A review of popcorn noise and smart filtering

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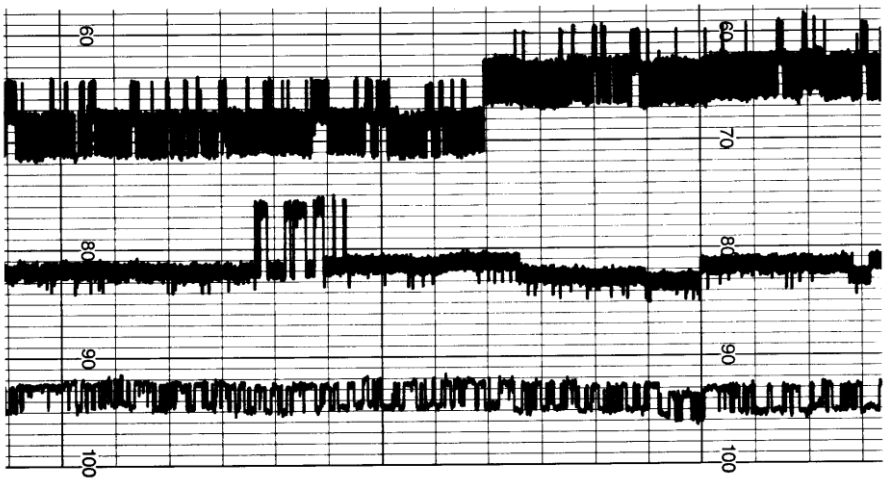
INTRODUCTION

Popcorn noise (also referred to as burst noise or random telegraph noise) is a special type of noise that is quite common in semiconductors (e.g. op-amps and voltage references), but it can also be seen in resistors and electrical contacts. Popcorn noise manifests itself as sudden 'jumps' in a signal between two or more discrete voltage or current levels at unpredictable times. Where the time between 'steps' varies anywhere from 1ms to several minutes, and would sound like the 'popping' of popcorn in a microwave if played on an audio system, hence the name.

Compared to Gaussian noise, these small steps are often very annoying and complicate signal analysis requiring correction algorithms (smart filtering) or specialised analogue filtering. Popcorn noise is often unpredictable in nature (changing from bursts of activity to silence in a whim), and can change a lot with temperature (lower temperatures are usually worse) and even within a batch of components, a wide variation can be seen. Although some manufacturers state that popcorn noise is somewhat a thing of the past, the opposite is more true: with the current focus on shrinking geometries, higher frequencies and low cost, popcorn noise is more alive than ever.

EXAMPLES

A figure of the more commonly known semiconductor popcorn noise for three op-amps of the same type as recorded with a plotter is shown on below. Where it can be seen that the discrete nature of the steps is easy to recognize, but notice how the noise differs per device, making a universal correction scheme difficult to design and implement.



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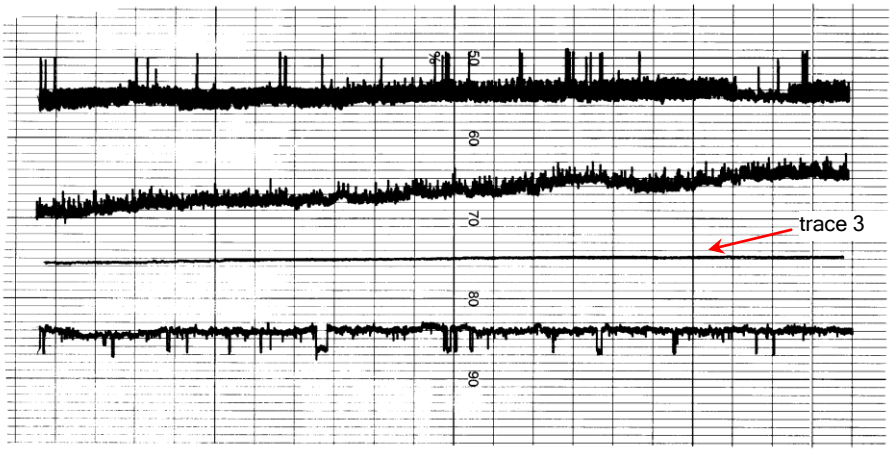
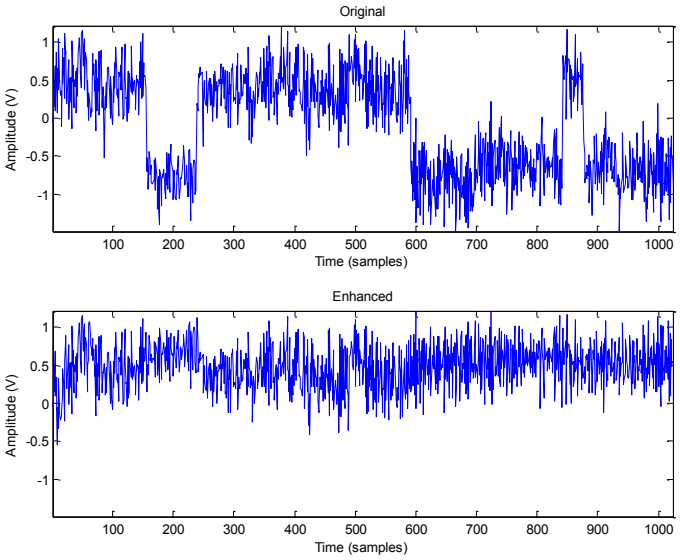
A figure of a second less known example of popcorn noise for three identical valued precision thin film resistors + a reference grade resistor (trace 3) is shown on the below. Notice that the reference resistor shows no signs of popcorn noise, while the three thin film resistors (taken from the same batch) each have a different noise signature, and bear no resemblance to the aforementioned semiconductor noise plots. As a consequence, any correction algorithm or filtering scheme would need to be customised for the type of noise profile to be corrected.



SMART FILTERING

Avoiding popcorn noise by using 'the right components' is not as easy as you might think. The component manufacturers are largely silent on this issue (in part, for good reason). Good advice on what to use (or what to avoid) is generally speaking not available in the public domain. Apart from using 'good' components, the special character of popcorn noise suggests it could maybe be filtered out. But due to its varying time duration, the noise is often within the signal bandwidth, making it difficult to filter out noise without killing the signal. The use of advanced smart filtering algorithms (see the figure on the right), that can analyse and correct the steps in real-time are tending to become much more popular with advances in powerful but affordable low power DSP/micro-controller devices. Although several other frequency domain methods have shown promising results, their usefulness in real life sensor applications is somewhat limited due to their batch processing requirements.



SUMMARY

Whether or not popcorn noise is a real problem, depends on your application, but when you work with small signals and low frequencies (or even DC), it is often a practical issue. As such, the resolution of today's ADCs is more than enough to see these small steps in a much larger signal, and the use of modern low-cost DSP technology leads to financially viable and technically sound solutions.

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