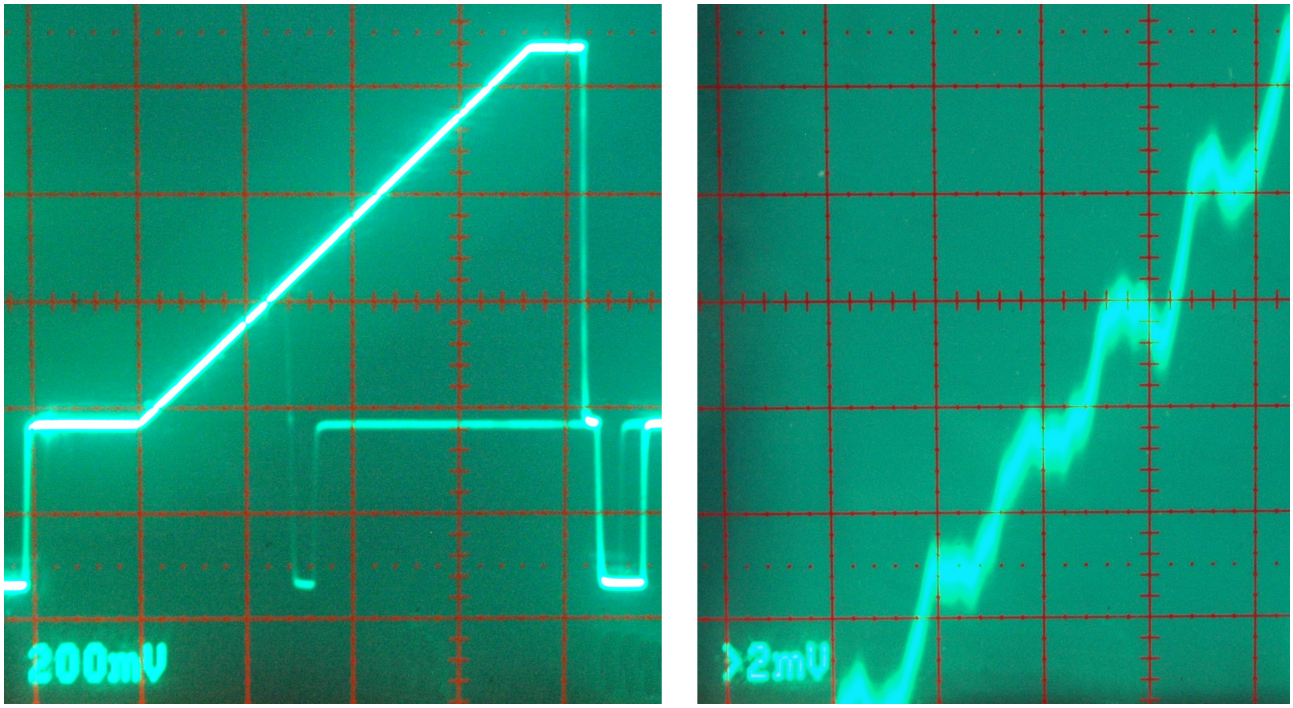


Fig.2: This sawtooth is from a digital 8 bit test signal generator. However when you expand the gain by 100 times the quantization steps can be seen.

another story.

In right of these two waveform pictures I have increased the oscilloscope Y gain (approx 2mV.) to the same value so, comparing the two, in the second waveform you can see that the sawtooth is actually a series of small steps of voltage increases. For each extra bit used the “step” value is halved. A 10 bit signal quantisation step is 0.8mV a quarter of the 8 bit value.

Like analogue video, there are lots of potential for distortions, just different ones for digital. A few things to consider are the number of bits in each sample and the sample rate. A function of increasing these two parameters is the bit rate. This leads to the staggeringly large size of the uncompressed video signal. 270Mbs for 10 bit SD video and 4 times this for HD and so on.

This short monograph, like it's predecessors, is a light and simplistic look at the subject. More serious descriptions can be found on the internet :-

Link to Wikipedia Quantization page

Link to Quantiazation lecture page

Princeton.edu Chaper 5 Sampling.

Elsewhere in this issue is an article about the Royal wedding and UHD HDR, (Ultra High Definition and High Dynamic Range) the sharp leading edge of TV development.